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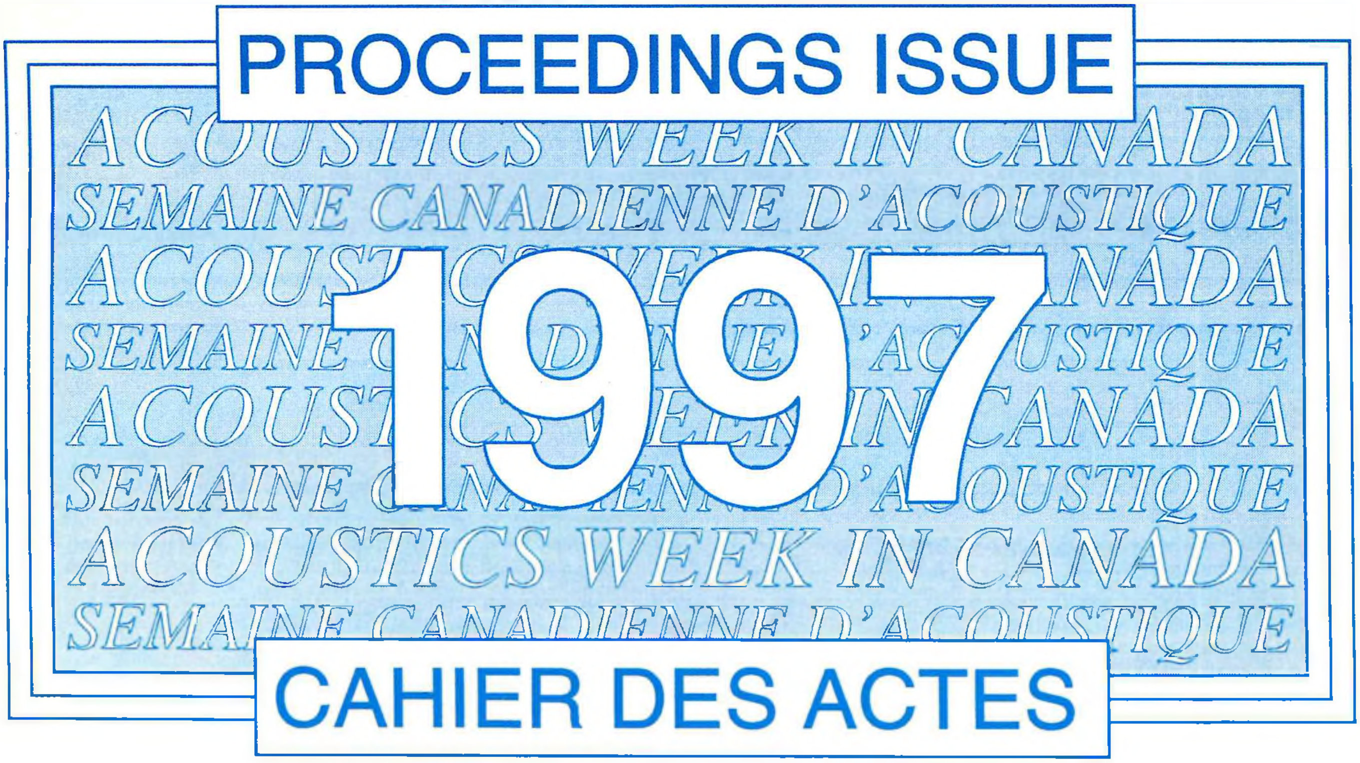
PROCEEDINGS OF ACOUSTICS WEEK IN CANADA 1997
ACTES DE LA SEMAINE CANADIENNE D'ACOUSTIQUE 1997

OTHER FEATURES / AUTRES RUBRIQUES



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ÉDITORIAL / EDITORIAL

Nous vous souhaitons bonne lecture des Actes de la Semaine canadienne d'acoustique 1997, qui se tiendra à Windsor en octobre. Vous trouverez, dans ce numéro, les résumés qui seront présentées lors des sessions techniques dans le domaine de la qualité du son, le bruit des transports et son contrôle, la perception de la parole, les effets du bruit, les normes acoustiques canadiennes, l'acoustique architecturale et l'acoustique musicale. Normalement, je devrais terminer ce paragraphe avec un "Au plaisir de vous voir à Windsor". Mais, à cause d'un engagement planifié depuis longtemps, je ne pourrai pas assister au congrès cette année. Laissez-moi alors souhaiter aux organisateurs et aux délégués une rencontre des plus réussies.

Puisque récemment, on m'a demandé des clarifications sur les critères d'admissibilité d'une publication dans l'Acoustique Canadienne, je profite de l'occasion pour aborder cette question. L'Acoustique Canadienne, à titre de journal technique canadien dans le domaine de l'acoustique, accepte des articles de recherche, des notes techniques, des tutoria et des articles de synthèse, qui sont tous révisés par des pairs. J'invite la communauté des consultants à joindre les académiciens et à soumettre des rapports intéressants. A titre de bulletin de nouvelles dans le domaine de l'acoustique canadienne, l'Acoustique Canadienne accepte aussi, sous forme de lettres à l'éditeur, des articles d'information, des lettres d'opinion ainsi que des revues de livres (sollicitées ou volontaires).

Welcome to the Proceedings of Acoustics Week in Canada 1997, to be held in Windsor in October. Included are one-page summaries of papers to be presented in the planned technical sessions on sound quality, transportation noise and control, speech perception, effects of sound, Canadian acoustical standards, architectural acoustics and musical acoustics. Usually I would end this paragraph with "See you in Windsor". Unfortunately, due to a previous committment, I cannot attend this year. Let me, therefore, wish the conference organizers and delegates a successful meeting.

Recently, I have had a number of requests for clarification of what is acceptable for publication in Canadian Acoustics, so let me address the issue here. Canadian Acoustics, in its capacity as Canada's acoustical technical journal, welcomes research, technical, tutorial and review articles, which are peer reviewed. I invite the consulting community to join academia in submitting interesting reports. In its capacity as Canada's acoustical newsletter, Canadian Acoustics also welcomes, in the form of letters to the editor, information articles and expressions of opinion, as well as book reviews (either solicited or volunteered).

An Investigation for Comparing Differently Measured HRTFs in a Speech Intelligibility Task

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INTRODUCTION

Virtual auditory displays are beginning to become accepted as a viable technology for enhancing human performance. A three-dimensional audio display gives the listener the perception that the signal is "outside" of his/her head even though the signal is delivered over headphones. Real-time performance for the positioning of a sound in virtual space is often achieved through time domain convolution of head-related transfer functions (HRTFs). These are digital filters that are based on measurements of finite impulse responses in the ear canals of humans and of artificial heads. HRTFs are unique to the ears that were measured, representing an "ear-print" of that head. There are different techniques for measuring HRTFs. Some parameters include the point in relation to the ear canal where the impulse response measurement is made, the number of physical source directions relative to the head for positioning a sound source, and the choice of sound stimulus to be localized. Each technique has its merits and undoubtedly yields different subjective binaural reproduction.

This study determined the auditory threshold levels for recognizing binaurally presented 3-digit numbers embedded in diotic speech babble. The same task was performed using three differently measured HRTFs. This study was motivated by the lack of published data that compare differently measured HRTFs.

METHOD

Participants

Twelve paid participants, six women and six men, volunteered to participate in this study. The average age was 24.7 years, and participants' hearing was normal in the range of 125 Hz to 8 KHz.

Stimuli and Apparatus

The signal consisted of 3-digit numbers spoken by a female talker. The numbers were stored as separate single channel sound files on the hard disk of the host computer. The Focal Point 3-D Audio (FP3D) and Tucker-Davis Technologies (TDT) equipment were used separately to spatialize the numbers in real-time. Continuous diotic speech babble served as a masker. The numbers and masker were simultaneously presented over headphones.

Task

Each participant was instructed to listen to a spoken 3-digit number and then prompted to enter the number that was believed to have been spoken via the computer keyboard. A "correct" response was defined as the participant's input matching the spoken number while an "error" was defined as an incorrect match.

Conditions

This study employed three differently measured HRTFs which are denoted as HRTF1 (used in conjunction with the FP3D hardware), and HRTF2 and HRTF3 (separately used in conjunction with the TDT hardware). These HRTFs were measured on three individuals who did not participate in this study. The measurement techniques for HRTF2 and HRTF3 are described in Wightman and Kistler (1989), and Pralong and Carlile (1994), respectively, while the measurement technique for HRTF1 is not provided. The numbers were spatialized at static azimuth positions between 30 degrees and 330 degrees at 30 degree increments on the horizontal plane. A diotic control condition was also used for the numbers. A session consisted of the numbers spatialized in the 11 static azimuth positions using the same HRTFs in addition to the diotic condition. The speech babble was played continuously throughout each auditory condition. The study consisted of a repeated measures between-subject design. The HRTF condition was treated as a between-subject factor. Each HRTF condition employed six participants. Three participants were chosen at random to participate in all three HRTF conditions (denoted as "multiple") while the others participated in only one (HRTF condition (denoted as "unique"). The combined performance of the two groups of participants for each HRTF condition is denoted as "combined".

Procedure

A computer program varied the level of the numbers against the speech babble. At the outset, the numbers were clearly audible over the speech babble. An adaptive psychophysical procedure was used for determining the auditory threshold at the 80% probability level. The starting step size was 4 dB and decreased to a minimum step size of 0.5 dB. The last trial of each condition constituted the threshold value. Testing was performed in an IAC sound booth. Participants completed a 15 minute training block in addition to four test sessions, each on separate days. The duration of each session was approximately 70 minutes.

RESULTS

For each participant the auditory threshold of each of the spatial conditions was subtracted from the diotic auditory threshold of that session. A positive difference represents a binaural advantage over diotic presentation while a negative difference represents the reverse. These differences formed the data in all subsequent analysis.

Figure 1 shows the binaural advantage for each group of participants ("combined", "multiple" and "unique") for the three HRTFs (HRTF1, HRTF2, and HRTF3) averaged over sessions. An analysis of variance (ANOVA) showed a significant difference in performance between diotic and spatial presentation. The only spatial condition that yielded a significantly poorer performance than the diotic condition was 180 degrees azimuth for HRTF1. A subsequent ANOVA on the spatial conditions revealed a significant difference. The spatial position that produced the greatest advantage in intelligibility was 60 degrees azimuth. However there was no significant difference between 60 and 90 degrees. HRTF3 was significantly better in performance over HRTF2 while HRTF2 was significantly better in performance over HRTF1. The performance of the "multiple" and "unique" groups were not significantly different from one another across HRTFs.

DISCUSSION

This study confirmed that the intelligibility of speech in noise is partially dependent upon the relative location of the speech and noise. When the speech and noise are close together then intelligibility is low; otherwise intelligibility is increased. Overall the obtained auditory threshold values using the three differently measured HRTFs met or exceeded the results obtained in previous studies. Although the results of HRTF1 were similar to those obtained in an earlier study, they were, however, significantly poorer than the results obtained with HRTF2 and HRTF3. This might be explained by the limitations of the FP3D hardware. This limitation could impose a smaller number of impulse responses in each ear which could reduce the perceptually salient features of the HRTF measurement. In addition there is comparatively little interaural processing occurring at low frequencies in HRTF1. Since the interaural time difference is one of several cues in binaural hearing, the diminution of this cue could impact the quality of spatialization. As for the difference in performance between HRTF2 and HRTF3, this might be partly explained by the different HRTF measurement techniques such as the cut-off frequency of the anechoic chamber, choice of loud speaker for the presentation of impulses, in addition to other parameters.

There are also some general factors that could influence performance. Up until recently it was believed that a factor, which may be of most significance, is the physical differences between the participants used to create the HRTFs. Previous studies have suggested that certain individuals are "better" localizers than others due to differences in physical anatomy. While no information is known to us about the participants used to measure the HRTFs used in this study, the performance differences between the three HRTFs suggest that a "better" localizer may have been used in the HRTF3 measurement. However, F.L. Wightman (personal communication, March 2, 1997) reported that this assumption seems no longer valid. Just because an individual is a "better" localizer is not a reason to use that person's HRTFs. Other factors that could have influenced our results are the choice of voice, speech babble, or the interaction of a female voice with the HRTF convolution, compared with that of a male talker. It is unlikely that individualized HRTFs would have significantly improved performance, as these aid primarily in determining elevation and resolving front-to-back confusions.

CONCLUSIONS

This study determined the auditory threshold levels for recognizing binaurally presented 3-digit numbers embedded in diotic speech babble using three differently measured non-individualized HRTFs. The results showed that the auditory threshold levels were significantly different across HRTFs. Consequently if virtual sources are to be used in a general purpose spatial auditory display then it is essential that the HRTFs be optimized for the targeted application. These results are specific solely to this study and are not meant to be generalized across all possible applications. Localization of speech or other stimuli in a single channel or multi channel spatial auditory display using the same three sets of HRTFs might yield a different ranking than in the study reported here. We continue to investigate the feasibility of employing 3-dimensional audio in a variety of applications for the improvement of human performance.

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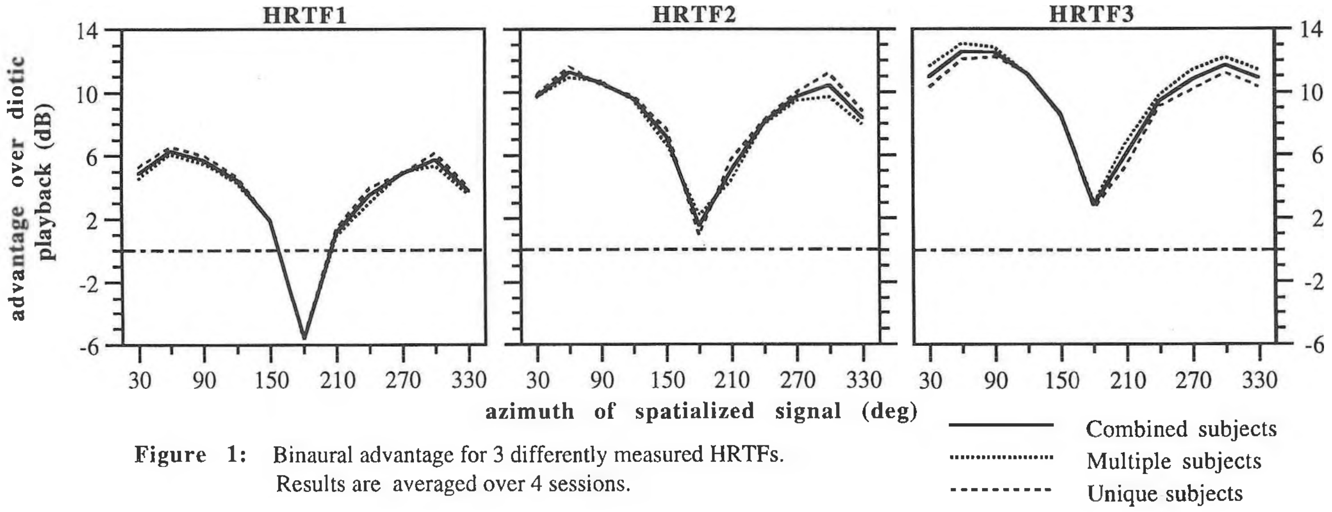

Figure 1: Binaural advantage for 3 differently measured HRTFs. Results are averaged over 4 sessions.

EFFECTS OF FACIAL PARALYSIS AND PRESENTATION MODE ON PERCEPTUAL-ACOUSTIC MEASURES OF CONSONANT PLACE

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1. INTRODUCTION

Listeners use both acoustic and visual cues to identify speech. Discrepancies between these cues increase the frequency of listener misidentifications of the speech signal[1]. A speaker with bilateral facial paralysis (BFP) may present conflicting visual and acoustic cues when producing bilabials. That is, despite the absence of lip movement because of facial paralysis, the speaker may compensate with the tongue and jaw to produce acoustic signals that listeners identify as bilabial sounds[2]. As the second formant frequency (F2) has been established as a primary cue to place of articulation[3], it was hypothesized that when sounds produced by a speaker with BFP are identified by listeners as bilabials, the acoustic cues to articulatory place contained in these sound productions are consistent with those normally associated with labial place of articulation.

The objectives of this study were:

1. To determine if listener identification of bilabial and alveolar consonants produced by a child with BFP and a child with normal facial muscle function (NFMF) was affected by mode of stimulus presentation, i.e., an auditory-only (A) versus an auditory-visual (A-V) signal. For the child with NFMF it was hypothesized that consonant identification scores would be high in both A and A-V conditions, with scores in the A-V condition expected to be slightly higher as there are more cues available for signal decoding. Conversely, consonants produced by the child with BFP were expected to be identified correctly with greater frequency in the A condition, due to conflicting auditory and visible articulatory cues in the A-V condition.
2. To determine if F2 coordinates and corresponding locus equations[4] of correctly identified bilabial and alveolar consonants in the A condition for the child with BFP were consistent with those produced by the child with NFMF. It was hypothesized that misidentifications would occur when F2 values were not consistent with those normally expected for the target place.

2. METHOD

Two girls, one with BFP and one with NFMF, were videotaped as they read CV words embedded in a carrier phrase. The consonant /b/ or /d/ was followed by one of the vowels /i, I, e, æ, ʌ, ɛ, a, o, u/, as in Sussman et al.[4]. Ninety utterances (2 consonants X 9 vowels X 5 repetitions) were recorded per child. Digital movie files of each utterance were created using a Macintosh Power PC 8500 and Avid VideoShop 3.0 software. HyperCard 2.1 was used to create a program that randomly presented the movie files to listeners and recorded and analyzed listeners' responses. After each item was presented, listeners selected the consonant that they perceived (either /b/ or /d/) by "clicking" on the appropriate letter choice displayed on the computer monitor. Listening sessions were conducted in a sound booth. For the A condition, only the audio track of the movie files was presented. Listeners were 47 speech-language pathology graduate students who were randomly assigned to the A (n=25) or A-V (n=22) condition. Within each condition, presentation order of the speaker (BFP and NFMF) was counterbalanced.

3. RESULTS

A three-way ANOVA tested the factors facial muscle function (BFP and NFMF), place of articulation (/b/ and /d/) and presentation mode (A and A-V). Each factor had a significant main effect and a significant three-way interaction was obtained ($p<.0001$). The child with NFMF had a higher number of correctly identified phonemes (b=99%; d=100%) than the child with BFP, regardless of consonant place and presentation mode. The child with BFP had a higher number of accurate identifications for /d/ (95%) than /b/ (30%), and a significantly greater number of correct identifications for /b/ in the A (51%) than the A-V (10%) mode. Acoustic analyses of the stimulus words were completed on a 486 personal computer, using CSpeech 4.0. F2 onset and offset were calculated for each "correctly identified" (validated) CV token, i.e., those CVs where at least 75% of listeners correctly identified the target consonant. Regression lines (locus equations) for each consonant place were generated following procedures outlined by Sussman et al.[4]. For both children's productions, /b/ regression lines had steeper slopes, while /d/ regression lines had higher y-intercepts. For the same consonant place, regression line slope was steeper, and y-intercept was higher for the child with BFP. Non-validated stimulus items were present only for the child with BFP. Her locus equation for the non-validated /b/ tokens had a slightly higher y-intercept but similar slope compared to the validated tokens.

Acoustic analysis revealed that the child with BFP produced some consonants in the CV syllables that were perceived by listeners as /b/ in the A-only condition and that had F2 values consistent with those expected for the bilabial place of articulation. These CVs tended to contain back vowels. However, in the A-V condition, her lack of lip movement caused listeners to perceive the CV tokens as starting with the alveolar consonant /d/, even when the F2 characteristics in the acoustic signal resembled those for the bilabial /b/. Thus, the visual cue for place "overrode" the conflicting acoustic cue, resulting in misperception of the intended consonant. The stimulus presentation procedures developed for this project show promise for measuring differential effects of auditory versus auditory-visual cues on speech identification scores of disordered speakers, and in the case of speakers with BFP, the effects of surgical or other treatments on speech intelligibility scores.

