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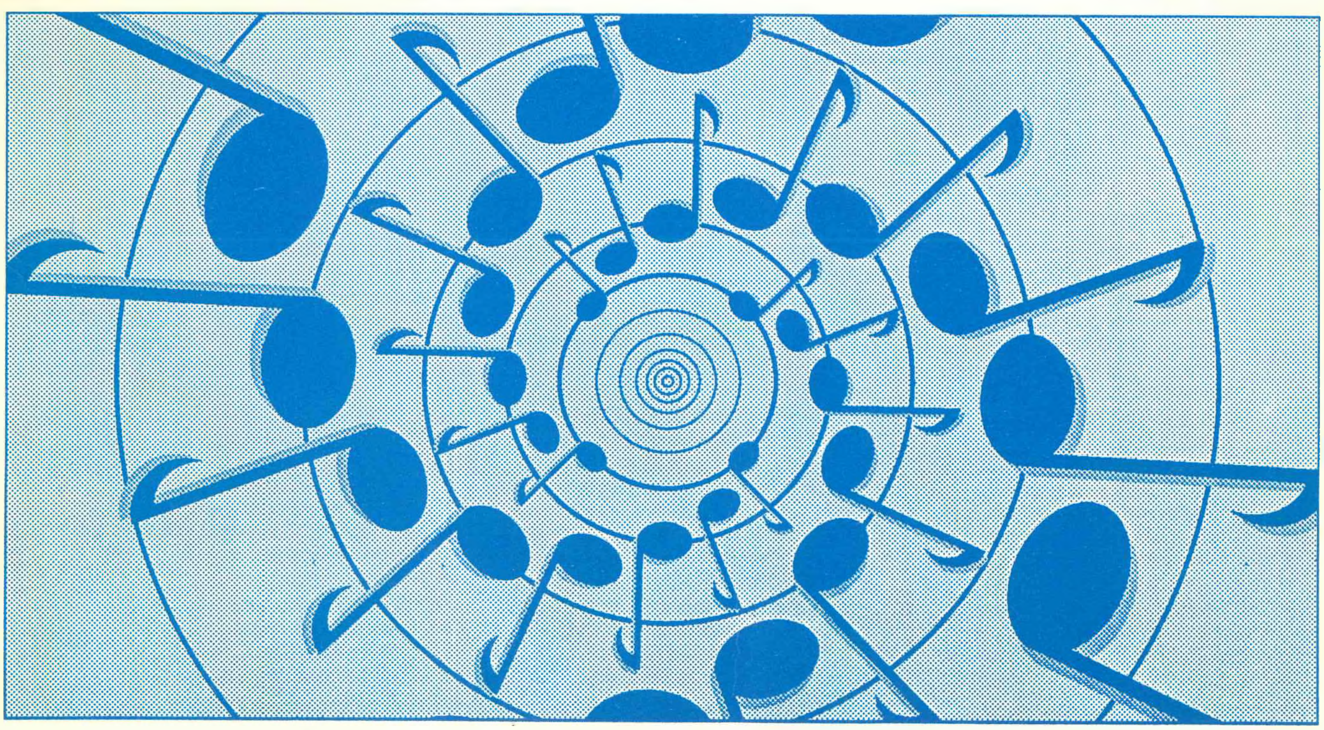