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ERROR PATTERNS IN SOUND LOCALIZATION BY YOUNG NORMAL HEARING-LISTENERS

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1.0 INTRODUCTION

The ability to localize warning signals, human voices and other sounds in space is an important component of communication. Spatial acuity improves over the first 18 months, and declines later in life.[1] These changes likely reflect early maturation of structures in the ear and brain and later peripheral hearing loss and/or central degeneration. Accurate identification of spatial sound sources depends on the encoding of interaural differences in the intensity and time of arrival of the sound at the two ears and spectro-temporal information contributed by the pinna of the ear. An experiment in progress is investigating life cycle changes in the use of these cues. Horizontal sound source identification is being studied in normal-hearing human subjects aged 10 to 79 years, in an acoustic environment which models real-world listening.

2.0 METHODS AND MATERIALS

2.1 Subjects

One group of sixteen subjects, aged 20-29 years has been tested thus far. All were screened for hearing loss in the region of 0.5-4 kHz. Within subject, pure-tone hearing thresholds in each ear were in the normal range. Differences between ears were no greater than 7 dB.

2.2 Apparatus

Subjects were tested individually in a semi-reverberant sound proof chamber. The chamber and the stimulus generating and loudspeaker systems have been previously described.[2] Subjects responded using a laptop response box with set of microswitches in the same configuration as the loudspeakers used to present the stimulus.

2.3 Procedure

The subject's task was to identify the direction of a 300-ms sound (1/3 octave noise band centred at 0.5 or 4 kHz or broadband noise) randomly emanating from a set of four or eight loudspeakers surrounding her/him, at a distance of 1 m. For the 4-speaker array, speakers were placed either close to the midline or the interaural axis, in each quadrant. For the 8-speaker array, the separation between pairs of speakers placed within quadrant was varied (15, 30, 45 or 60 deg).

One block of trials, comprising 16 random presentations of the stimulus through each speaker in the array, was given for each of the eighteen listening conditions. A trial began with a 0.5-s warning light on the response box, followed by a 0.5-s delay, and then the presentation of the stimulus. The warning light was the subject's cue to keep the head steady and fixate a straight-ahead visual target attached to the wall of the booth. A maximum of 7 s was given for choice of the response key corresponding to the speaker that had emitted the stimulus. No feedback was given about the correctness of the judgements.

3.0 RESULTS AND DISCUSSION

For all six speaker arrays, accuracy was higher for the broadband than the 1/3 octave band stimulus, and for the higher of the two 1/3 octave band centre frequencies. Neither interaural vs midline positioning for the 4-speaker array nor the separation between speakers for the 8-speaker array affected overall percent correct. A comparison of quadrant accuracy scores indicated a frontal superiority, regardless of frequency, for the 4-speaker midline array and the 8-speaker array with 15 deg separation of speaker pairs which were located close to the midline, and a left frontal superiority at 500 Hz for the 8-speaker array with 30 deg and 45 deg separations.

An analysis of midline front/back (15 deg vs. 165 deg) and interaural front/back (75 deg vs. 105 deg.) reversal errors showed a higher predominance of mirror image confusions on the right side of space, particularly for the 500 Hz stimulus. In the midline, front-to-back errors were relatively more common than back-to-front errors. The opposite trend was evident for speakers placed in front of and behind the ear.

Differences in accuracy favouring speakers on the left side of space have not been previously documented in any detail. A possible explanation of the result is right hemisphere superiority for spatial resolution.[3]

Acknowledgments

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City Noise: Report of the Urban Noise Task Force of the City of Vancouver

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1. BACKGROUND.

In March 1996, the Vancouver City Council formed a task force of citizens to address growing concerns regarding an apparent increase in the adverse effects of noise on everyday life in Vancouver. As a result of the work of the task force, in April 1997, City Council adopted numerous recommendations that were made in City Noise: Report of the Urban Noise Task Force of the City of Vancouver. The terms of reference, process, findings, recommendations, and implementational consequences of the work of the Task Force will be described.

2. TERMS OF REFERENCE.

The Task Force was to explore the nature and extent of impacts on the urban soundscape, including impacts from motor vehicle sources, with a view to recommending a package of tools and initiatives to be implemented to reduce these impacts. The seven terms of reference were to:

1. Identify the current status of the urban soundscape as compared with the early 1970s when the last Community Noise Survey was completed and identify some significant sources of noise and noise complaints.
2. Identify public expectations about the noise environment through social surveys to measure the community's reaction to noise, the level of annoyance in the community and community awareness of and satisfaction with current regulations and their enforcement.
3. Inventory the issues and impacts of noise on the environment, on public health and on the enjoyment of peace, quiet and rest in the City.
4. Inventory and evaluate the instruments currently in use to control and minimize these impacts on the natural environment and humans, including regulations, educational approaches, citizen action, land-use policy and advocacy on the City's part.
5. Seek advice from City staff, professionals, academics, and others on solutions to the identified soundscape issues.
6. Involve the public, including requests for written submissions, focus group discussions, and a symposium at which the public shares information and is asked for input.
7. Prepare a final report summarizing the key issues and proposed strategies, and containing a series of recommendations, with timelines and priorities to be widely distributed for both staff and public consideration prior to its final consideration by Council.

3. PROCESS.

The 10 members of the Task Force selected by City Council were recruited from the public by newspaper ads. The members included male and female citizens living in different areas of Vancouver; two members, Kathy Pichora-Fuller and Barry Truax were academics; two members, Dick Hiscocks and Mike Noble, had related professional training in physics or engineering; two members, Tom Detlor and Margaret Eberle, had experience in urban planning, Roy Silverson was a member of the Society for Soundscape Awareness and Protection (Right to Quiet), Errol Hannigan was a member of the BC Coalition of Motorcyclists, Susan Kainer and Bradley Jang were citizens with personal experiences of the adverse effects of noise in the community. Two City Councillors, Lynne Kennedy and Gordon Price acted as liaisons with City Council. Five members of staff also participated: Judy Rogers, Deputy City Manager; Nick Losito, Director of Environmental Health; Alfred Guthrie, Noise Control Officer; and, Gail Johnson and Larry Cantrell, City Clerks.

Three subcommittees were formed to address different categories of problems and solutions: public education, regulation, industrial initiatives.

The entire Task Force held 18 meetings and additional sub-committee meetings were also held. Public input was gathered by various means: a contracted telephone survey of 1000 citizens; letters, e-mail, and telephone calls from 250 individuals and groups, including both Vancouver-based and other groups; two public meetings; and, invited presentations.

4. FINDINGS.

The telephone survey results indicated that the majority of citizens, especially those living in the more densely populated downtown and west end areas, considered noise to be a problem and one that has become worse in the last five years. The most significant noise sources identified in the telephone survey were noise related to traffic, specific types of vehicles and sirens, followed by noise from parties. Other major noise sources that were identified were noise related to gardening, aircraft, alarms, garbage dumpsters, and special public events. The most common problems that were described in the correspondence that was received involved noise from house and garden maintenance and vehicles. Overall, public input highlighted how noise is a symptom as well as a cause of social stress, and it raised issues regarding the cultural significance of sound, quiet, and noise.

5. RECOMMENDATIONS.

A total of 165 recommendations were made. Rather than emphasize regulatory control, emphasis was put on public education solutions. The solutions were organized under the headings: education, traffic, air transportation, other transportation, signals, events, recreational and entertainment, home and neighbours, residential maintenance, construction, and industrial noise controls.

6. IMPLEMENTATION.

City Council immediately and unanimously approved 51 recommendations that had been designated by City staff as being readily implementable and supportable. Decisions on 49 other recommendations are pending reports back from staff on resource implications, legal consultation, or further consultation with stakeholders. The City resolved to advocate for action from other levels of government or external agencies concerning an additional 35 recommendations that fell outside the mandate of the City. Finally, 27 recommendations were not endorsed because they were not considered to be supportable and no action was taken on the remaining 3 recommendations. Sector-specific work teams consisting of appropriate City and Health Board staff and at least one member of the Task Force will be formed in Fall 1997 to begin implementation.

ACOUSTIC DESIGN FOR AN OFFICE BUILDING LOCATED DIRECTLY UNDER AN AIRCRAFT RUNWAY FLIGHT PATH

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INTRODUCTION

A new truck terminal was constructed adjacent to Toronto's Pearson International Airport. Aircraft using one of the east-west runways fly directly over the site. While most of the activities associated with the operation of the truck terminal are not noise-sensitive, a two-storey office building was constructed on the site for administrative staff, and acceptable noise levels had to be achieved in the office spaces. This paper describes the acoustic design recommendations for the exterior walls, roof, windows and doors of the office building to ensure that the aircraft noise intrusions would be reduced to a suitable noise-criteria level.

AIRCRAFT NOISE MEASUREMENTS

Prior to construction, sound-pressure-level readings were taken at the location of the proposed office building during aircraft takeoffs for a wide variety of airplanes. The sound-level meter was programmed to hold the maximum level in each frequency band during the measurement duration. The top curve in Fig. 1 shows a typical noise-level spectrum measured at the site during the takeoff of a jet aircraft (Boeing 737). The overall noise level associated with this spectrum is 98 dBA.

OFFICE-BUILDING NOISE CRITERIA

Background noise levels in typical office spaces are set by noise from building mechanical systems, office equipment and functional activities. These noise levels are assessed using standard noise criterion (NC) curves. The maximum recommended background noise level in a typical office space is NC-40.

The design recommendations presented in this paper are based on the premise that, if the aircraft noise intrusions are reduced to the background noise level in the office spaces, they will not be obtrusive.

Various designs for exterior construction elements were assessed by computer modeling until the resulting noise levels in all of the office spaces met the NC-40 criteria.

DESIGN RECOMMENDATIONS

The exterior walls were constructed in a cavity-wall configuration with concrete block on the inside and a high-density exterior cladding material on the outside. The roof was also constructed using an acoustic-cavity configuration consisting of built-up roofing on the outside and a resiliently-suspended sound-isolation drywall ceiling on the inside. A typical T-bar acoustic-tile ceiling was also suspended below the drywall membrane ceiling. Supplementary ballast material was provided on the roof to increase the surface density. The exterior glazing consisted of two panes of glass, the outer pane having a thickness of 13 mm and the inner pane having a thickness of 6 mm. The panes were separated by an air space having a depth of 50 mm. Vestibules were provided for all entrance doors.

PREDICTED NOISE-INTRUSION LEVEL

The predicted aircraft noise-intrusion level in the 2nd-floor office spaces, with all of the above design recommendations implemented, is shown in Fig. 1. The overall noise level associated with this spectrum is 46 dBA. The predicted noise level meets the NC-40 criteria.

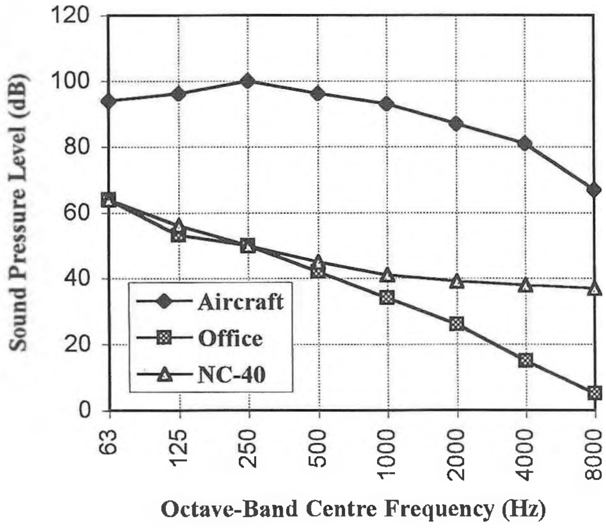

Fig. 1: Aircraft Noise-Intrusion Level in Office Spaces.

New Sound Transmission Challenges - A Case Study

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The focus of this paper is the sound transmission issue as it relates to revitalization and development projects in "The Kings" (two recently rezoned districts in the central area of Toronto). The preamble to the zoning changes involved a great deal of input by politicians, planners, building regulators and the development industry and the goal is to provide for revitalized development in the target districts which over the years have become rundown and under-utilized. Many of the buildings in these two districts are old abandoned industrial structures. The goal of the rezoning is to allow a broad range of mixed uses within buildings by lifting existing land-use controls which would normally restrict certain combinations of uses.

Current sound transmission regulations contained in the Ontario Building Code call for minimum sound transmission class (STC) levels of 50 where residential occupancies are to be separated from other uses. The only exception to this requirement is where a residential occupancy is separated from a mechanical machine room such as an elevator. In this instance the Ontario Building Code requires a minimum STC level of 55.

At the time the existing Ontario Building Code sound transmission regulations were set out it may well be that the concept of a "mixed-use building" included a narrower spectrum of uses than those now being developed in the two target areas of Toronto known as "The Kings". It is anticipated that levels of 50 STC will not adequately separate residential uses from other uses such as industrial or studio uses where heavy machinery may be present, or from entertainment facility uses which include high-tech sound systems and assemblies of large crowds.

Efforts were undertaken to request the Province to include higher STC levels in the most recent amendments to the Ontario Building Code. No support has been provided at the Provincial level. Conceivably, the Province is attempting to keep the Ontario Building Code more generic to the needs of smaller municipalities where such large-scale developments are less likely to occur.

It is now incumbent on municipalities such as Toronto to look for other means to secure adequate STC levels where merited. One mechanism under review in Toronto is to incorporate such STC levels in property standards regulations which govern existing buildings once occupied. This process would, however, need to be addressed at the time of renovation in order to ensure that adequate measures are introduced into buildings in the most cost-effective manner. Similarly, related objectives are being sought in Toronto through the Development Approval process which precedes permit applications and construction.

It is anticipated that developers and builders will share an interest, along with Planners and By-law Enforcers, to ensure adequate sound protection in new-style developments. Proper construction most certainly is a key to better marketability.

The planning process is still ongoing to address the somewhat unique issues in the two target districts, with a focus on sound transmission concerns. Related issues include the need to create a model for a simplified planning/permit process as well as a need to elicit the support of designers and developers by ensuring that the process doesn't impede their objectives to develop property in these two areas which are in need of revitalization. The issues relate to construction and renovation, as well as to the ongoing and changing building uses expected during the lifetime of the buildings in the areas in question.

Traditional land-use controls do not appear to answer these special concerns in regard to sound transmission. The challenge to be looked at is how to seek out creative and workable solutions. As new design concepts continue to evolve, municipalities are challenged to ensure that planning and permit processes incorporate the sound attenuation aspects of both new construction and renovation of broad spectrum mixed uses in buildings. These types of developments are the trend for the future. It is incumbent upon municipal processes to assist and nurture such projects in a manner that will facilitate the revitalization of neighbourhoods and will allow mixed uses to reasonably co-exist within buildings.

Etude expérimentale de l'insonorisation d'une entrée d'air latérale de turbomoteur d'hélicoptère

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Summary

Helicopters are of considerable interest for short haul flights especially between airports and downtown. However, the high sound levels involved represent one of the main obstacles to the development of this very promising market.

The paper deals with the use of a lining for reducing the noise radiated by the inlet of a turboshaft engine at blade passing frequency of the compressor (8 to 10 kHz). The inlet is perpendicular to the shaft axis. The used liners consists of a solid backplate and a layer of feltmetal material separated by an internal partition in the form of a honeycomb. The efficiency of the acoustic treatment is evaluated in an anechoic room by comparing the total power radiated by full-scale models of the inlet with both reflecting and absorbent walls. It is shown that a 12 dB reduction of the BPF tone can be achieved by using the proposed lining.

Introduction

Les hélicoptères offrent un intérêt indéniable pour les liaisons à courte distance, en particulier en ville, mais les fortes nuissances sonores qu'ils engendrent constituent une des principales entraves au développement de ce marché très promotteur. Sur certaines machines, le turbomoteur est alimenté par une entrée d'air latérale, inclinée de 90° par rapport à l'axe de l'arbre de rotation. La section d'entrée d'air est alors rectangulaire et se raccorde au compresseur par un plénum. Le rayonnement vers l'amont est dominé par le fondamental du premier étage de compression, dont la fréquence se situe typiquement entre 8 et 10 kHz. Face à ce problème, une étude expérimentale et théorique a été menée au département d'acoustique de l'Ecole Centrale de Lyon en collaboration avec Eurocopter-France.

Procédé

Deux revêtements absorbants, désignés par R1 et R2, ont été réalisés à partir de feutre métallique collés sur une structure en nid d'abeilles pour le traitement de la surface intérieure du plénum. Ils ont été optimisés grâce à des mesures dans un tube à ondes stationnaires de petites dimensions, conformément à la méthode à deux microphones (Chung et Blaser 1980). L'épaisseur totale des revêtements est de 9.1 mm et 5.5 mm respectivement pour R1 et R2.

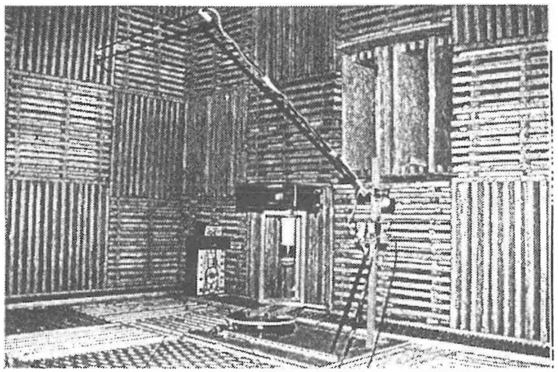

Fig. 1. Photographie de l'installation expérimentale

Une maquette de plénum à l'echelle 1 a été installée en chambre sourde (voir fig. 1). La puissance acoustique rayonnée par l'entrée d'air est obtenue par intégration de l'intensité acoustique mesurée sur une sphère d'écoute centrée sur le centre de la section rectangulaire de l'entrée d'air. L'étude a été mené pour plusieurs fréquences entre 8 et 10 kHz, de façon à explorer la gamme de fréquence couverte par le fondamental du compresseur de turbomoteur lors d'un fonctionnement opérationnel, et pour différentes configurations utilisant deux types de revêtements. La procédure expérimentale a été complètement automatisée, dont la gestion a été confiée à un micro-ordinateur.

Résultats

La différence des puissances acoustiques rayonnées respectivement par une entrée d'air non traitée et une entrée d'air traitée permet alors de chiffrer l'atténuation globale due à un revêtement donné. Le gain en puissance obtenu de cette manière est représenté sur la fig. 2 en fonction de la fréquence et appelle les remarques suivantes:

- On constate un gain de 8 à 16 dB selon les cas.
- En moyenne, l'adjonction d'un baffle traité (plaque séparant en deux la section d'entrée d'air) entraîne une légère amélioration.
- Bien que les essais aient été effectués dans un seul tiers d'octave, des différences sensibles apparaissent d'une fréquence à l'autre, ce qui peut provenir de phénomènes de résonance de l'ensemble.

Conclusion

L'étude démontre la faisabilité d'une atténuation de l'ordre de 12 dB par insonorisation du plénum d'entrée d'air de turbomoteur d'hélicoptère.

Références

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J. Y. Chung and D. A. Blaser (1980), " *Transfer Function Method of Measuring in-Duct Acoustic Properties"*, J. Acoust. Soc. Amer. Vol. 68(2).

Remerciements

Cette étude a bénéficié du soutien financier de la société Eurocopter-France (Commande Eurocopter-Metraflu n° 21/182-402).

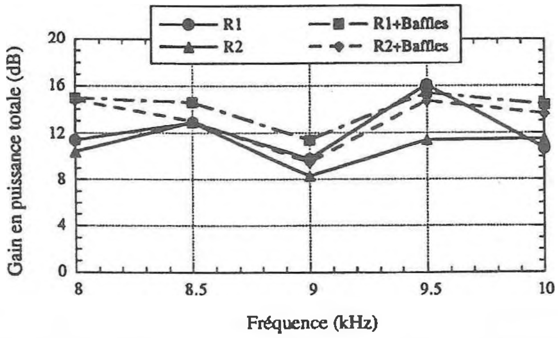

Fig. 2. Gain en puissance obtenu pour chaque traitement

NEW NOISE INSULATION MATERIAL
Expanded Polystyrene Granules with Heavy Core

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SCOPE OF THE INVENTION

The present invention relates to an insulating material which may be used either as loose material or as part of a panel construction, and more particularly to a granular or chip-type insulating material having a sound absorbing and sound isolating high density central core, and a relatively less dense thermally insulating outer coating.

BACKGROUND OF THE INVENTION

Granular-type insulating materials used in providing thermal insulation are well known. Typically, conventional granular insulating materials consist of expanded or foamed light-weight polymers, such as polystyrene. The polymers are formed into approximately spherical granules which have an average diameter of about 1.5 millimetres.

It is known to use conventional polystyrene granules in construction where, for example, the granules are used as thermal insulation which is blown loose into cavities, or are compacted together to form aggregate panels which range in thickness between 0.5 and 6 inches. While expanded polystyrene has low thermal conductivity and provides good thermal insulation, the low density of polystyrene makes conventional granules very poorly suited to absorb sound energy and substantially transparent to sound energy.

A further disadvantage with conventional polystyrene insulating granules exists in that if the granules are exposed to a flame, the polystyrene will readily burn producing noxious fumes and potentially hazardous bi-products on combustion.

Conventional granular insulating materials also suffer the disadvantage that they are highly susceptible to damage by rodents and insects. In particular, mice and rats may easily burrow through and nest in either loose blown granules or aggregate panels made from such granules.

SUMMARY OF THE INVENTION

To overcome at least some of the disadvantages associated with the prior art, the present invention provides for an insulating particulate material which may be used in construction and which has a sound absorbing and/or sound isolating high density core which is surrounded by a relatively less dense thermally insulating outer coating. The insulating outer coating advantageously prevents thermal conduction, while the higher density core absorbs, reflects and/or refracts sound waves to reduce the propagation of sound waves through the granules.

Another object of the invention is to provide a thermally insulating granule having a sound absorbing high density core which may be easily and economically manufactured.

Another object of the invention is to provide an acoustical panel for use as a construction material which is formed from a plurality of thermally insulating granules having a high density core which incorporates rodent and/or insect deterring compounds or compositions.

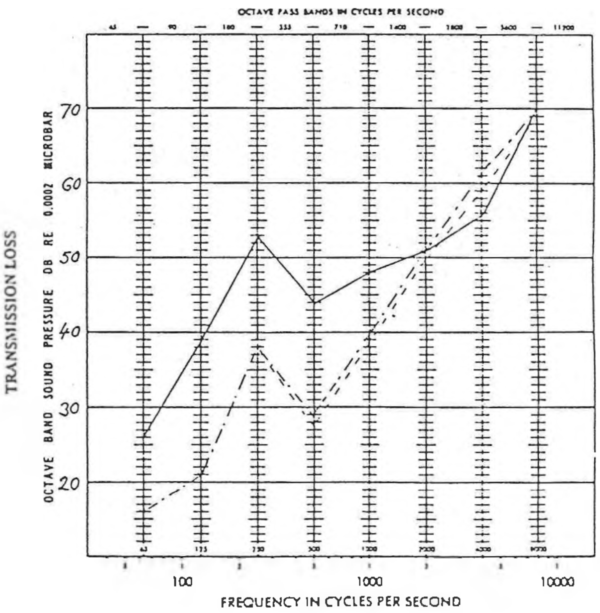
A further object of the invention is to provide an insulating granule for use as a construction material and which may safely incorporated flame retardant compounds and/or compositions without concern of degradation of such compounds over prolonged periods of time.

The applicant has appreciated that at least some of the foregoing objects may be achieved by providing an insulating granule which includes a sound absorptive central core which has a density of at least 1.0 grams/cm^3, and an outer less dense thermally insulating coating provided at least partially about the core. The outer coating preferably has an expanded cellular structure and a density of less than 0.75 grams/cm^3, with the core comprising between about 5 to 80% of the granule by volume, and more preferably about 10 to 40% by volume.

The granules may be either generally spherical or have an amorphous shape and have an average diameter of between about 0.5 to 30mm. More preferably, the outer coating is provided evenly about the core with the ratio of average cross-sectional diameter of the core to that of the overall granule diameter being selected at between about 5:6 and 1:6, and more preferably between about 1:2 to 1:4.

PRELIMINARY RESULTS:

Measurement of panel 25" x 25" made of frame from 2 1/2" metal stud with 1/2" gypsum board on each side. There is to compare: empty panel - - - - panel filled with fiberglass _ . _ . _ Panel filled with exp. Ps granuls with heavy core _____ Density approx. 300 kg/m^3 or 18.7 lbs/ft^3.



Reference: Patent Application

Blachford

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Noise treatments can be categorized into three basic elements: Vibration Damping, Sound Absorption and Sound Barriers.

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ANTIVIBE DL is a liquid damping material that can be applied with conventional spray equipment or troweled for smaller/thicker application.

It is water-based, non-toxic and provides economical and highly effective noise reduction from vibration.

ANTIVIBE DS is an effective form of damping material provided in sheet form for direct application to your product.

Sound Barriers

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 barriers can be a very effective and economical method of noise reduction.

Blachford Sound Barrier materials:

BARYMAT

Limp, high specific gravity, plastic sheets or die cut parts. Can be layered with other materials such as acoustical foam, protective and decorative facings to achieve the desired TL for individual applications.

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Working with data supplied by you, H.L. Blachford will make recommendations or treatment methods which may include specific material proposals, design ideas, or modifications to components.

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DEVELOPMENT OF SENSITIVITY TO SPEECH ERRORS*

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BACKGROUND

About 10% of all children show some form of speech production difficulty. A substantial proportion of these children have related speech perception difficulties [1]. Unfortunately, little is known about the abilities of normally-developing children to distinguish correct speech from incorrect speech. This study investigated the development of children's ability to distinguish between correct pronunciations of common English words and words containing common childhood speech errors. Information obtained should contribute to improved understanding of how children acquire adult-like mastery of their native language and guide perceptual assessment and treatment procedures for children who have speech production difficulties.

OBJECTIVES

This study attempted 1) to confirm the classification of a corpus of speech samples by reference to a sample of native English-speaking adults with normal hearing and speech abilities; 2) to determine how well children aged 3;6 through 7;0 (years;months) can identify correct and incorrect pronunciations of various target sound categories; 3) to identify patterns in the development of such speech perception abilities, including how sensitivity to particular types of speech errors changes over time; and 4) to apply this information to help improve our understanding of the *process* through which children acquire adult-like speech perception abilities.

METHOD

Participants. One hundred and thirty-two children between the ages of 3 years 6 months and 7 years were tested. All participants had normal hearing and all had age-appropriate speech production. In addition, 10 adults were tested with each of the 16 target sounds used in the study.

Stimuli. Testing used high-quality digitized speech samples within a video game based format. The samples were natural speech utterances of sixteen target words containing word-initial consonants that are a source of common production errors for young children. Tokens were spoken by a range of adult male, adult female and child talkers.

PROCEDURE

Each child was tested individually in a quiet room. The digitized utterances were replayed over the computer's 16-bit DAC and presented through speakers. The child indicated whether the sound presented was a correct or an incorrect pronunciation of the target sound. Using the sample screen in figure 1, the child indicated a correct pronunciation by pointing to the picture corresponding to the target word ('cat' in the example) and indicated an incorrect pronunciation by pointing to the 'X'.

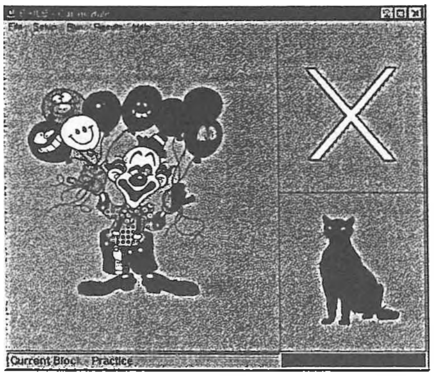

Figure 1: Sample screen showing response alternatives for the module 'cat'.

RESULTS AND DISCUSSION

The overall ability to distinguish between correct and incorrect utterances improved with increasing age (see Figure 2). Moreover, for each target word, all tokens showed an improvement in perceptual sensitivity (d') with age. However, the levels of initial and asymptotic performance and the rate of acquisition differed for different target categories.

Importantly, hit rates remained relatively constant across age groups for each target word. Rather, the improvement in performance occurred because false alarm rates decreased substantially as the age of the child increased (see Figure 3).

Different tokens were acquired at different rates, and even some adults did not distinguish certain error sounds. These data are taken as supporting the following views of the development of speech perception abilities: 1) the initial acquisition of a sound category involves the recognition that sounds with particular acoustic characteristics are linguistically distinct from other sounds; 2) the mastery of a particular sound category involves the sequential elimination of specific sound errors from membership in the sound category; 3) such perceptual mastery is a long-term process representing an interaction of specific listener experience and acoustic salience; 4) children whose speech perception abilities are developing normally show considerable variation in their abilities to distinguish correct from particular incorrect utterances.

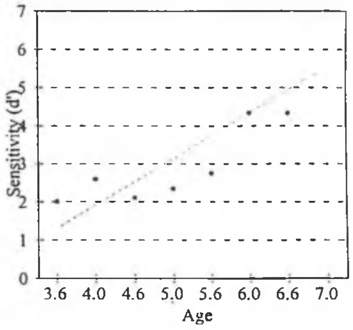

Figure 2: Change in d' (sensitivity) with age when the target sound was 'feet'.

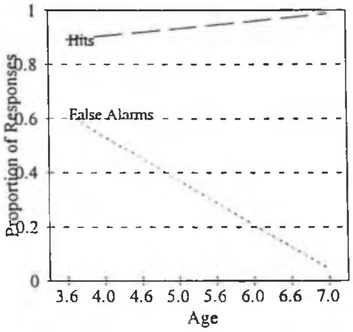

Figure 3: Hit and false alarm rates as a function of age when the target sound was 'rat'.

A child's ability to identify certain speech errors at certain ages may be particularly valuable for the early assessment of speech disorders. Overall, this study provides information about the maturation of speech perception abilities in children with normal speech production abilities. Further, the results may help to guide the interpretation and assessment procedures for use with children who have speech production difficulties.

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*Supported by a grant from NSERC to DGJ. Correspondence should be addressed to jamieson@audio.hhcru.uwo.ca.

A Comparison of F0 Extraction Algorithms for Sustained Vowels*

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I Introduction

Measures of vocal perturbation are routinely used in clinical evaluation of a patient's voice and also in monitoring the patient's progress over the treatment period [1]. These measures can be broadly classified into: a) jitter, which measures the cycle-to-cycle variation of the fundamental frequency, b) shimmer, which calculates cycle-to-cycle amplitude variations, and c) Signal-to-Noise Ratio (SNR) which represents the amount of vocal noise. These measures are calculated pitch-synchronously, hence accurate estimation of the fundamental frequency is crucial.

II Fundamental frequency (F0) estimation

Several algorithms are proposed in the literature for F0 extraction [2]. In a recent study, Titze *et al.*[3] compared the performance of waveform matching, peak picking and zero crossing based pitch algorithms and concluded that the waveform matching (WM) algorithm, one which adjusts the pitch period such that consecutive cycles are matched in a mean-squared sense, offers the best performance under a variety of conditions. This waveform matching technique is also the heart of a high resolution pitch algorithm proposed by Medan *et al.* [4].

The WM algorithm requires an initial F0 estimate. Titze *et al* [3] accomplished this by making an initial pass through the entire waveform and judiciously marking negative going zero-crossings. This could be a time consuming process, especially for longer signals. This study is an extension to [3] where the performance of six additional algorithms based on the Average Magnitude Difference Function (AMDF), Autocorrelation Function (AF), Autocorrelation function with Center Clipping (ACC), Inverse Filter Autocorrelation (IFAC), Cepstrum (CEP), and Harmonic Product Spectrum (HPS) respectively, is compared . In addition, the possibility of using these algorithms to provide an initial F0 estimate to the waveform matching algorithm is investigated.

III Results

To evaluate these algorithms, synthetic vowel waveforms were used. The vowel waveform was generated following the procedure described in [4] with a sampling rate of 20 kHz. The performance of the algorithms was tested in the presence of background noise with a fixed F0 = 150 Hz and no amplitude variations. The Signal-to-Noise Ratio (SNR, also termed Harmonics-to-Noise Ratio in [2]) was varied from -2 to 20 dB, a range that covers both normal and pathological voices. Note that the F0 is not an integer multiple of the sampling frequency, hence interpolation techniques are required. We used the interpolation technique proposed in [4] as we found this to be better than the second order interpolation used in [3]. Algorithm performance was quantified by mean relative deviation, α, between the true pitch contour, P_N, and the estimated pitch contour, Q_N, where N is the number of pitch values.

Figure 1 shows the effect of background noise on the performance of these algorithms. The salient points from this graph are: a) the performance of all the algorithms deteriorates with an increase in the background noise, b) the AMDF method is more sensitive to background noise compared to others, b) the AC and ACC methods are more robust to background noise than IFAC, and the ACC method breaks down at low SNRs, as both the center-clipping and inverse filtering operations are affected at larger noise levels, c) time-domain methods (AC, ACC, IFAC) are more accurate than frequency domain (HPS and CEP), due to lower resolution in the frequency domain. A window size of 2048 samples was used resulting in a frequency resolution of around 9 Hz. Larger window sizes will no doubt improve the pitch estimates but also increase the computational complexity. Figure 2 depicts the performance of these algorithms when they were used to provide the F0 estimate to the WM algorithm. The F0 was estimated using the first 50 ms of the signal, and this estimate was refined using the WM algorithm over the entire waveform. Notice that almost all algorithms perform equally well with increased robustness to background noise. The HPS method appears to break down towards the lower end of the SNR spectrum due to the loss of distinct harmonic structure.

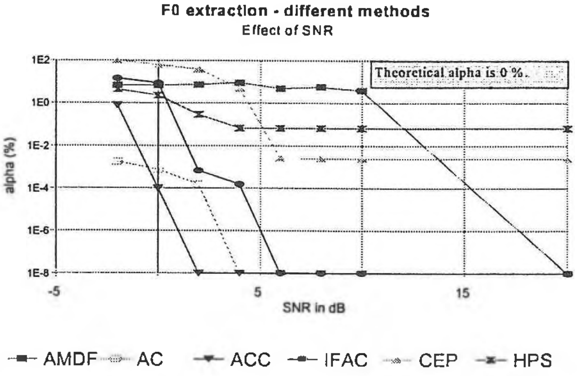

Figure 1: Effect of background noise on F0 estimation.

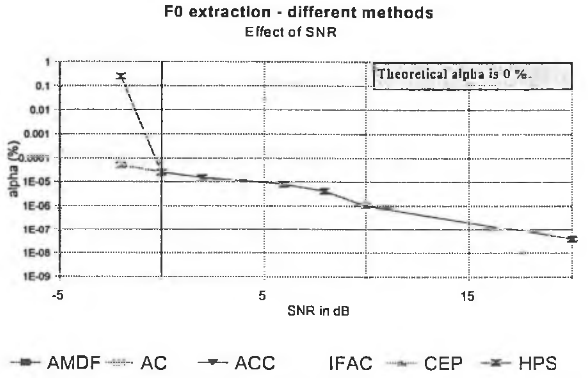

Figure 2: Effect of SNR on WM algorithm with initial F0 provided by different methods.

IV Conclusions

The WM algorithm provides a high resolution F0 estimate. Any of the AC, ACC, IFAC and CEP algorithms can be chosen to provide an initial estimate of the F0 based on the initial few cycles of waveform. This averts the need for marking the whole waveform based on zero-crossings, resulting in a computationally more efficient pitch estimation.

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* supported by NSERC and the CAA Shaw postdoctoral fellowship.

Behavioural Speaker Identification for Forensic Applications*

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Background

Behavioural speaker identification refers to the process of identifying an individual as the speaker of a given utterance, based only on auditory information. This type of identification is periodically used in forensic applications [1,3], although such usage is not without controversy [2,3]. Given that successful speaker identification is not always achieved under the most ideal conditions [3], it is of dubious value in forensic environments, where conditions are usually far less than ideal [1]. Nevertheless, when a recorded or remembered voice constitutes the strongest evidence in a case, behavioral speaker identification may be an invaluable resource.

This situation occurred in a recent criminal investigation, where the police hypothesized that a specific person was the speaker in a number of potentially incriminating telephone calls. These calls had been made on another person's telephone and recorded under court order. The suspect acknowledged speaking on some calls, but denied being a participant in most of the calls. He cooperated by permitting recording of his voice for comparison.

Objectives

The objectives of the present study were to test the hypothesis of the police, and to specify which calls were likely made by the suspected speaker.

Method

Two listeners rated 40 samples of the word "okay" as same or different in a paired comparison task. Twenty-six of the samples were obtained from police wire-tap (where the identity of the speaker was not known), while the remaining 16 samples were obtained directly from the suspect (also via telephone wire-tap).

The samples were digitized at a frequency of 22 kHz, low-pass filtered at 10 kHz, and edited using CSRE [4], to isolate the word "okay" from the surrounding acoustic information. All samples were presented to the subjects monaurally, via an ER-3A insert earphone, using a listening test generated in ECoS/Win [5].

All possible pairs of different samples were used in the task. Thus, each subject rated 1560 pairs of samples, divided equally into 20 blocks. The pairs were randomized across the 20 blocks, and were further randomized for each subject. Due to the length of the task, raters completed the experiment in two sessions, with 10 blocks in each session. Immediately after hearing each pair of samples, raters indicated whether the speaker of the samples was the same or different, and whether they were certain or uncertain of this decision. Raters could replay the samples as many times as they wished.

Results

Different samples from within telephone calls were not differentiated, as they could not represent different speakers. Thus, there were 143 unique pairs of calls. In order to test the hypothesis of the police, only those voice samples that were obtained by the police were used for the analysis. Thus, 129 unique pairs, along with presentation order and rater, were subjected to an ANOVA, with the assigned rating as the dependent variable. While there was no significant effect of presentation order, there was a significant effect of rater ($p < .005$). The effect of sample pair was also significant ($p < .0001$). Therefore, the hypothesis generated by the police (ie. that the voice samples were produced by a single speaker), was not supported.

A rough estimate of accuracy was generated by comparing the hit and miss rates for voice samples that were known to have been generated by the same speaker (ie. samples obtained from a single telephone call). The wire-tap samples obtained by the laboratory were not included in this comparison, however, because the superior quality of these samples oversimplified the same-different task. The average hit rate was 0.89, and the average miss rate was 0.11. This estimate of accuracy should be interpreted with caution, however, because samples from within single telephone calls share acoustic information apart from the voice spectra (such as specific telephone noise), which could have simplified the same-different decision, and inflated the accuracy rate.

The significant effect of rater indicates differences in rater judgement. Unfortunately, this lack of agreement adds difficulty to the task of speaker identification. If raters do not consistently agree, there is no way to know which rater is correct, and the rating task provides little useful information. The potential for accurate speaker identification diminishes in accordance with lack of inter-rater agreement. Nevertheless, in accordance with the second objective, the data were subjected to a cluster analysis. Two very distinct clusters emerged, with eight calls in each cluster. Only one call did not fit into a cluster. Interestingly, the calls in one cluster were those to which the suspect admitted participating, with only one exception. The suspect denied participating in one call in the cluster, and admitted to participating in one call from the other cluster.

Summary and Conclusions

The present experiment tested the hypothesis that a particular individual was the only speaker in a large set of calls. Results of the experiment failed to support this hypothesis, indicating that there was more than one speaker in the set of calls. Moreover, a cluster analysis revealed two distinct clusters, suggesting the participation of a second speaker. Interestingly, although the police hypothesis was not supported, the cluster analysis clearly attributed to the suspect one call in which the suspect denied participating.