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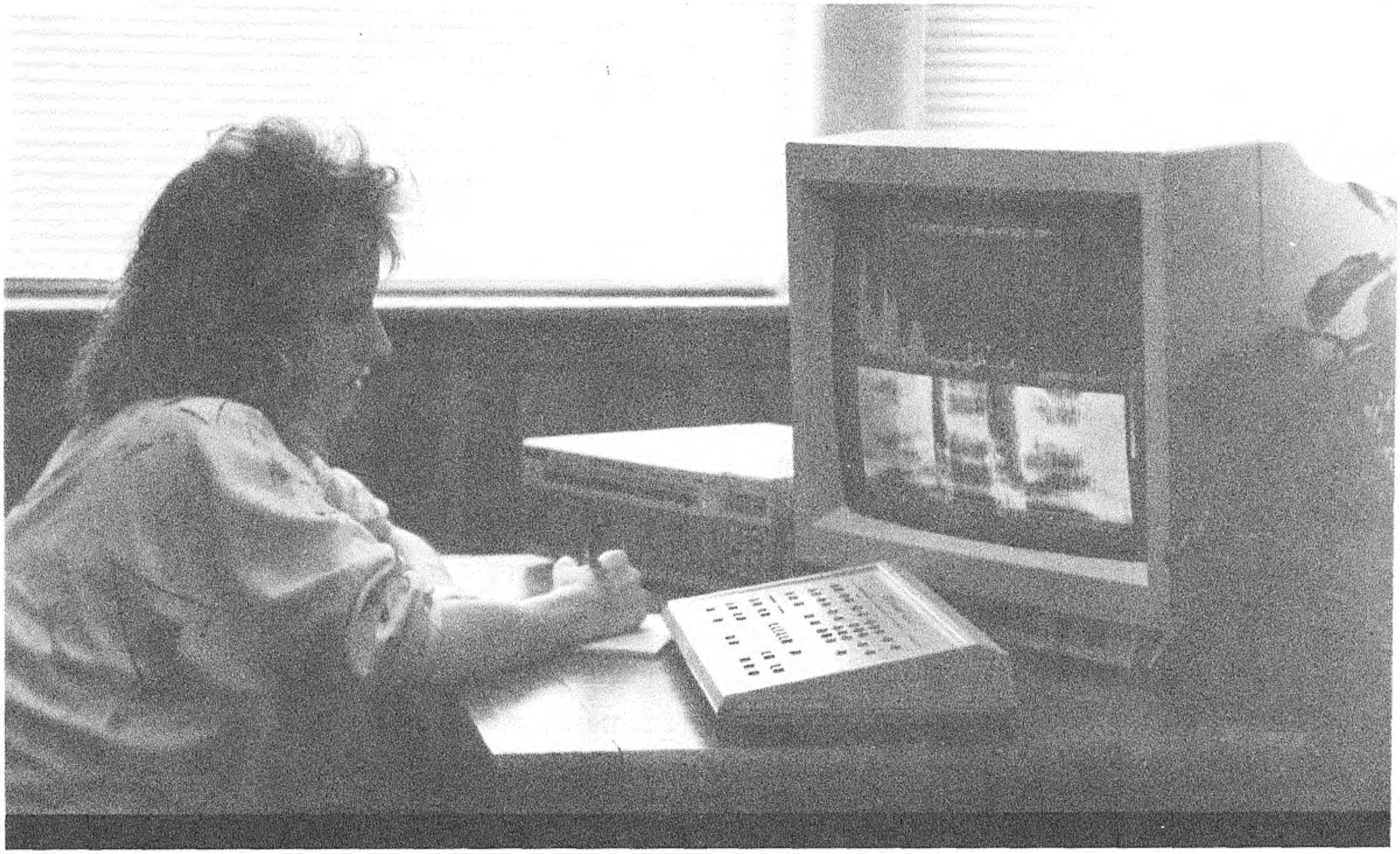
EDITORIAL

L'équipe de rédaction de l'Acoustique canadienne est heureuse de présenter un article de recherche dans le domaine de la psycho-acoustique appliquée à la musique. Il s'agit d'un domaine encore faiblement représenté dans les rangs de l'Association et nous espérons ainsi susciter l'intérêt des chercheurs et professionnels concernés. Par ailleurs, ce numéro est un témoin particulièrement convaincant de la vitalité de notre Association. Le recrutement de nouveaux membres, les activités d'un nouveau chapitre local et le programme détaillé du symposium dans le cadre de la *Semaine de l'acoustique*, sont très éloquents à cet égard. A propos du symposium, soulignons la contribution très variée de diverses disciplines et de plusieurs champs d'intérêt associés à l'acoustique. Il ne faut donc pas manquer le rendez-vous de la Semaine de l'acoustique à Toronto.