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EFFECTS OF NOISE AND LANGUAGE EXPOSURE ON SPEECH INTELLIGIBILITY PERFORMANCE

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BACKGROUND

Native speakers of Korean often have difficulty producing and perceiving the distinctions between English sounds [1]. Particular problems may arise when communicating against a background of noise. Non-native listeners may display greater difficulty than native listeners under difficult listening conditions [6]. In view of the foregoing, the present study was designed to: (1) characterize the speech perception abilities of adult native speakers of Korean who have had very extensive exposure to the English language; (2) examine the degradation in word identification under difficult listening conditions. Performance was assessed in relation to the performance of native speakers of English.

METHOD AND PROCEDURE

We tested 30 native speakers of Korean, aged 35 to 58 (M = 49 years). All were native to Korea but had resided in Canada for between 10 and 28 years (M = 20 years) immigrating between the ages of 20 to 40 (M = 29 years). All subjects had studied English (mean time = 7 years) before coming to Canada. Twenty subjects had also studied in ESL programs in Canada (mean time = 6 months). Nine native Canadian English speakers with normal hearing also participated.

Our test battery consisted of three tests of speech perception: (1) the adaptive SRT (ASRT; [2]) provides an efficient, accurate, and reliable estimate of a listener's speech reception threshold for spondees. The SRT was administered in quiet and in a background of white noise; (2) the UWODFD [3] is a test of speech intelligibility, standardized for central Canadian English. It consists of 21 nonsense syllable stimuli; the target is the middle consonant of a VCVC word. All consonants are presented in the same context (A_IL). The UWODFD was administered in quiet and in noise at 4 Signal to Noise Ratios (SNRs; +10, +5, 0, and -5 dB); and (3) a two alternative [r-l] forced-choice identification task was used to assess the ability to distinguish English /r/ versus /l/ contrasts. This test used a subset of the stimuli used by Logan et al. [5]. This [r-l] test consisted of five minimal pairs (e.g., rock-lock) within each of five phonetic environments: initial singleton (IS), initial consonant cluster (IC), medial (M), final consonant cluster (FC), and final singleton (FS). Five native English speakers (3 male and 2 female) produced each of the ten words, contrasting /r/ and /l/ in the phonetic environments mentioned. Each of the five experimental tests was administered in 5 listening conditions: (1) in quiet and (2) in noise at 4 SNRs (10, 5, 0, and -5 dB). For both the UWODFD and the [r-l] tests, listening conditions were presented in sequence from most favourable (i.e., in Quiet) to the most difficult (i.e., -5 SNR) with the block order and stimuli randomized within each level. All aspects of stimulus sequencing and presentation (in both noise and quiet conditions), response recording, and experimental control were carried out using the experiment generator and controller utility contained in the CSRE 4.5 software package [4]. During all aspects of testing and training, signals were presented to listeners through Etymotic Research ER-2 insert phones.

RESULTS AND DISCUSSION

Accuracy Under Optimal Listening Conditions. The results from the three tests, in Quiet, show that the overall level of accuracy under optimal listening conditions was high for both native Korean listeners and native English listeners, with native English speakers having an advantage of ~5dB in SRT performance and ~18% and ~27% correct overall, in the UWODFD and [r-l] tests, respectively.

Figure 1. Identification of English consonants in the UWODFD test as a function of the signal to noise ratio.

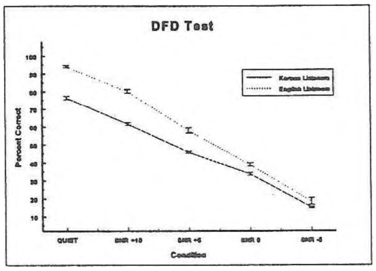
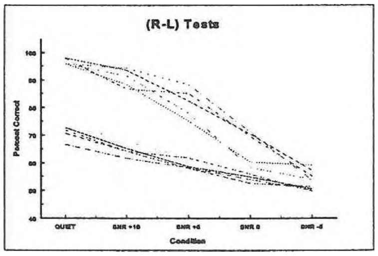


Figure 2. Identification of English /r/ and /l/ for target sounds in various syllable positions, by native Korean listeners (lower fan of curves), and by native English listeners (upper fan of curves), as a function of the signal to noise ratio



Accuracy Under More Difficult Listening Conditions. Under less optimal listening conditions, the performance of the Korean listeners declined rapidly for the UWODFD and [r-l] tests. Performance also declined with both tests for the native speakers of Canadian English, but this decline was more precipitous, reflecting the higher initial levels of performance in quiet. There was no indication that performance declined more rapidly in a noise background for our native Korean subjects on the ASRT.

Distribution of Identification Errors. When the format of the task does not constrain subjects' responses to just "L" and "R", the observed perceptual confusions are not limited to confusing /r/ with /l/ and vice versa. In fact, when listening in quiet during the UWODFD test, when /r/ targets were presented, 59% of the confusion errors Korean listeners made were with "W" responses, 34% were "L" responses. Under the same conditions, when /l/ targets were presented, 59% of confusion errors were presented were "R" responses, while 37% were "N" responses.

GENERAL DISCUSSION

The present study provides clear evidence that non-native listeners operate at a moderate to large disadvantage to native listeners even after many years of intensive experience with the English language. However, the disadvantage is seen most clearly under favourable listening conditions, not under degraded conditions. Furthermore, examination of the details of the confusion responses of Korean listeners shows that the two-alternative forced choice paradigm fails to characterize /r/-/l/ perception for non-native listeners. Future work may profit from the use of a wider range of response alternatives when assessing speech perception as well as for training listeners to perceive non-native contrasts.

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Effects of Speech Coders and Speech Disorders on Speech Quality and Intelligibility*

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1. INTRODUCTION

Telecommunication providers employ speech coders to compress signals for more economical spoken language telecommunication. Such coder processing always introduces some distortion. To increase efficiency, speech coders make certain assumptions about speech input. These assumptions are violated for talkers who have certain voice and speech disorders. As a result, modern speech coding systems may interact with voice and/or speech disorders to degrade communication differentially for particular talkers. This study investigated the effect of five common speech coders on both the intelligibility and the voice quality of various disordered speech samples.

2. METHOD

Our database of disordered speech samples [1] was obtained from 26 voices. Samples consisted of 22 isolated consonants in the UWODFD[2] format (the /aCil/ environment), 15 isolated vowels in the /hVd/ environment, and two continuous speech samples consisting of the first two sentences of the Rainbow Passage [3]. Speech disorders sampled included dysarthria and multiple sclerosis, while voice disorders included hypernasality, breathiness, harshness, pitch problems, vocal fold granules and vocal fold paralysis. Most of the disordered voices exhibited a combination of these elements. Whenever possible, the full range of severity from mild to severe was represented for both voice and speech disorders. Twenty disordered and six normal talkers were sampled.

Five speech coders were investigated. GSM 6.10 (a standard European coder), CELP and LPC-10e (commonly used in North America), and two sub-band coders, a 16 kbps (SBC16) and a 32 kbps (SBC32) version. Each speech sample was processed through each of the five speech coders resulting in six conditions for each sampled item including the original. The isolated consonants and vowels were used to evaluate intelligibility while the Rainbow Passage was used to measure speech quality.

To evaluate the effect of the coders on speech intelligibility, 10 young adults with normal hearing were asked to identify the processed and unprocessed isolated consonant and vowel samples. To evaluate the effects of the coders on speech quality, 10 young adults with normal hearing were asked to rate the quality of each voice in each of the six conditions. Ratings were obtained using a set of 28 visual analog scale items including voice pitch, speed of speech, breathiness, harshness, tinniness, presence of extraneous sounds, acceptability, naturalness and overall disorderedness.

3. RESULTS AND DISCUSSION

Intelligibility was highest for the original samples, and declined in a consistent manner for the coders examined [cf figure 1], with GSM speech often as intelligible as the original, with CELP next, followed by LPC, SBC32 and SBC16. Coding scheme and talker often interacted, so that the magnitude of the differences observed between processing techniques was different for different talkers.

Voice quality was rated highest for the original unprocessed samples, and declined in a consistent manner for the coders examined, with GSM speech being sometimes rated as highly as the original, with CELP next, followed by LPC, SBC32 and SBC16. Coding scheme and talker interacted so that the magnitude of the differences observed between processing techniques was different for different talkers. These interactions were sometimes quite pronounced [cf figure 2].

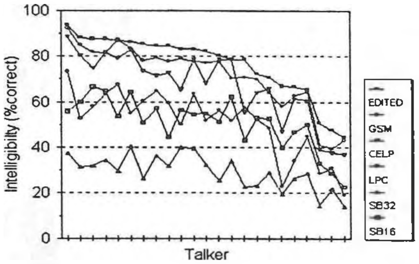

Figure 1. Intelligibility (in percent correct) on UWODFD.

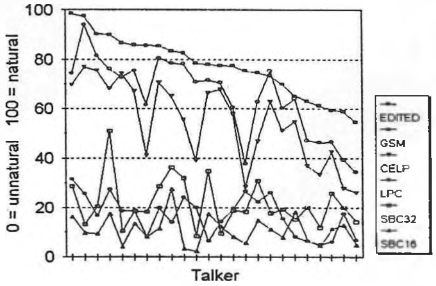

Figure 2. Voice quality ratings for the scale item "Naturalness".

These results have important implications for telecommunications. GSM and CELP appear to use coding schemes that degrade the input significantly less than LPC, or either of the subband coders. LPC, SBC32 and SBC16 substantially degrade the quality of the speech and therefore are not desirable for use in telecommunications. However, CELP and to a less extent GSM, *interact* with different voices so that degradation is differential.

4. CONCLUSIONS

Coded speech is less intelligible and perceived to be of lower quality than the natural speech of the same talker. Talker and coder interact to affect the intelligibility and perceived quality of speech at the output of the coder, so coder effects are much larger for some talkers than for others.

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Balance Measurements in Four Canadian Theatres

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Introduction

A proscenium arch theatre is fundamentally different from a concert hall in many ways, not the least of which is acoustics. The classical concert hall has a single distributed sound source, the orchestra, in the same acoustic space as the audience. A theatre has two sound sources in acoustically dissimilar rooms - the singers on stage and instrumentalists in the orchestra pit. The audience is in yet another dissimilar acoustic space. Therein lies the unique aspect of theatre acoustics: the balance that must be struck between singers on stage and the instrumentalists in the orchestra pit. To date, this has received little attention in the literature.

Trained operatic singers develop a fifth formant, one more than a typical speaker[1]. The formant is centred around 2500 to 3000 Hz and is the principle mechanism by which a single singer is able to project over the formidable forces of an orchestra. Poor acoustic coupling between the pit and the audience chamber also works to the singer's benefit.

Measured Balance is a simple logarithmic ratio of sound emanating from the stage to sound from the pit. Values greater than zero indicate that the sound from the stage predominates. Optimum balance may lie in the range of +2dB, although there have been no subjective studies as yet to substantiate this.

Measurement Procedure

Measurements were performed in four unoccupied theatres. These are the Royal and McPherson Theatres, both in Victoria, Saskatoon Centennial Auditorium and the former O'Keefe Centre, now known as the Hummingbird Centre. More information on these theatres may be found in ref. 2. Directional and omni-directional sound sources were used on stage and in the pit, respectively. The source locations are similar to those employed by Barron[3]. Measurements were performed at ten different seating locations in each theatre.

Balance ratios were calculated in 1/3 octave bands according to:

$$B_t = 10\log\left(\frac{\int_0^t p_{stage}^2(f,\tau)d\tau}{\int_0^t p_{pit}^2(f,\tau)d\tau}\right) + K(f) \qquad (1)$$

Where t is time and $K(f)$ is the frequency dependant difference (in dB) between the directional and omni-directional sound sources. Three different temporal integrands were chosen: 10 ms (Direct), 50 ms (Early) and ∞ (Steady State).

Results

The most demonstrative interpretation of the measurements came in the form of the 50 ms Balance ratios, please see Figure 1. Note how low frequency balance is much lower on the orchestra level. In many proscenium arch theatres, the sound is thought to be best on the balcony. This may suggest one reason why.

The measurement survey suggests the following trends:

(i) Low frequency balance favours the pit for listeners on the orchestra level. For listeners on the balcony level, low frequency balance is about even.
(ii) At high frequencies, in the range of the singers' formant, the balance curve dips in favour of the orchestra pit. Also, at high frequencies the directional orientation of the stage source influences the balance. There is no significant difference between the balcony and the orchestra levels for either of these effects.
(iii) Lowering an orchestra pit effects direct sound much more than early or late reflected sound.

Conclusions

Low frequency balance is typically better on balconies than it is on orchestra levels and is most likely influenced by the seat dip effect. A high frequency reduction of balance has been measured on both the balcony and orchestra levels and is likely to be exacerbated in occupied rooms by an interference effect known as the head dip phenomenon[4].

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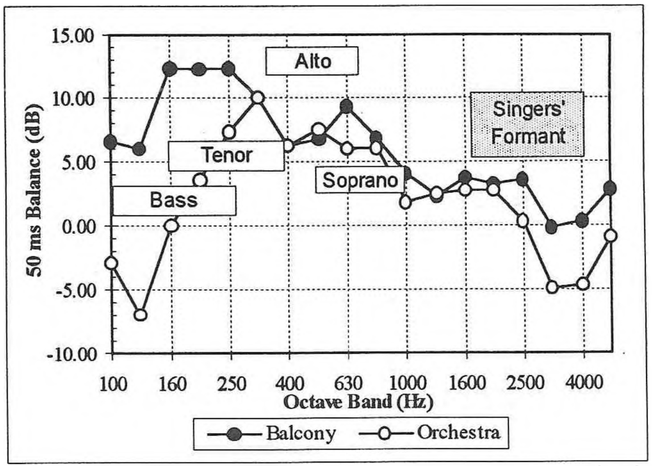

Figure 1 50 ms Balance (B50) measured in The Royal Theatre, Victoria, B.C. Also shown in the graph are the approximate ranges of the four singing groups and the range of the singers' formant.

PERFORMANCE ENHANCEMENT STUDY OF ACOUSTICAL PRIVACY SCREENS

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INTRODUCTION

Modular office furniture systems are used extensively in the design and layout of open office spaces. To enhance auditory privacy, modular privacy screens often incorporate acoustically absorptive elements to help reduce intelligible sound from being transmitted to adjacent workspaces or public areas.

Teknion Furniture Systems is involved in the design and manufacture of modular office furniture, including privacy screens. Each screen is based on a constructed metal frame, in which electrical or mechanical services for the workspace may be integrated. On either side of the frame, modular elements are clipped in, effectively making the screen a double-walled partition. Historically, acoustically absorptive elements have been constructed from a solid steel pan of variable thickness, containing fibreglass batt insulation of variable density, and faced with acoustically transparent cloth or vinyl. The study described herein was undertaken to identify alternative methodologies toward improving the acoustical performance of these elements, while maintaining the cost competitiveness of the finished product.

METHODOLOGY

Acoustically speaking, the design challenge was to identify new potential configurations for the acoustical elements which would improve the Noise Reduction Coefficient (NRC) of the screen without substantially diminishing its sound transmission performance. In the open office environment, much of the sound between workstations is transmitted *over* the screen, not *through* it. Thus the importance of the Sound Transmission Class (STC) value of a screen in an actual office installation is dependent on a number of factors, including the proximity of the talker and the listener to the screen, the heights of both the talker and the listener relative to the top of the screen, the type of ceiling in the office, and the frequency spectrum of the talker's voice. It is apparent that the STC of the screen need only be enough to prevent sound transmitted through it from being more important than sound transmitted over it.

To rationalize the importance of sound transmission from one side of the screen to the other, a "worst case" scenario was hypothesized in which a sitting male talker speaks directly at the screen (e.g. while using the phone) and is heard by a listener sitting directly opposite on the other side. Both talker and listener are assumed to be only 0.5 m from the screen, and 0.75 m below its top (for a 2 m high screen). The ceiling is assumed to be very high or very absorptive, and does not reflect any sound over the top of the screen. Under this scenario, the total A-weighted sound pressure level (LpA) reaching the listener's ears via both paths (i.e. over the screen and through it) may be calculated.

An analytic multiple-layer model was developed to predict both the NRC and LpA (as defined above) of various element configurations. Estimates of sound absorption and transmission through the panel were based on published models [1], modified to account for air absorption properties and panel leakage factors, and a more accurate model for sound propagation through bulk absorbing media [2]. Estimates of the resulting LpA utilized a typical male speech spectrum as described in [3], and well-known equations for diffraction over barriers. The model concentrated on the differences between a given configuration and the existing design (i.e. Δ NRC, Δ LpA) rather than the absolute values.

MODELLED CONFIGURATIONS

For brevity, only the important results are described below, for a standard single acoustical element (double and triple elements with higher performance ratings are also manufactured by Teknion).

Benchmark (existing) Single Element: 13 mm thick fibreglass batt, 24 kg/m^3 density, in nominal 13 mm deep 24 g steel pan.

Increased Batt Thickness / Density: Increasing thickness of batt to 16 mm provides Δ NRC of +0.04. Increasing density to 64 kg/m^3 without changing thickness also provides Δ NRC of +0.04. Increasing both thickness and density simultaneously provides Δ NRC of +0.12.

Perforated Pan: Only low percentage perforations are acceptable from the standpoint of sound transmission performance. Δ NRC considerably higher for some combinations of porosity and perforation hole diameter. Predicted improvements in Δ NRC range from +0.04 to +0.18, with corresponding increases in Δ LpA of +2 to +4.

Batt Stood Off Pan: 3 mm batt behind gap modelled. For both solid and perforated pan, additional improvement in Δ NRC predicted for some configurations.

No Pan, Foil Backing on Fibreglass: Substitution of solid steel pan by foil backing on fibreglass provides improvements in Δ NRC from +0.04 to +0.15, depending on fibreglass density. For some configurations, corresponding increase in Δ LpA may be unacceptable.

RESULTS AND DISCUSSION

Based on the modelled results and both economic and technical considerations, revised element configurations were selected which incorporated a slightly thicker fibreglass layer, in conjunction with a perforated back pan having low percentage, small diameter perforations. Modified prototype screens were tested in an ASTM accredited laboratory, and were found to exhibit NRC values on the order of +0.15 higher than the corresponding benchmark models. The prototype screens were also found to have STC ratings only 2 to 3 points lower than the corresponding benchmark models, which roughly corresponds to a 2 dB increase in LpA. As a 2 dB increase in transmitted sound is unlikely to be perceptible to most individuals, and the increased NRC will create a "softer" acoustical environment inside the workspace, the modified screens are hoped to be a popular item.

Teknion begins full production of the modified acoustical screens in January 1998.

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MEASURING THE ABSORPTION OF BARRIERS AND SCREENS

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Introduction

Traffic noise barriers with a sound absorbing face and absorbing office screens are two examples of sound absorbing screens and barriers. They are intended to be both a barrier to sound (with high transmission loss) as well as sound absorbing. Laboratory tests (such as ASTM C423) are required to verify the effectiveness of the sound absorbing surfaces.

A number of the details of the test procedures are not precisely specified, and it is possible to get a range of results for the same material. It is also not always clear exactly what is required of an absorbing screen.

This paper reviews the problems associated with measuring the sound absorption of screens and presents suggestions for recommended measurement procedures and areas in need of further research.

The Problems

Absorption coefficients obtained in a reverberation chamber test are angular averages. If the sound field is ideally diffuse these averages represent an even distribution of all possible angles of incidence. In practice reverberation chambers are not perfectly diffuse and all angles of incidence are not equally represented. Measured absorption varies accordingly.

Depending on the type of screen and the application, all possible angles of incidence may not be equally important. For an absorbing traffic noise barrier, near to normal angles of incidence will be most important because near to normally incident sound will be of greater intensity.

The sound absorption coefficients of samples installed on the floor of a reverberation chamber vary with sample size. Due to diffraction effects at the edges of the sample, smaller samples tend to be more effective than larger samples and measured absorption coefficients relate to the sample perimeter/area ratio (*P/A*). (See Figure 1).

The sound absorption of screens is most commonly tested by mounting the screen vertically in the middle of the reverberation chamber rather than lying it on the floor. These two different types of sample mounting produce quite different sound absorption coefficients. (See Figure 2). The sample size effects and the variation with sample perimeter/area ratio are reduce for free standing vertical samples.

It is common to measure both the absorption and the sound transmission loss of the screens. It would be convenient to use the sound transmission loss mounting for both tests. However this mounting restricts the angles of incidence and has larger sample size effects than the vertical mounting.

Recommendations

- Sample size should be representative of actual applications.
- Sample size should be standardised and as large as possible.
- Free standing vertical mounting is preferred.
- A sound transmission loss mounting is not recommended.
- We need to assess the influence of angle of incidence.
- We need to determine representative angles of incidence.
- We need to determine preferred absorption versus frequency characteristics for each type of screen.

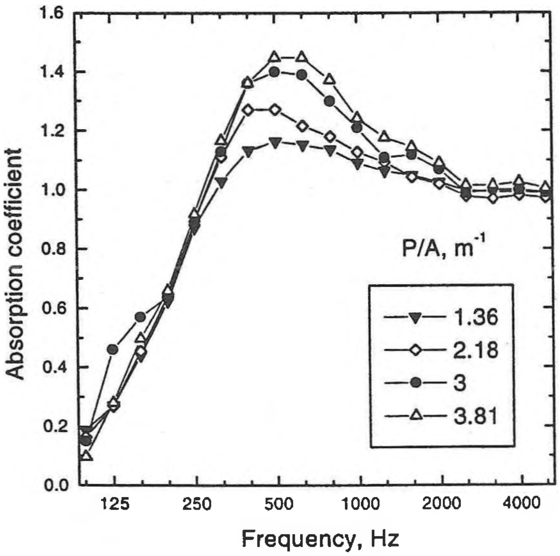

Fig. 1. Glass fibre sample absorption coefficients for four perimeter/area ratios (P/A).

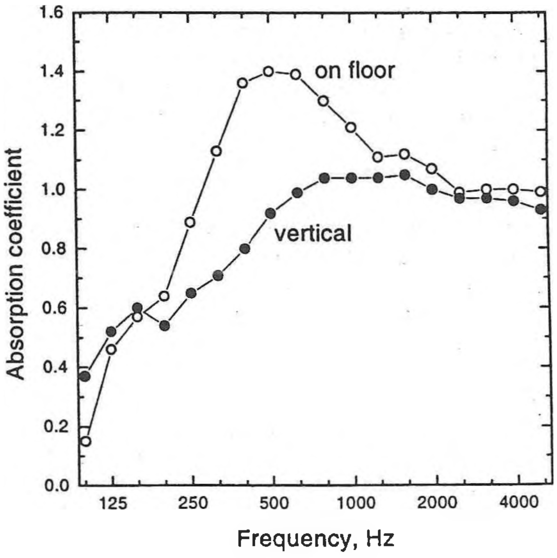

Fig. 2. Glass fibre sample absorption coefficients for vertical and flat on floor mounting .

Sound pressure levels during amplified orchestra rehearsals and performances

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INTRODUCTION

Sound levels in orchestra settings have been reported to vary greatly as a function of position in the orchestra, performance hall acoustics, type of music, and whether the measures are made during rehearsals or performances. In some cases, sound levels have been reported that are high enough to be of potential risk to performers' hearing. However, the duration of performances and rehearsals may be short enough to not pose a serious hearing hazard[1].

Measures of hearing loss in orchestral musicians has demonstrated that many musician show signs of noise-induced hearing loss following many years of music exposure[1,2]. The amount of loss as measured by pure-tone thresholds is extremely variable, like all noise-induced hearing loss, but in general is mild and restricted to frequencies around 4000 Hz.

A noise exposure survey was conducted at the request of members of a professional orchestra, who were concerned about sound exposure levels during some performance situations. The orchestral members were most concerned by the sound levels during certain performances in which electrically amplified instruments were being used. Some performers reported having increased difficulty hearing their own instruments while performing, and having symptoms of excessive noise exposure (tinnitus and dulled hearing) after some performances.

METHOD

A noise survey was conducted over a period of five months in the primary performance hall of a professional orchestra. Sound measures were made during both rehearsals and performances. The music included country and pop musical styles. Many of the performances included the use of amplified instruments.

A Bruel & Kjaer model 2231 sound level metre with integrating module BZ 7100 and a type 4155 microphone were positioned on the performance stage at several locations adjacent to performers' shoulders. Sound measures were made during a sample of musical pieces and during the musical breaks. All measurements reported here are based on 10-minute measurement intervals with A-weighting and the fast measurement setting.

RESULTS

Sound levels (Leq) ranged from 70 dBA (ambient noise level when not performing) to 89 dBA (conductor) with maxima around 100 dBA. The sound levels were lower during the rehearsal performances, and more interruptions of the music resulted in greater time between the louder musical segments.

Position	Leq (dBA)	Maximum level (dBA)	% of time above 85 dBA
Woodwinds	82	100	10
Strings near monitors	85	97	30
Between violins and cellos	82	96	15
Strings near woodwinds	85	98	37
Ambient	70	83	0.1
Conductor	89	100	53
Brass	85	99	25
Strings below woodwinds	75	85	9

DISCUSSION

These measures indicate that the performers are exposed to significant sound levels during the performances, that could, if exposure length at these levels was sufficient, cause permanent noise-induced hearing loss in some musicians.

These levels are higher than would be expected for the average levels experienced by these musicians because only amplified concerts, representing only a portion of the performance schedule for the orchestra, were surveyed. In order to determine an individual musician's risk for hearing loss caused by sound exposure, the total daily sound exposures would need to be ascertained.

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Research supported by NSERC.

Echo Suppression in a Large Fan Shaped Auditorium

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Introduction

In 1996, the acoustically be-leaguered O'Keefe Centre received a $5M grant from the software developer Hummingbird Corporation and, not long after, assumed that company's name. Part of the grant was used to address the well known acoustical problems, this time with the LARES electro-acoustic enhancement system[1]. Prior to installation, a full set of acoustic measurements was undertaken to quantify the existing natural acoustics and to identify any potential impediments to the operation of the enhancement system.

Measurements

Initially, measurements were performed in the traditional fashion: sound source on the stage and receivers in the audience chamber. The results of this round of measurements give objective credence to some thirty-five years of acoustical complaints. The room is virtually devoid of reflected sound. One seat in the balcony had an Early Decay Time of 0.25 seconds. A room of this kind should have Early Decay Times in the range of 1.2 to 1.4 seconds. Lack of loudness had always been a problem at O'Keefe Centre and the Strength measurements shown in Figure 1 show clear physical evidence to corroborate the complaint.

The paucity of reflected sound demonstrated in Figure 1 led to another chronic problem at O'Keefe Centre - echoes. The back wall of the audience creates an audible echo on stage, even though it has been treated with acoustic absorption. Half way through the measurements a side wall echo was discovered. The echo was severe and can be best described as "head spinning". For a source on one wall, the opposite (partially curved) wall returned reflections at 160 to 180 ms. The focus of the curved portion of the wall was outside the room and in other halls might not cause too much concern. In this room however, the lack of late masking reflections meant that any impulsive sound from the sixty-two (62) loudspeakers that were planned for each of walls would be heard as an echo. These speakers were to be used for LARES enhancement and other multi-media presentations. It was the latter of these two applications that would be most affected by the echo. This formidable concern led to a second series of measurements, this time with the source on the side wall. At this point in the project, the feasibility of a successful enhancement installation was seriously in doubt.

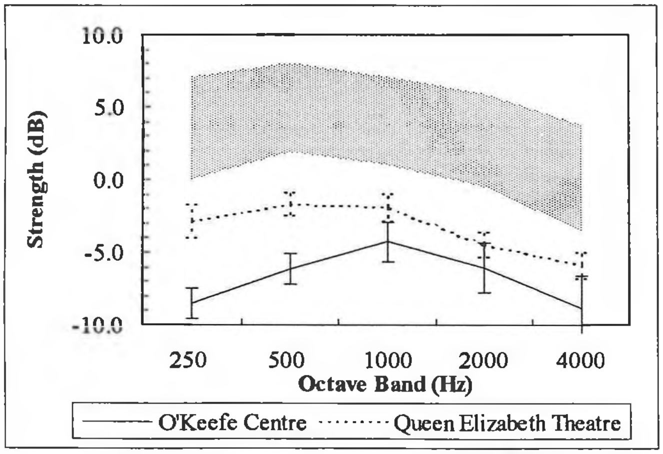

Figure 1 Strength measured in the former O'Keefe Centre compared to Vancouver's Queen Elizabeth Theatre and the 12 halls measured by the Concert Hall Research Group[2] (shaded area of the graph)

Scale Model and Diffuser Design

A 1:50 scale model was built to investigate ways to eradicate the echo. Scale model measurements were carried out using the MIDAS small scale modelling techniques[3]. Four different diffusers were designed; the first three using the stepped type of diffuser profiles originally suggested by Schroeder[4] and the last employing a smooth profile generated by a boundary element optimising algorithm[5]. Trevor Cox, the developer of the algorithm, assisted in this final design, working in association with RPG Diffusor Systems. The crescent shaped optimised diffuser that came out of this exercise fits seamlessly into the room's difficult though elegant architectural aesthetic.

The scale model tests of the stepped diffuser suggested that the echo could be significantly reduced, although not completely eradicated. Boundary element calculations on the optimised diffuser indicated a 4 to 7 dB improvement over the stepped diffuser. This would render what was thought to be appropriate reduction in echo and it was decided to proceed with the enhancement installation.

The diffusers were fastened to the walls and, in keeping with heritage concerns, may be easily removed if so required in the future. Measured results were not available at press time but listening tests indicate that the side wall echo has been eliminated. A full set of measurements with and without the enhancement system will be presented at the meeting. Both staff and users at the new Hummingbird Centre have expressed satisfaction with the room's new acoustics.

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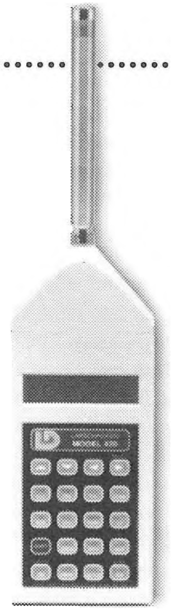


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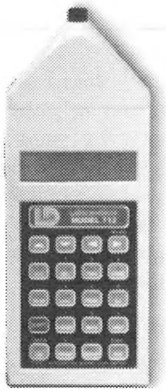

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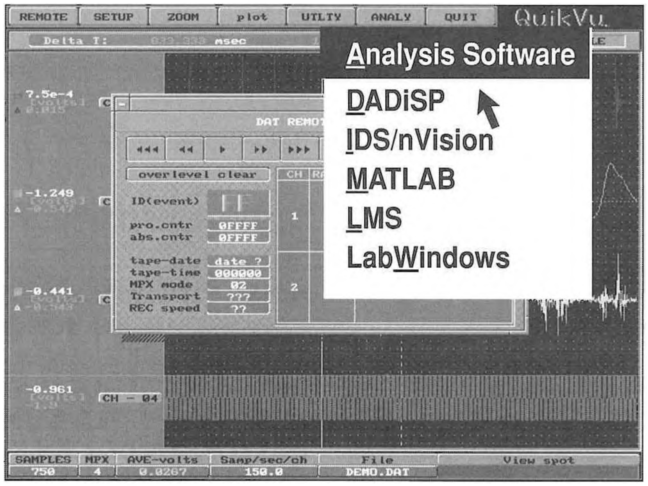

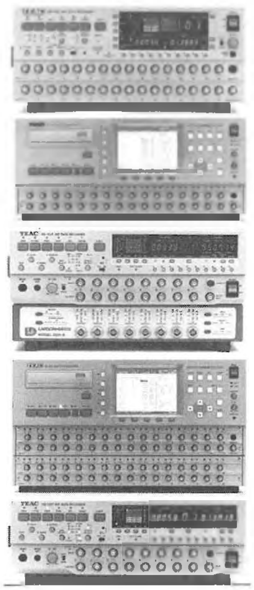

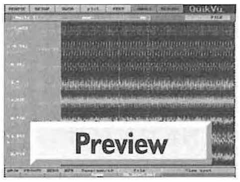

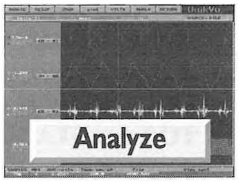

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DO WE NEED CANADIAN ACOUSTICAL STANDARDS?

Cameron Sherry - Enviro-RISQUE

Do we, Canadian Acousticians, really need to concern ourselves with the development and maintenance of acoustical and vibration standards? Surely we can carry out our acoustical research or our acoustical measurements without having to think about standards. Or can we?

The series of papers that will be presented in this session will take a look at which standards some Canadian Acousticians feel require input from the Canadian community. The papers will include information on what the effects would be of ignoring the rest of the world and what the benefits could be of participating in international acoustic standard development.

Is there really a field of endeavour in which acoustics does not play a role? The most obvious is the role of voice communication, one with another. There is on going research to determine how we speak, how we learn to speak, how we hear, how we can discriminate one sound from another and what actions we take on hearing a command.

When it comes to leisure time or a party, we often turn to music. To make sure we are providing high quality sounds to a discriminating ear we need information about how the ear perceives sounds, how enclosures affect the sounds we make and how sounds can be mixed with each other to produce the effect we want.

We live and work in enclosures but how much privacy is required and how much communication is required. Since we all sleep at some time, is there a limit to how high the noise background can be?

The acoustical concerns can be extended to questions about the nature of our planet whether it be in the air, on the land, under the land or underwater. We use machines that create both pleasurable and annoying noises depending upon their location and use. Our machines cause vibrations to buildings and ourselves. What are the limits of acceptability from both a health and annoyance point of view?

The common acoustical tools required to develop an understanding of each of the subject areas is standards. They come in many guises such as terminology, measurement procedures, specifications for instrumentation, guidelines, practices and classifications.

WHICH NATIONAL OR INTERNATIONAL ACOUSTICAL STANDARDS SHOULD CANADIANS DEVELOP AND MAINTAIN?

Draft Canadian Guidelines for Machinery Noise Emission Labelling

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INTRODUCTION

Occupational noise-induced hearing loss (NIHL) is a significant public health problem in Canada. Statistics obtained from Provincial and Territorial Workers' Compensation Boards indicated that, for the years 1991-93, there were about 7000 new noise-induced hearing disability claims accepted annually. During this period, the direct cost to employers of all noise-induced hearing disability claims was approximately 25 to 30 million dollars in compensation each year.

An effective way of ameliorating this situation is to ensure that, the actual noise level in a workplace is as low as reasonably achievable. This is the most reliable way to reduce noise exposure and, thereby, the risk of NIHL. The method does not interfere with the worker, unlike administrative controls and personal hearing protection, and it can improve the ability of workers to communicate on-site and hear warning sounds.

This paper describes draft Canadian guidelines for the voluntary labelling of machinery noise emission levels for use in the reduction of noise in new or significantly modified workplaces. At the time of writing, the document has been prepared by the Radiation Protection Bureau, Health Canada for development as a National Standard of the Canadian Standards Association (CSA).

PROPOSED LABELLING RECOMMENDATIONS

Machinery noise emission labelling is a standardized declaration of the emission sound pressure level of a machine and, if required, its sound power level. This information is not affixed to the machinery; rather, it is included in the instructions and technical information accompanying machinery being offered for sale. Both noise emission quantities are measured under typical operating and mounting conditions. The emission sound pressure level is usually measured near the operator's ear position and excludes contributions from background and reflected noise.

To facilitate international trade, the draft labelling recommendations are consistent with the regulatory requirements of the European Union (EU)[1-3]. The draft recommendations for non-impulsive noise are: (i)the A-weighted, equivalent continuous (time averaged) emission sound pressure level is labelled if it is greater than 70 dB(A), (ii)if this quantity is less than 70 dB(A), only a statement of this fact is needed, (iii)the A-weighted sound power level is labelled if the equivalent continuous emission sound pressure level is greater than 85 dB(A). For impulsive noise, the peak C-weighted emission sound pressure level is labelled if it is greater than or equal to 130 dB(C). The above criteria were chosen so that labelling would be needed only for machines that could create potentially hazardous occupational exposure levels [4].

The intent of the labelling is to facilitate, during either the construction or significant modification of a workplace, the purchase of quieter machinery and the prediction of noise exposure levels. This enables noise control to be cost-effective. For example, the purchase of quieter machinery reduces or eliminates the need for costly noise controls after the plant is operational. In addition, the requirements and effectiveness of noise controls, such as absorbing panels or enclosures, can be ascertained ahead of time [5]. Furthermore, the use of quieter machinery can cut maintenance costs and improve product quality because such equipment often has a smoother action, greater reliability and a longer life [6].

IMPLEMENTATION STANDARDS

There are a number of standards of the International Organization for Standardization (ISO)[7] which can be used to meet the draft Canadian recommendations. The standards have been prepared to provide methods for the determination, disclosure and use of the sound power and emission sound pressure levels, primarily to enable compliance with EU Directives[1-4]. Two types of standard are available for measuring a noise emission level. They are: (i)test codes, which prescribe the accuracy, operating and mounting conditions of the measurement for a particular type of machine and, (ii)basic standards, of which there are 14, for describing the methods for making the measurements.

The draft Canadian guidelines recommend that measurements of noise emission levels should be made according to test codes, if available. However, the choice of the basic measurement standard is up to the person responsible for the measurement. The draft Canadian guidelines contain guidance for choosing the appropriate basic measurement standard to determine sound power level and emission sound pressure level. The guidance is provided principally as a series of tables, which enables the reader to examine, in a systematic way, the compatibility of a measurement standard with 8 criteria: (i)background noise, (ii)instrumentation, (iii)measurement accuracy, (iv)size and average absorption coefficient of the room available for the measurement, (v)character of the noise, eg., impulsive or steady, (vi)frequencies to be measured, (vii)mounting surface, and (viii)measurement speed. This guidance is intended to alleviate the complexity that can arise in choosing one standard, of the 14 available, according to 8 different criteria.

CONCLUSIONS

Reductions in the risk of occupational noise-induced hearing loss are facilitated through machinery noise emission labelling. International trade considerations and the availability of a suitable system of International Standards have increased the feasibility of implementing machinery noise emission labelling for workplace noise reduction in Canada. To help interested parties meet this goal, Canadian Guidelines have been drafted providing recommendations for labelling and guidance on the selection of available standards.

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Activities in the Canadian Standards Association Industrial Noise Subcommittee

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The CSA Industrial Noise Subcommittee is the largest and most active subcommittee reporting to the main Acoustics and Noise Control Committee. They currently have 6 active standards. Each standard is described below and expected future activities are outlined:

The following table summarises the standards for which the subcommittee is responsible:

Number	Standard	Status
Z107.51	Procedure for In-Situ Measurement of Noise from Industrial Equipment	Widely used; based on Lp at 1m. To be reviewed in light of ISO 3740 series endorsation.
Z107.52	Recommended Practice for the Prediction of sound Pressure Levels in Large Rooms Containing Sound Sources	To be revised using prediction being developed by Murray Hodgson.
Z107.53	Procedure for Performing a Survey of Sound Due to Industrial, Institutional or Commercial Activities	Out of date. Requires extensive revision or replacement.
Z107.54	Procedure for Measurement of Sound and Vibration Due to Blasting Operations	Blasting standard being rewritten with a new section on underwater blast evaluation.
Z107.55	Recommended Practice for the Prediction of Sound Levels From an Industrial Plant	Working group to be set up to review standard and recommend changes and possible adoption/endorsation of "*ISO 9613-2:1996 Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*" This group will coordinate with MOEE's review of propagation issues.
Z107.56	Procedures for the Measurement of Occupational Noise Exposure	Recently reconfirmed. This was the first standard of its type in the world and is the bestselling CSA Acoustics Standard. It is explicitly referred to in Federal Noise Regulations and is accepted by most provinces.

The most widely used Canadian Standard in Acoustics is Z107.56, Procedures for the measurement of Occupational Noise Exposure. First issued in 1986, it was the only such standard in the world. ISO has a similarly titled standard, but it is much more general and less prescriptive. ANSI has finally come out with their version. At this point, because Canada is further ahead in the use of L_{eq}, the ANSI standard is less suitable. As the Federal noise regulation refers specifically to this standard, it is expected to remain in widespread use across Canada.

Z107.51, Procedure for In-Situ Measurement of Noise from Industrial Equipment, is widely used. The subcommittee has recommended the endorsation of the ISO 3740 series of standards and will be examining other international standards for possible endorsation or adoption. However, the ISO standard is based on L_W, while the CSA standard is based on L_p at 1m, which is simpler to measure and more reflective of actual plant conditions. It is not yet clear whether the ISO standards will replace or supplement the existing standard.

Z107.55, Recommended Practice for the Prediction of Sound Levels From an Industrial Plant, requires revision in order to be compatible with MOEE concerns. In addition, ISO has recently passed a similar standard, with Canadian involvement. A working group will be formed shortly to decide whether to endorse or adopt the ISO standard. In addition, it will recommend whether the simpler CSA standard will continue to exist in parallel or be replaced.

Finally, a proposed working group is proposed to prepare a standard on Noise Labelling of Industrial Machines in cooperation with Health and Welfare Canada. This standard would provide guidance for Canadian Industry on noise labelling and would be in compliance with EEC / ISO initiatives.

Activities in the Canadian Standards Association Transportation Noise Subcommittee

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The CSA Transportation Noise Subcommittee deals with transportation related standard for the main Acoustics and Noise Control Committee. They currently have three active standards. Each standard will be described and expected future activities outlined:

The following table summarises the standards for which the subcommittee is responsible:

Z107.21	Procedure for Measurement of Maximum Exterior Sound Level of Pleasure Motorboats	Out of date. Can be replaced with *"ISO 2922:1975 Acoustics -- Measurement of noise emitted by vessels on inland water-ways and harbours"* or *"ISO/DIS 14509 Small craft - Measurement of sound pressure level of airborne sound emitted by motor craft"* or *by a series of SAE Standards.* Requires industry representatives for working group to review alternatives.
SAE 1096	Measurement of Exterior Sound Levels for Heavy Trucks Under Stationary Conditions	Endorsed. Endorsation should be reviewed soon.
Z107.25	Procedure for Measurement of the Exterior Sound Level of Motorcycles	Out of date. Can be replaced with SAE standards. Requires industry representatives for working group to review alternatives.
Z107.9	Standard for Noise Barriers on Roadways (see below)	Approved by subcommittee and out for Letter Ballot by main committee.
P 1.51	Procedures for Measurement of Ground Vibration from Transportation Sources	Being drafted.

Standards Z107.21 and Z107.25 are old standards prepared to assist the Federal and Ontario governments in regulating boats and motorcycles. Although the latter is very much in the news, the standards are not in active use. Before they are withdrawn and possibly replaced with ISO or SAE standards, representatives of these industries must be contacted and included in the Subcommittee. This was done with an earlier truck noise standard, which was replaced with an SAE standard and with an old draft railway noise standard, which was abandoned.

Standard Z107.9 Standard for Noise Barriers on Roadways, is currently out for ballot by the main Acoustics and Noise Control Committee. It describes the physical requirements for noise barriers. This standard was based on the Ontario Ministry of Transportation barrier procurement guidelines and prepared to address the problems associated with premature failure of residential noise barriers. It provides uniform construction standards for noise barriers. The draft standard has already been adopted by Mississauga and Ottawa and forms the basis for an American highway standard.

P1.5.1 is being drafted by a committee chaired by Vic Schroter of the Ontario Ministry of the Environment and Energy. They had earlier reviewed the state of the art and concluded that there was a need for a measurement standard for vibration from rail and road vehicles.

Psychophysics of Windnoise and Sound Quality Engineering

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At relatively high speeds, windnoise becomes a dominant component in the interior of most automobiles and is often determined to be objectionable in customer evaluations. While subjective ratings improve when the loudness of the windnoise is reduced, it is not always possible to achieve such level reduction. The present paper addresses whether it is possible to improve the sound quality of the windnoise without altering its loudness, e.g., whether some shapes of windnoise spectra are preferred over others.

To determine whether spectral shape affects the sound quality of windnoise, active sensory tuning (AST) was used [Sterian, Runkle, and Wakefield, Intl. Conf. Acoust. Speech and Sig. Proc., 1995]. This methodology, in general, allows listeners to efficiently and selectively adjust the parameters governing an acoustic signal to optimize along some subjective dimension. In the particular case, we chose spectral shape as the key attribute of our windnoise investigation, parameterized shape using an equalizer model, and asked listeners to judge candidate signals according to a preference criterion. A genetic-algorithm version of the AST procedure was implemented based on psychophysical studies of shape sensitivity. Results from these studies, the slope and shape quantization model, and preferred shapes will be presented and discussed in light of the controllable surfaces in windnoise generation. [Work supported by grants from the Ford Motor Company and the Office of Naval Research.]

LEXICON FOR PRODUCT SOUND QUALITY

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1. INTRODUCTION

As applied to sensory evaluation methods, a lexicon is a list of terms used to describe fundamental sensory attributes of products or materials. The list is a collection of terms organized by category and subcategory that are neither consumer language nor engineer-speak. The lexicon consists of precise and succinct terms that clearly describe the perceived attribute. As part of analytical discrimination sensory methods, the lexicon provides clear and precise descriptions related to consumer acceptance to ultimately understand those characteristics that drive consumer preferences. Using proper terminology and calibrated intensity scales, sensory descriptive techniques are applied widely across several consumer products industries to characterize perceived properties.

2. CURRENT WORK

The development of a lexicon for Sound Quality is in progress under the auspices of the ANSI S12/WG36 group 3 with the following goals:

· Invite a broad cross section of sound engineers and scientists to participate in sound lexicon development workshops.

· Collect a large array of automotive sounds to serve as stimulants for term generation by workshop participants; use additional natural sources [thunder, babbling brook, animals, musical instruments, small motors, etc.] to expand the terms and use of the lexicon beyond automotive sounds.

· Develop a standard lexicon for sound with initial emphasis on automobile sounds.

· Identify current practitioners of sound quality measurement and potential users of a SQ lexicon.

· Establish a model for the underlying properties and corresponding terminology for naming sounds.

Currently lexicon interest has reached critical mass in automotive SQ so that there are adequate participants willing to meet to name attributes and build categories. An exhaustive lexicon that can be used as a model is the "Aroma and Flavor Lexicon for Sensory Evaluation". [2] Examples for the various entries for a given term are shown. Term: almond; Definition: aromatic associated with almonds, almond extract; Reference: oil of bitter almonds, almonds; Preparation: unroasted slivered almonds, baked at 190 C ° for 6 min; Example 1: marzipan; Example 2: benzaldehyde.

For the Sound Quality lexicon work, the sound stimuli are digital audio AachenHEAD binaural recordings of nature and product sounds. This catalog is supplemented by filtered and synthetic variants of the "real" sounds. For best results, sounds should be auditioned through high quality headphones to ensure everyone is listening to the same auditory event and remove any bias introduced by the acoustics of the listening room. It is beneficial to name sound characteristics independently then have participants share adjectives and look for similarity. The terms for sound description can be, but are not limited to, onomatopoeic words that immediately evoke an auditory image of the sound. An example of a term of this type can be found in "Proposal for Aurally-equivalent Acoustic Testing of Small-size Electric Motors". [3] The entry "chirp" from this small motor lexicon has the description "rising and falling amplitude modulated high-frequency sound impression". When the formant frequency lies outside the normal range of human speech, sounds are difficult to mimic. An analytic description including the period and degree of fluctuation may be appropriate when representing low frequency sound characteristics, as in the preceding reference.

3. PRELIMINARY RESULTS

For product sounds already discussed in the Lexicon working group, some distinct patterns are developing. Three groups of sound samples were explored: natural, appliance, and automobile. Descriptive terms such as flutter, hum, tick, hiss and whine were generated multiple times for different sounds. Pitch, spectrum, and time structure are important sound elements that are directly related to the naming process.

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Identification and Characterization of Powertrain Sound Quality Attributes

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INTRODUCTION

Powertrain sounds are probably the most distinctive and the most dominant automotive sound source. These sounds are also capable of generating a number impressions in the listener. This study attempts to identify and quantify these impressions for a series of powertrains with 4, 6, and 8 cylinder engines.

METHODS

Binaural recordings were made of first gear wide-open-throttle accelerations from three separate vehicle classes (compacts, entry level luxury and luxury sport sedan), each class having a different engine size (4, 6, and 8 cylinders respectively). For each vehicle segment, a separate listening clinic was conducted using owners of vehicles in the class. At least a hundred subjects participated in each of these clinics. The powertrain sounds were evaluated using a seven point semantic differential method as well as a paired comparison of preference. The adjective pairs for the semantic scaling were obtained from focus groups in which subjects described their engine sound. From this discussion, twelve semantic categories were defined. These consisted of acoustic terms (quiet/loud, rough/smooth), quality indicators (pleasant/annoying, cheap/expensive) and engine performance descriptors (stressed/unstressed, powerful/weak).

RESULTS AND DISCUSSION

We focus first on the semantic differential results within a vehicle segment. For each segment, significant rating differences are found in 8 of the 12 semantic categories. In addition, a good distribution of ratings among the vehicles is observed. Results from the V-8 study are shown in Figure 1 for three semantic categories; quiet/loud (solid), rough/smooth (dashed), pleasant/annoying (dotted). It is apparent that typical car owners have no difficulty evaluating powertrain sound quality attributes. The ratings for the acoustic categories are then correlated to objective sound quality metrics. The quiet/loud ratings correlate very well with peak loudness [1] for all segments while the smooth/rough ratings correlated with an internally developed roughness metric [2]. Of course, there are no metrics for the non-acoustic, impressionistic attributes. However, one can relate these to their underlying objective metric by correlation. For example, an engine sound is perceived as stressed if it is loud and perceived as reliable if it is smooth and quiet.

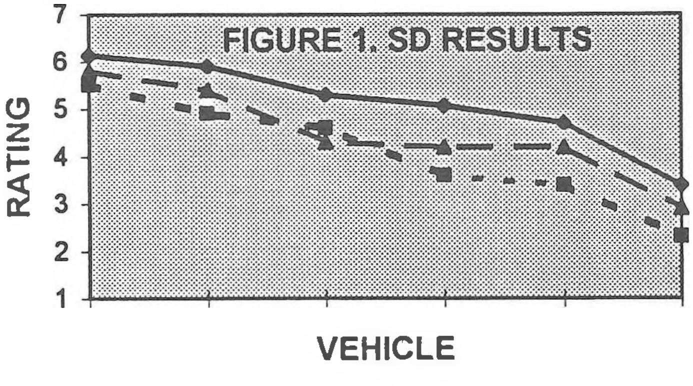
FIGURE 1. SD RESULTS

Cross-segment comparisons show no great differences between segments. In fact, the segment differences are much less than the differences between vehicles within a segment. This is largely because of the limitations of a seven point scale. Subjects use most of the rating range in all segments so one would not expect to see large segment differences. A cross-segment comparison which is meaningful is to look at how each sound quality attribute contributes to overall preference. This is done by correlating the semantic data to the preference results. If an attribute's semantic ratings correlate highly to the preference data, then that attribute contributes to preference. This type of contribution analysis shows some striking segment differences. For C class vehicles, the two most important sound attributes are not stressed and quiet. These results reflect the fact these owners use their engine sound as a diagnostic aid. On the other hand, the two least important attributes are powerful and expensive. Owners of these relatively inexpensive vehicles, with 4 cylinder engines, do not expect their powertrain to sound either powerful or expensive. Contrast this with the results for the entry level luxury vehicles, where smooth and expensive are the two most important sound attributes while engine stress is relatively unimportant. For the luxury cars, quietness is the biggest contributor to preference.

CONCLUSIONS

A method for measuring customer impressions of powertrain sounds has been presented. Using this method, vehicle owners can readily evaluate numerous engine sound quality attributes for a variety of vehicle segments. In addition, attribute contributions to preference can be measured and differences between segments identified.

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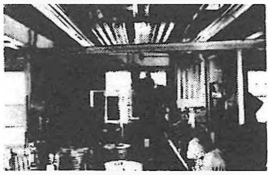

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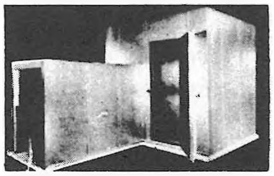

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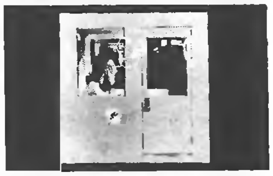

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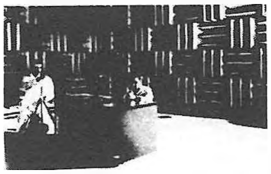

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EVALUATION OF PERCEIVED TONALITY ACROSS THE MUSICAL PITCH RANGE

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1. INTRODUCTION

A three-level hierarchy of tonal stability (tonic triad, other scale, nonscale notes) has been empirically demonstrated for the perception of key structure within the Western tonal-harmonic idiom (e.g., Cuddy & Badertscher, 1987; Krumhansl & Kessler, 1982). This study addresses the issue whether this hierarchy is stable throughout the frequency range typically employed in music.

2. METHOD

2.1 Participants

Forty participants, 23 females and 17 males, were recruited from the Queen's University community. Participants received course credit or cash payment. Twenty of the participants had extensive formal music training (mean = 12.3 yrs., minimum of VIII Royal Conservatory). The other 20 participants had little formal training (mean = 2.52 yrs.). No participant reported any hearing difficulties.

2.2 Materials

Stimuli were sampled piano tones generated by a Roland FP-1 under the control of a Macintosh PowerPC. A trial consisted of a 4-note tonal sequence (do-mi-do-sol) in the key of D# major or A major followed by a probe tone, one of the 12 possible notes of the chromatic scale. Sequences and probe tones were contained within one octave. Fifteen different (overlapping) octaves were sampled within the range of fundamental frequencies 19.4 to 4709.1 Hz. All tones were equalized for loudness.

2.3 Procedure

The listeners' task was to rate the degree to which a probe fit into the preceding sequence, on a 7-point scale that ranged from "Fits very well" to "Fits very poorly". Listeners were encouraged to assess the probe within the context of the entire 4-note sequence rather than on how well the probe continued the melody.

3. RESULTS AND DISCUSSION

Following Krumhansl and Kessler (1982), the set of 12 ratings is called a probe-tone profile. To assess recovery of the tonal hierarchy, correlations were calculated between the obtained profiles from individual listeners and the standardized profile for key-defining contexts provided by Krumhansl and Kessler (1982). Figure 1 reveals that recovery of the tonal hierarchy was most evident for trained listeners in the central octaves. In the shaded areas of figure 1, however, it can be seen that the number of trained and untrained listeners able to recover the tonal hierarchy was particularly low in the pitch ranges below A1 (55 Hz) and above D#7 (2489 Hz). Hence, for most listeners, the audible pitch range of tonality may be narrower than the musical pitch range. These findings implicate a dominance region for musical pitch perception.

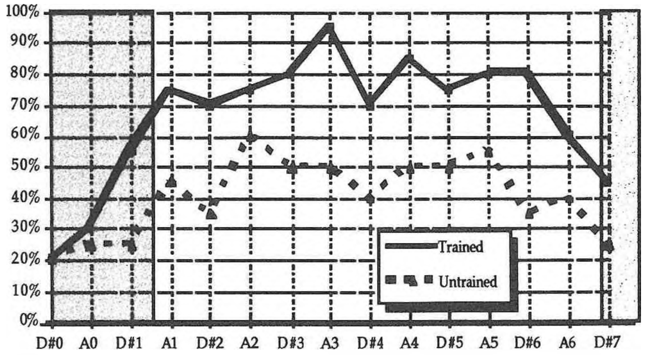

Figure 1: Recovery of tonal hierarchy as expressed by percentage of listeners having responses significantly correlated with standardized profile in each octave tested

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MUSICAL SAND CHARACTERIZATION

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1. INTRODUCTION

Over the years, our research group and others have conducted several investigations into the properties of musical sands. It is generally agreed that a particular combination of factors such as composition, shape, texture, degree of sorting, moisture content and surface characteristics must be met in order to produce these peculiar sands. The present report will summarize some of the most significant observations made in studying this unusual effect; hopefully, this will benefit those readers who are similarly intrigued by this enigmatic phenomenon.

2. RESULTS

There are two types of musical sand: booming sand, generally found on desert sand dunes and singing sand, which appears on certain beaches. Studies on both types have revealed the following observations, features and properties:

Acoustic: These sands emit very intense sounds in the field when disturbed. Coherent sound from booming sand is sometimes so loud that it carries over several kilometers from a sand dune, sometimes accompanied by a recognizable beat. When small samples are shaken in a jar, they generate a rhythmic thrum of a few hundred Hertz, producing noticeable vibrations in the hand. Acoustic emission created by the rubbing of particles in motion features coherent beat patterns when displayed on a storage oscilloscope. (1) Time parameters of these signals have been related to sample and grain size. (2)

Physical: Musical sands are usually well-sorted with respect to size and shape. Electron micrographs show that their grains are moderately spherical and rounded and that grain surfaces appear smooth, clean and polished and contain a critical amount of moisture. Muteness of smooth, spherical and clean glass beads and other ordinary sands indicates however that regularity of size, shape and smoothness by themselves cannot account for musicality. (3) Solid infection experiments, whereby grains of silent sands are mixed with musical ones, show that surface contaminants as well as dampness quickly silence musical sands. Subdivision of field samples of musical sand into narrow size ranges has also revealed that no particular fraction has a monopoly on musicality.

Chemical: X-ray fluorescence tests have shown that the grain composition of musical sands is primarily quartzitic, although calcareous musical sands, which can never be as dry as desert ones, are found in Hawaii. Evidently the musical property is partly determined by a particular frictional force which is attained with little water for clean quartz grains, but requires some water absorption for calcareous ones. However, the presence of a thin silica gel-type surface layer on musical sand grains has been detected by Fourier transform infrared spectroscopy. A broad absorption band at 3400 cm^{-1}, extending from 3700 cm^{-1} to 2800 cm^{-1}, is due to clusters of water in an amorphous silica layer on the surface of the sand grains. (4) This has been confirmed by demonstrating that commercially available silica-gel materials, which give the characteristic 3400 cm^{-1} IR band, also produce an audio beat pattern typical of natural singing sands. (5) The composition and condition of the particle surface seem to play a very delicate role.

3. CONCLUSION

From the experiments reported above, it can be concluded that a combination of several agents is responsible for the musical sand phenomenon. In individual cases the presence of too much water, of finely divided material, or of grain angularity has a deleterious effect; but dry, clean and rounded grains by no means always sing and some sands with presumed high moisture content do sing. Smoothness has been shown to be important, but glass spheres smoother than any sand grain do not sing. It is likely that musicality is mediated by a very specific grain-grain surface interaction to which individual grains systems can be tuned in a variety of ways. It then becomes an accident of grain history and environment as to whether a combination of factors will be right for musicality to occur.

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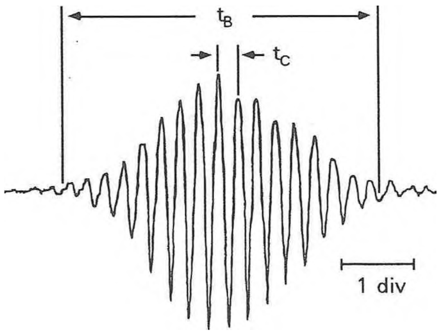

Typical Signal Emitted by Musical Sand

THE GEOGRAPHY OF ACOUSTIC (MUSICAL) SANDS

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INTRODUCTION

What is acoustic sand? Acoustic or sound generating sand is one of the least understood natural phenomena, and is known in different parts of the world as: singing sand, squeaking sand, barking sand, booming sand, whistling sand, and musical sand. Their physical character in terms of particle size, surface texture and shape have been discussed extensively in the literature (Lewis, 1936; Folk and Ward, 1957; Brown et al, 1961; Clarke, 1973; and Lindsay et al, 1976). According to Sholtz et al (1997), there are two types of acoustic members. "Squeaking" sands, which generate a fairly high frequency (>500 Hz) output and are found on shorelines, beaches and riverbeds worldwide. The second type, "booming" sands, generate a low (<100 Hz) to medium (c. 500 Hz) frequency sound and are associated with slope failure on desert dunes. The phenomena have been reported in the literature and folklore for nearly a millennia. A Chinese report dating from 880 AD records a festival of booming sand (Ton-Fan) and "singing sands" have been documented in Japanese folklore (Miwa et al, 1983). The first European report was by Marco Polo (1295) in his travels along the Silk Road. The earliest reports in the literature by Darwin (1889 (*1832*)) and Miller (1858) noted the uniqueness and rarity of the phenomenon, recent research suggests that acoustic sands are not rare. The distribution of acoustic sand has been given spotty recognition in the literature, though individual sites have been documented. Little has been compiled on geographic distribution and environmental conditions that produce the acoustic character.

DISCUSSION AND RESULTS

Musical sands are associated with two natural environments: deserts (arid), and coasts (humid). Deserts typically dry, often exhibit a "wet" season. Coasts, associated with humid conditions, can be arid and have weather cycles similar to deserts (Bowden, 1968). The climatic regime, and geographic location are necessary to determine how musical sands are created in nature.

Acoustic phenomena have been duplicated with both "conditioned" natural sand and "man-made" products (Brown et al, 1965; Goldsack et al, 1997). Sand particle size and texture influence the frequency of resonance. Relative surface roughness and/or a chemical coating (silica gel) appear as the most important characteristic, and influence acoustic output by controlling shear strength and angle of repose.

Herein, it is the intent to present the geographic distribution of musical sand, and identify the environmental conditions creating the phenomena of "musical" sand. The geographic distribution of "musical sand" invites a comparison with the climate and climatic cycle of each site. The grouping of known sites and comparison with weather station data allows depiction of the climate regime of a musical sand. The mapped musical sands are depicted in Figure 1.

CONCLUSIONS

Geographically the distribution of "musical" sands as depicted in Figure 1, shows the phenomenon on all continents. Sites are associated with both sere desert environments and lacustrine, riverine and oceanic shorelines. Musical sands (Leach et al, 1997) are formed by: 1. A wet cycle to "wash" or purify the sand; 2. A dry cycle, when combined with a wet cycle create conditions under which the "coating" (silica gel) on individual sand grains is chemically produced; and 3. A "windy" location to dry and polish the sand grains, and further, allowing a "stacked-up unstable position, allowing the generation of acoustic resonance upon slope failure or slip.

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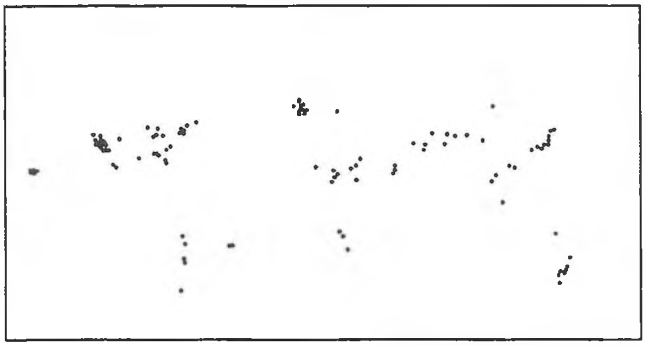
FIGURE 1. The global distribution of acoustic (musical) sand. Specific sites have been gleaned from the literature, obtained either by the researchers or others in the field. (a comprehensive, annotated bibliography of "musical" sand is in preparation).



Patterns of tension/relaxation in music: A consideration of psychoacoustic and cognitive influences

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Perceiving patterns of tension/relaxation is essential to the comprehension and appreciation of music. Since music exists both as a collection of psychoacoustical events and as a system of hierarchical relationships understood at a cognitive level, it is reasonable to explore different influences on the perception of tension. To what degree do psychoacoustic and cognitive factors influence listeners' perception of tension in music? Recent work (Bigand, Parncutt, & Lerdahl, 1996) has addressed this question using short chord sequences. The present studies pursue the issue using an excerpt of real music that has received much attention from music theorists--the first nine bars of the second movement of Beethoven's *Waldstein* (Opus 53) piano sonata. We evaluated the psychoacoustic dissonance conveyed by isolated elements of the excerpt and compared perceived dissonance with perceived patterns of tension/relaxation conveyed by the musical context to musically sophisticated listeners.

Experiment 1

The aim of the first experiment was to obtain measurements of listeners' perceptions of dissonance of isolated chords extracted at different time points in the *Waldstein*.

Participants

Fourteen volunteers from the Queen's University community all met the minimum musical training requirement of Royal Conservatory grade VIII or equivalent, and had an average 13.7 years of musical training. None reported any degree of familiarity with the *Waldstein*.

Materials and Procedure

The stimuli consisted of the 15 successive solid or arpeggiated chords that constitute the first nine bars of the second movement of the *Waldstein*. The sonata was performed by an accomplished pianist and recorded in MIDI format. Chords were then extracted from the MIDI file. The chords were heard through Sennheiser HD-480 headphones connected to a Roland FP-1 digital piano. A Macintosh computer running MAX software controlled the timing and presentation of stimuli and the collection of responses. After each presentation of a chord, listeners rated perceived dissonance on a six-point scale. Each of eight blocks of trials contained each of the 15 chords, randomly ordered. The first block was a practice block, and its data were not included in the analyses. In order to avoid any carryover effects of the tonality of the previous trials the chord heard on each trial was randomly transposed within the range 3 semitones below to 3 semitones above the original notation of the excerpt.

Results

Perceived dissonance varied significantly among different chords ($F_{(14,182)} = 26.70$, $p < .001$). The mean dissonance rating for each chord is plotted in Figure 1, where the x-axis represents the successive time points, from 1 to 15, at which each chord was extracted.

Experiment 2

The first aim of the second experiment was to measure listeners' perceptions of tension for segments of the Waldstein presented in context. The second aim was to assess the degree to which the ratings could be accounted for by the dissonance ratings from Experiment 1, as well as by our quantification of phrase structure derived from a music theoretic analysis of the excerpt (Lerdahl, 1988).

Participants

Fourteen volunteers from the Queen's University community all met the same musical training requirement as Experiment 1, and had an average 12.3 years of musical training. They had all participated in a previous experiment in which they had been required to perform the *Waldstein* excerpt from memory.

Materials and Procedure

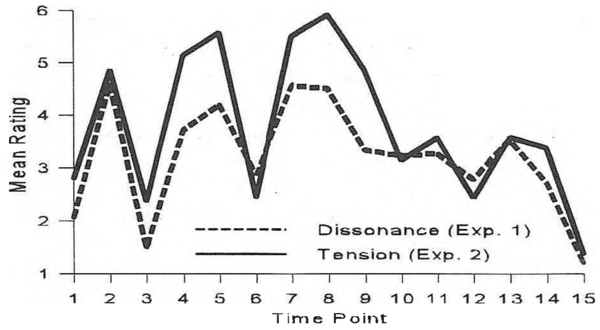
The stimuli consisted of 15 segments from the *Waldstein*. Each segment contained all the musical material up to one of 15 successive time points in the first nine bars of the second movement. Thus the final chord of each segment was one of the chords tested in Experiment 1. The segments were presented in chronological order and were not randomly transposed between trials. In other respects, the procedures was the same as Experiment 1. After each presentation listeners rated the perceived tension at that time point on a six-point scale.

Results

Listeners' ratings of perceived tension varied across time points ($F_{(14,182)} = 37.91$, $p < .001$). The mean tension rating for each segment is plotted in Figure 1, where the x-axis represents the successive time points at which each segment stopped. It can be seen that the fluctuation in tension ratings for the segments closely resembles the fluctuation in dissonance ratings for the isolated chords. As well as the fluctuations, however, the tension ratings show an increase up to time point 8 that is not present in the dissonance ratings. This difference may be attributed to the phrase structure of the excerpt.

The tension ratings collected in the Experiment 2 were highly correlated ($r_{(13)} = .90$, $p < .001$) with the dissonance ratings collected in Experiment 1. In addition, however, the tension ratings were also highly correlated ($r_{(13)} = .65$, $p < .01$) with a quantified predictor representing phrase structure. This predictor was derived from a music-theoretic analysis of the excerpt (Lerdahl, 1988). A multiple regression was then performed using dissonance ratings and phrase structure as predictors of perceived tension ($R = .96$). A significant contribution to the predictability of perceived tension was made by both the dissonance ratings ($t = 8.67$, $df = 12$, $p < .001$) and phrase-structure ($t = 4.23$, $df = 12$, $p < .01$).

Figure 1



General Discussion

The present experiments attempted to assess the role of both psychoacoustic and cognitive factors in listeners' experience of musical tension. The results reported here show that listeners' perceptions of tension are best predicted by a model that includes both information about the dissonance associated with individual musical events, as well as information about how the individual events are organized in terms of phrase structure.

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Sound Transmission through Buildings using Statistical Energy Analysis
by Robert J.M. Craik

This book provides a comprehensive summary of the principles of Statistical Energy Analysis. Whilst the title would suggest that the book be applicable to only buildings it has a much broader appeal. Of the eight chapters, the first six represent a thorough discussion of the general theory and application of SEA to arbitrary structures. It is the last two chapters which focus on the application of SEA to buildings.

The book begins with a simple prediction of a single monolithic construction and compares the SEA formulation to the classic formula for the transmission loss of an element installed between two reverberation rooms. This may seem an abrupt start but may comfort persons unfamiliar with SEA by illustrating that traditional methods have their roots in, or can be traced to, the fundamental concept of power balance.

Chapter 2 provides a detailed discussion of how to break the system into a series of subsystems by considering modal energy, stiffeners, and size of the potential system as well as defining subsystems for the different wave types and frequency ranges. A discussion of the interconnections between subsystems and the transmission types; resonant and non-resonant, are also given here. Perhaps the most enlightening for users of SEA packages is the discussion on accuracy which considers the impact of errors in CLF's and the impact of inadequate modal overlap.

The properties which define a subsystem are given in Chapter 3 and include discussions of wavespeed, bending stiffness, critical frequency, energy, damping, modes, and mobility. The relationship between the fundamental material properties for a homogeneous plate are thoughtfully summarized in a table for easy reference.

A complete chapter is devoted to derivation and discussion of coupling loss factors room to wall, wall to room, common joints (cross, tee, corner, inline, and column/plate for simple bending waves). Extensive references are given for more complex joints involving elastic interlayers, beams, and other wave types. Particular attention is paid to plate radiation efficiency and the effect of anisotropy which should be especially useful for people applying SEA to framed buildings where even the finish building materials, such as gypsum board and plywood, are anisotropic.

Chapter 6 provides useful information on numerical techniques to improve speed and accuracy when solving the set of simultaneous equations defining the subsystem energies. Also included is a very informative discussion of the bias error associated with measuring the coupling loss factor between two connected subsystems when there are multiple paths between the two subsystems.

The last two chapters are devoted to prediction of direct and flanking transmission and will certainly be of great interest to experienced SEA users. The chapter on direct transmission includes suggested models for predicting airborne transmission through double masonry walls (with consideration to coupling between the leaves in the form of cavity air stiffness, point connections due to masonry ties, line connections due to window and door frames as well as foundations), airborne transmission through lined masonry walls, and also lightweight timber frame walls.

The final chapter on flanking transmission provides worked examples which result in simple equations for the sound reduction of common flanking paths between adjacent rooms. There is a discussion of predicting level differences in large models and the error associated with considering only bending wave transmission.

The book draws on Professor Craik's fifteen years of SEA experience and presents it in a well organized and concise manner. It provides theory at a level which would make it an ideal graduate level textbook, but unlike a textbook, it provides numerous practical examples making it a very useful tool for SEA practitioners. The book also provides a unique opportunity to learn of the power and limitations of SEA that are often taken for granted when using commercial SEA packages. In short, this book is highly recommended for both the experienced SEA user and persons wishing to learn more about the technique.

Reviewed by: Trevor Nightingale, Institute for Research in Construction, National Research Council Canada

[This book (ISBN 0-566-07572-5) is available from Ashgate Publishing Co. at the price of US$94.95.]

Yokohama meeting of the World Congress in Ultrasonics

Hugh Jones

I attended the meeting of the WCU in Yokohama (24 to 27 August) as the CAA delegate to the Steering Committee. A short report of the activities follows:

The meeting was attended by over 370 people from 23 countries; Canada was represented by one person emphasizing the progressive closing down of the field of acoustics in this country. The major activities are centered in industry and universities in Europe, USA and Japan.

Exciting new developments were reported in several different areas of ultrasonics most of which had direct applications for industry usually on a large scale. Noteworthy among these was:

1. ultrasonic gyros of a variety of types for use in many fields including automobiles;
2. ultrasonic motors with performances ranging from microinches per second to 4000rpm. These motors had a wide range of torques and some were of a size to be used in micro miniature machines;
3. ultrasonic voltage transformers particularly for use in laptop computers to provide a power source for display backlighting and operation;
4. a variety of developments in ultrasonic levitation systems for chip processing and physical acoustics measurements (including laboratory work in microgravity aboard the space shuttle).

Those who may be interested can obtain a copy of the proceedings of the 2nd WCU from the Acoustical Society of Japan. I am seeking permission to reproduce the index of the proceedings and make it available to the CAA so that they can, if they wish, provide members with a copy on request.

The next meeting is to be held in Copenhagen in two years time i.e. at the middle or end of August 1999.

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

1997

1-4 September: Modal Analysis Conference - IMAC-XV Japan, Tokyo, Japan. Contact: N. Okubo, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Yokyo 112, Japan; FAX: +81 3 3817-1820; E-mail: jmac@okubo.mech.chuo-u.ac.jp

7-11 September: American Academy of Otolaryngology--Head and Neck Surgery, San Francisco, CA. Contact: American Academy of Otolaryngology--Head and Neck Surgery, One Prince St., Alexandria, VA 22314. Tel.: 703-836-4444; FAX: 703-683-5100.

9-12 September: 31st International Acoustical Conference "Acoustics - High Tatra 97", High Tetra, Slovakia. Contact: E. Rajcan, Technical University Zvolen, 96053 Zvolen, Slovakia; FAX: +42 855 321 811; E-mail: 31iac@tuzvo.sk

10-12 September: New Zealand Acoustical Society Biennial Conference, Christchurch, New Zealand. Contact: NZ Acoustical Society, P.O. Box 1181, Auckland, New Zealand.

10-12 September: Biomechanics of Hearing, Delft, The Netherlands. Contact: W. Schiehlen, Inst. B of Mechanics, Universitat Stuttgart, 70550 Stuttgart, Germany; Email: wos@mechb.uni-stuttgart.de

15-18 September: 3rd EUROMECH Fluid Mechanics Conference, Gottingen. Contact: G.E.A. Meier, DRL-Institut fur Stromungsmechanik, Bundestrasse 10, 37073, Gottingen, Germany; E-mail: efmc972msfdl.gwdg.de

16-19 September: 44th Open Seminar on Acoustics, Jastrzebia Gora, Poland. Contact: E. Kozaczka, Akademia Marynarki Wojennej, ul. Smidowicza 71, 81-919 Gdynia, Poland; Fax: +48 58 25 48 56; Email: amw@beta.nask.gda.pl

18-19 September: 4th Mexican Congress on Acoustics, Gunnajuato, Gto., Mexico. Contact: The Mexican Institute of Acoustics, P.O. Box 7805.07300, Mexico City, Mexico; Fax: +52 5 523 4742; Email: sberista@vmredipn.ipn.mx

18-20 September: Intonation: Theory, Models and Applications, Athens, Greece. Contact: ESCA Workshop Dept. of Informatics, Univ. of Athens, Panepistimioupolis, Ilisia, 15784 Athens, Greece, Fax: +30 1 722 8981; Email: tonesca@di.uoa.gr

22-24 September: Second Biennial Hearing Aid Research and Development Conference, Bethesda, MD. Contact: National Institute of Deafness and Other Communication Disorders, 301-970-3844; FAX: 301-907-9666; E-mail: hearingaid@tascon.com

22-25 September: 5th European Conference on Speech Communication and Technology, Patras, Greece. Contact: G. Kokkinakis, Department of Electrical and Computer Engineering, University of Patras, 26110 Rion-Patras, Greece; Fax: +30 61 991 855, E-mail: gkokkin @wcl.ee.upatras.gr

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

1997

1-4 septembre: Conférence sur l'analyse par modes - IMAC-XV Japon, Tokyo, Japon. Info: N. Okubo, Chuo University, 1-13-27 Kasuga, Bunkyo-ku, Yokyo 112, Japan; FAX: +81 3 3817-1820; E-mail: jmac@okubo.mech.chuo-u.ac.jp

7-11 septembre: Académie américaine d'otolaryngologie - Chirurgie de la tête et du cou, San Francisco, CA. Info: American Academy of Otolaryngology--Head and Neck Surgery, One Prince St., Alexandria, VA 22314; Tel.: 703-836-4444; FAX: 703-683-5100.

9-12 septembre: 31e conférence internationale d'acoustique "Acoustics - High Tatra 97", High Tetra, Slovakia. Info: E. Rajcan, Technical University Zvolen, 96053 Zvolen, Slovakia; FAX: +42 855 321 811; E-mail: 31iac@tuzvo.sk

10-12 septembre: Conférence biennale de la Société d'acoustique de la Nouvelle-Zélande, Christchurch, Nouvelle-Zélande. Info: NZ Acoustical Society, P.O. Box 1181, Auckland, New Zealand.

10-12 septembre: La biomécanique de l'audition, Delft, Pays-Bas. Info: W. Schiehlen, Inst. B of Mechanics, Universitat Stuttgart, 70550 Stuttgart, Germany; Email: wos@mechb.uni-stuttgart.de

15-18 septembre: 3e conférence EUROMECH sur la mécanique des fluides, Gottingen. Info: G.E.A. Meier, DRL-Institut fur Stromungsmechanik, Bundestrasse 10, 37073, Gottingen, Germany; E-mail: efmc972msfdl.gwdg.de

16-19 septembre: 44e séminaire sur l'acoustique, Jastrzebia Gora, Pologne. Info: E. Kozaczka, Akademia Marynarki Wojennej, ul. Smidowicza 71, 81-919 Gdynia, Poland; Fax: +48 58 25 48 56; Email: amw@beta.nask.gda.pl

18-19 septembre: 4e congrès mexicain sur l'acoustique, Gunnajuato, Gto., Mexique. Info: The Mexican Institute of Acoustics, P.O. Box 7805.07300, Mexico City, Mexico; Fax: +52 5 523 4742; Email: sberista@vmredipn.ipn.mx

18-20 septembre: Intonation: théorie, modèles et applications, Athènes, Grèce. Info: ESCA Workshop Dept. of Informatics, Univ. of Athens, Panepistimioupolis, Ilisia, 15784 Athens, Greece, Fax: +30 1 722 8981; Email: tonesca@di.uoa.gr

22-24 septembre: 2e conférence biennale sur la recherche et le développement des prothèses auditives, Bethesda, MD. Info: National Institute of Deafness and Other Communication Disorders, 301-970-3844; FAX: 301-907-9666; E-mail: hearingaid@tascon.com

22-25 septembre: 5e conférence européenne sur la communication et la technologie de la parole, Patras, Grèce. Info: G. Kokkinakis, Department of Electrical and Computer Engineering, University of Patras, 26110 Rion-Patras, Greece; Fax: +30 61 991 855, E-mail: gkokkin @wcl.ee.upatras.gr

23-26 September: Fluid-structure Interaction in Acoustics, Delft, The Netherlands. Contact: A.H.P. van der Burgh, Faculty of Technical Mathematics and Informatics, Univ. of Technology, P.O. Box 5031, 2600GA Delft, The Netherlands; Email: burgh@dv.twi.tudelft.nl

27-28 September: Audio-Visual Speech Processing, Rhodes, Greece. Contact: ESCA, ICP-Universite Stendhal, BP 25X, 38040 Grenoble, Cedex, France; Email: esca@icp.grenet.fr

6-9 October: Oceans '97 MTS/IEEE, Halifax, Canada. Contact: IEEE Travel and Conference Management Services, 445 Hoes Lane, Piscataway, NJ, 08855-1331, USA. Tel: (908) 562-5598; Fax: (908) 981-1203.

7-10 October: 1997 IEEE Ultrasonics Symposium, Toronto, Canada. Contact: S. Foster, Department of Medical Biophysics, Sunnybrook Health Science Ctr., 2075 Bayview Avenue, Toronto, Ontario M4N 3M5, Canada; E-mail: stuart@owl.sunnybrook.utoronto.ca

8-10 October: 1997 Acoustics Week in Canada, Windsor, Canada. Contact: Dr. R. Ramakrishnan, Vibron Ltd, 1720 Meyerside Drive, Mississauga, Ontario, L5T 1A3. Tel.: (905) 670-4922; FAX: (905) 670-1698.

23-26 October: Reproduced Sound 13, Windermere, UK. Contact: Inst. of Acoustics, Agriculture House, 5 Holywell Hill, St. Albans, Herts AL1 1EU, UK, Fax: +44 1727 850 533; Email: acoustics@clus1.ulcc.ac.uk.

30-31 October: Swiss Acoustical Society Meeting, Bern, Switzerland. Contact: Swiss Acoustical Society, P.O. Box 251, 8600 Dubendorf, Switzerland.

19-21 November: WESTPRAC VI 97, Hong Kong. Contact: S.K. Tang, WESTPRAC Secretary, Department of Building Services Engineering, The Hong Kong Polytechnic University, Hung Hum, Hong Kong; FAX: +852 27746146; E-mail: besktang@polyu.edu.hk

27-30 November: IOA Autumn Conference: Environmental Noise, Windermere, UK. Contact: Institute of Acoustics, Agriculture House, 5 Holywell Hill, St. Albans, Herts AL1 1EU, UK, Fax: +44 1727 850 533; Email: acoustics @clus1.ulcc.ac.uk

1-5 December: 134th Meeting of the Acoustical Society of America, San Diego, CA. Contact: Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797, Tel.: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; WWW: http//asa.aip.org

15-18 December: 5th International Congress on Sound and Vibration, Adelaide, Australia. Contact: ICSV5 Secretariat, Department of Mechanical Engineering, University of Adelaide, South Australia 5005, Australia; FAX: +61 8 8303 4367; E-mail: icsv5@mecheng.adelaide.edu.au

1998

2-6 February: Ultrasonic Technological Processes - 98, Moscow, Russia. Contact: Secretariat, UsTP-98, 64 Leningradski prospekt, MADI-TU, Moscow, Russia; Fax: +7 095 151 7911; Email: utp@madi.msk.su

9-13 February: 1998 Ocean Sciences meeting, San Diego, CA. Contact: American Geophysical Union, 2000 Florida Ave., N.W., Washington, DC 20009; Tel.: 202-462-6900; Fax: 202-328-0566; WWW: www.agu.org

23-26 septembre: Intéraction fluide-structure en acoustique, Delft, Pays-Bas. Info: A.H.P. van der Burgh, Faculty of Technical Mathematics and Informatics, Univ. of Technology, P.O. Box 5031, 2600GA Delft, The Nehterlands; Email: burgh@dv.twi.tudelft.nl

27-28 septembre: Traitement du discours audio-visuel, Rhodes, Grèce. Info: ESCA, ICP-Université Stendhal, BP 25X, 38040 Grenoble, Cedex, France; Email: esca@icp.grenet.fr

6-9 octobre: Oceans '97 MTS/IEEE, Halifax, Canada. Info: IEEE Travel and Conference Management Services, 445 Hoes Lane, Piscataway, NJ, 08855-1331, USA. Tel: (908) 562-5598; Fax: (908) 981-1203.

7-10 octobre: Symposium de 1997 de l'IEEE sur les ultrasons, Toronto, Canada Info: S. Foster, Department of Medical Biophysics, Sunnybrook Health Science Ctr., 2075 Bayview Avenue, Toronto, Ontario M4N 3M5, Canada; E-mail: stuart@owl.sunnybrook.utoronto.ca

8-10 octobre: Semaine canadienne d'acoustique 1997, Windsor, Canada. Info: Dr. R. Ramakrishnan, Vibron Ltd, 1720 Meyerside Drive, Mississauga, Ontario, L5T 1A3. Tel.: (905) 670-4922; Fax: (905) 670-1698.

23-26 octobre: Sons reproduits 13, Windermere, Royaume-Uni. Info: Inst. of Acoustics, Agriculture House, 5 Holywell Hill, St. Albans, Herts AL1 1EU, UK, Fax: +44 1727 850 533; Email: acoustics@clus1.ulcc.ac.uk

30-31 octobre: Rencontre de la Société d'acoustique suisse, Berne, Suisse. Info: Swiss Acoustical Society, P.O. Box 251, 8600 Dubendorf, Switzerland.

19-21 novembre: WESTPRAC VI 97, Hong Kong. Info: S.K. Tang, WESTPRAC Secretary, Department of Building Services Engineering, The Hong Kong Polytechnic University, Hung Hum, Hong Kong; FAX: +852 27746146; E-mail: besktang@polyu.edu.hk

27-30 novembre: Conférence d'automne de l'IOA: Bruit environmental, Windermere, Royaume-Uni. Renseignements: Inst. of Acoustics, Agriculture House, 5 Holywell Hill, St. Albans, Herts AL1 1EU, UK, Fax: +44 1727 850 533; Email: acoustics@clus1.ulcc.ac.uk

1-5 décembre: 134e rencontre de l'Acoustical Society of America, San Diego, Californie. Info: Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797, Tel.: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; WWW: http//asa.aip.org

15-18 décembre: 5e congrès international sur les sons et vibrations, Adelaïde, Australie. Info: ICSV5 Secretariat, Department of Mechanical Engineering, University of Adelaide, South Australia 5005, Australia; FAX: +61 8 8303 4367; E-mail: icsv5@mecheng.adelaide.edu.au

1998

2-6 février: Procédés technologiques ultrasoniques - 98 Moscou, Russie. Info: Secretariat, UsTP-98, 64 Leningradski prospekt, MADI-TU, Moscow, Russia; Fax: +7 095 151 7911; Email: utp@madi.msk.su

9-13 février: Rencontre 1998 sur les sciences de l'océan, San Diego, CA. Info: American Geophysical Union, 2000 Florida Ave., N.W., Washington, DC 20009; Tél.: 202-462-6900; Fax: 202-328-0566; WWW: www.agu.org

23-27 March: DAGA 98 - German Acoustical Society Meeting, Zürich, Switzerland. Contact: DEGA, Physics/ Acoustics Department, Universität Oldenburg, 26111 Oldenburg, Germany; FAX: +49 441 798 3698; E-mail: dega@aku.physik.uni-oldenburg.de

5-8 April: NOISE-CON 98, Ypsilanti, MI. Contact: Noise Control Foundation, P.O. Box 2469, Arlington Branch, Poughkeepsie, NY 12603; Tel.: 914-462-4006; Fax: 914-463-0201; Email: noisecon98@aol.com; WWW: users.aol.com/noisecon98/nc98_cfp.html

25-27 May: Noise and Planning 98, Naples, Italy. Contact: Noise and Planning, Via Bragadino 2, 20144 Milano, Italy, Fax: +39 248018839; Email: md1467@cmlink.it

8-10 June: EAA/EEAA Symposium "Transport Noise and Vibrations", Tallinn, Estonia. Contact: East-European Acoustical Association, Moskovskoe Shosse 44, 196158 St.-Petersburg, Russia; FAX: +7 812 127 9323; E-mail: krylspb@sovam.com

9-12 June: 8th International Conference on Hand-Arm Vibration, Umea, Sweden. Contact: National Inst. for Working Life, Physiology and Technology Dept., P.O. Box 7654, 90713 Umea, Sweden; Fax: +46 90 165027; Email: hav98@niwl.se

22-26 June: 135th meeting of the Acoustical Society of America/16th International Congress on Acoustics, Seattle, WA. Contact: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797, Tel.: 516-576-2360; FAX: 516-576-2377; E-mail: asa@aip.org, WWW: http://asa.aip.org

7-12 July: Vienna and the Clarinet, Ohio State Univ., Columbus, OH. Contact: Keith Koons, Music Dept., Univ. of Central Florida, P.O. Box 161354, Orlando, FL 32816-1354; Tel.: 407-823-5116; Email: kkons@pegasus.cc.ucf.edu

13-17 September: American Academy of Otolaryngology--Head and Neck Surgery, San Francisco, CA. Contact: American Academy of Otolaryngology--Head and Neck Surgery, One Prince St., Alexandria, VA 22314. Tel.: 703-836-4444; FAX: 703-683-5100.

12-16 October: 136th meeting of the Acoustical Society of America, Norfolk, VA. Contact: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797, Tel.: 516-576-2360; FAX: 516-576-2377; E-mail: asa@aip.org; WWW: http://asa.aip.org

16-18 November: Inter-Noise 98, Christchurch, New Zealand. Contact: New Zealand Acoustical Society, P.O. Box 1181, Auckland, New Zealand.

23-27 November: ICBEN 98: Biological Effects of Noise, Sydney, Australia. Contact: N. Carter, NAL, 126 Greville St., Chatswood 2067, Australia, Fax: +61 2 411 8273.

30 November - 4 December: 5th International Conference on Spoken Language Processing, Sydney, Australia. Contact: ICSLP Secretariat, Tour Hosts, GPO Box 128, Sydney, NSW 2001, Australia; Fax: +61 2 9262 3135; Email: tourhosts@tourhosts.com.au; WWW: http://cslab.anu.edu.au/icslp98

23-27 mars: DAGA 98 - Rencontre de la Société allemande d'acoustique, Zürich, Suisse. Info: DEGA, Physics/ Acoustics Department, Universität Oldenburg, 26111 Oldenburg, Germany; FAX: +49 441 798 3698; E-mail: dega@aku.physik.uni-oldenburg.de

5-8 avril: NOISE-CON 98, Ypsilanti, MI. Info: Noise Control Foundation, P.O. Box 2469, Arlington Branch, Poughkeepsie, NY 12603; Tél.: 914-462-4006; Fax: 914-463-0201; Email: noisecon98@aol.com; WWW: users.aol.com/noisecon98/nc98_cfp.html

25-27 mai: Bruit et planification 98, Naples, Italie. Info: Noise and Planning, Via Bragadino 2, 20144 Milano, Italy, Fax: +39 248018839; Email: md1467@cmlink.it

8-10 juin: Symposium EAA/EEAA "Bruit et vibrations des transports", Tallinn, Estonia. Info: East-European Acoustical Association, Moskovskoe Shosse 44, 196158 St.-Petersburg, Russia; FAX: +7 812 127 9323; E-mail: krylspb@sovam.com

9-12 juin: 8e conférence internationale sur les vibrations main-bras, Umea, Suède. Info: National Inst. for Working Life, Physiology and Technology Dept., P.O. Box 7654, 90713 Umea, Sweden; Fax: +46 90 165027; Email: hav98@niwl.se

22-26 juin: 135e rencontre de l'Acoustical Society of America/16e congrès international d'acoustique, Seattle, WA. Info: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797, Tel.: 516-576-2360; FAX: 516-576-2377; E-mail: asa @aip.org; WWW: http://asa.aip.org

7-12 juillet: Vienne et la clarinette, Ohio State Univ., Columbus, OH. Info: Keith Koons, Music Dept., Univ. of Central Florida, P.O. Box 161354, Orlando, FL 32816-1354; Tél.: 407-823-5116; Email: kkons@pegasus.cc.ucf.edu

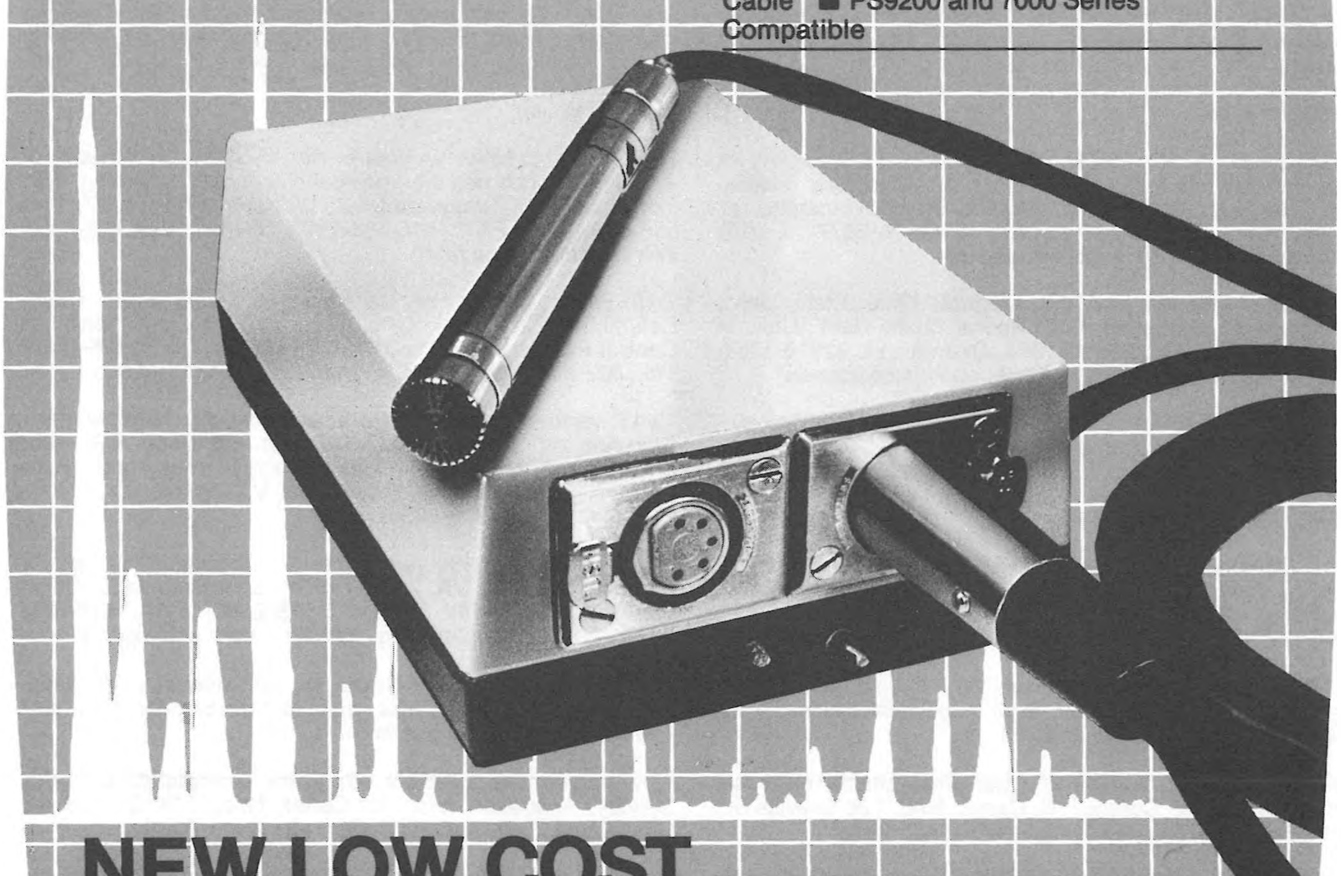
13-17 septembre: Académie américaine d'otolaryngologie - Chirurgie de la tête et du cou, San Francisco, CA. Info: American Academy of Otolaryngology--Head and Neck Surgery, One Prince St., Alexandria, VA 22314. Tel.: 703-836-4444; FAX: 703-683-5100.

12-16 octobre: 136e rencontre de l'Acoustical Society of America, Norfolk, VA. Info: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797, Tel.: 516-576-2360; FAX: 516-576-2377; E-mail: asa@aip.org; WWW: http:// asa.aip.org

16-18 novembre: Inter-Noise 98, Christchurch, Nouvelle-Zélande. Info: New Zealand Acoustical Society, P.O. Box 1181, Auckland, New Zealand.

23-27 novembre: ICBEN 98: Effets biologiques du bruit, Sydney, Australie. Info: N. Carter, NAL, 126 Greville St., Chatswood 2067, Australia, Fax: +61 2 411 8273.

30 novembre- 4 décembre: 5e conférence internationale sur le traitement de la langue parlée, Sydney, Australie. Info: ICSLP Secretariat, Tour Hosts, GPO Box 128, Sydney, NSW 2001, Australia; Fax: +61 2 9262 3135; Email: tourhosts@tourhosts.com.au; WWW: http://cslab.anu.edu.au/icslp98



The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT

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

EDGAR AND MILLICENT SHAW POSTDOCTORAL PRIZE IN ACOUSTICS

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

1990	*Li Cheng*	*Université de Sherbrooke*	*1995*	*Jing-Fang Li*	*University of British Columbia*
1993	*Roland Woodcock*	*University of British Columbia*	*1996*	*Vijay Parsa*	*University of Western Ontario*
1994	*John Osler*	*Defense Research Estab. Atlantic*			

ALEXANDER GRAHAM BELL GRADUATE STUDENT PRIZE IN SPEECH COMMUNICATION AND BEHAVIOURAL ACOUSTICS

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

1990	*Bradley Frankland*	*Dalhousie University*	*1993*	*Aloknath De*	*McGill University*
1991	*Steven D. Turnbull*	*University of New Brunswick*	*1994*	*Michael Lantz*	*Queen's University*
	Fangxin Chen	*University of Alberta*	*1995*	*Kristina Greenwood*	*University of Western Ontario*
	Leonard E. Cornelisse	*University of Western Ontario*	*1996*	*Mark Pell*	*McGill University*

FESSENDEN STUDENT PRIZE IN UNDERWATER ACOUSTICS

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

1992	*Daniela Dilorio*	*University of Victoria*	*1994*	*Craig L. McNeil*	*University of Victoria*
1993	*Douglas J. Wilson*	*Memorial University*	*1996*	*Dean Addison*	*University of Victoria*

ECKEL STUDENT PRIZE IN NOISE CONTROL

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

1994	*Todd Busch*	*University of British Columbia*	*1996*	*Nelson Heerema*	*University of British Columbia*
1995	*Raymond Panneton*	*Université de Sherbrooke*			

DIRECTORS' AWARDS

Three awards are made annually to the authors of the best papers published in *Canadian Acoustics*. All papers reporting new results as well as review and tutorial papers are eligible; technical notes are not. The first award, for $500, is made to a graduate student author. The second and third awards, each for $250, are made to professional authors under 30 years of age and 30 years of age or older, respectively. Coordinator: David Quirt, Acoustics Section, Institute for Research in Construction, NRCC, Ottawa, ON K1A 0R6.

STUDENT PRESENTATION AWARDS

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

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

ANNONCE DE PRIX

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

PRIX POST-DOCTORAL EDGAR ET MILLICENT SHAW EN ACOUSTIQUE

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

1990	*Li Cheng*	*Université de Sherbrooke*	*1995*	*Jing-Fang Li*	*University of British Columbia*
1993	*Roland Woodcock*	*University of British Columbia*	*1996*	*Vijay Parsa*	*University of Western Ontario*
1994	*John Osler*	*Defense Research Estab. Atlantic*			

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	Fangxin Chen	*University of Alberta*	*1995*	*Kristina Greenwood*	*University of Western Ontario*
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