The editors of Canadian Acoustics are pleased to publish a paper in the field of psycho-acoustics and music. This area is still poorly represented within the Association and we hope to raise more *interest in our journal among* the professionals and researchers in this field. In other respects, the present issue is a convincing illustration of the vitality of our Association. Recruitment of new members, the meeting of a new local chapter and the program of the symposium of the Acoustics Week speak for themselves. Regarding the symposium, it is worth emphasizing the highly *varied contributions in various* disciplines and fields of interest related to acoustics. One should not miss the meeting of the Acoustics Week in Toronto.



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OCTAVE DISCRIMINATION: TEMPORAL AND CONTEXTUAL EFFECTS

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ABSTRACT

Discrimination of the musical octave was studied using the psychophysical method of constant stimuli. Stimuli were two successive pure tones whose ratio varied in discrete steps from 100 cents below to 100 cents above the physical octave of 1200 cents. Listeners judged whether each pair was flat or sharp with respect to a correctly tuned octave. Two measures were estimated for each of ten listeners. The first was a measure of sensitivity, the difference limen. The second was the subjective criterion for the octave, or that tuning judged equally likely to be sharp or flat. For two tones in immediate succession the results were in accord with previous investigations: the discrepancy between the subjective octave and the physical octave was typically in favour of a "stretched" subjective octave about 20 cents wider than the physical octave. However, the magnitude of the stretch decreased, and sensitivity of discrimination increased, when the two tones were separated either by silence or by two musically related tones—in this case, the notes of the equal-tempered major triad. The results suggest that the criterion for the subjective octave is influenced by context and by the listener's strategy. Thus, in music, a flexible choice of tuning criteria may be desirable.

SOMMAIRE

La discrimination de l'octave musicale a fait l'objet d'une étude psychophysique au moyen de la méthode des stimuli constants. Les stimuli étaient constitués de deux sons purs successifs dont le rapport variait par pas discontinus de 100 cents en-deça à 100 cents au-delà de l'octave physique de 1200 cents. Les sujets jugeaient si chaque paire était bémol ou dièse en fonction d'une octave correctement accordée. Deux mesures ont été obtenues auprès de chacun des dix sujets. La première était une mesure de sensibilité, soit le seuil différentiel. La seconde était le critère subjectif pour l'octave ou l'accord jugé de façon équi-probable comme étant dièse ou bémol. Pour deux sons se suivant immédiatement, les résultats étaient en accord avec les études antérieures: la différence entre l'octave subjective et l'octave physique était généralement en faveur d'une octave subjective "étendue" d'à peu près 20 cents par rapport à l'octave physique. Cependant, l'ampleur de l'extension diminuait et la sensibilité de la discrimination augmentait lorsque les deux sons étaient séparés soit par un silence soit par des sons interreliés musicalement—dans ce cas, les notes de la triade majeure également tempérée. Ces résultats suggèrent que le critère de l'octave subjective est partiallement influencé par le contexte et par la strategie de l'auditeur. Ainsi, dans la musique, un choix flexible du critère accordable peut être désirable.

INTRODUCTION

Experiments have shown that the subjective musical octave is an interval somewhat wider than the physical octave of frequency ratio 2 to 1. That the subjective octave is stretched with respect to the physical octave is a finding that holds across variations in fundamental frequency, timbre and intensity (Sundberg & Lindqvist, I973; Ward, 1954), across levels of musical experience, and different methods of measurement (Dobbins & Cuddy, I982), and across cultures (Dowling & Harwood, 1986, Ch. 4). The extent of the stretch—about one-third of a semitone on the average—is nevertheless quite variable among listeners. In a previous report (Dobbins & Cuddy, I982), we noted a dispersion of individual estimates over more than a semitone, and commented upon the difficulties that would attend music performance if individual tuning preferences had to be taken into account. Obviously, the setting of tuning standards for performance involves a fair degree of compromise.

Even within a single listener, preferences vary, and the selection of a given musical intonation may reflect a compromise between conflicting influences (e.g., Hall & Hess, 1984; Terhardt, 1984). Makeig and Balzano (1982) suggest a number of possible factors influencing preference. One is that tuning preferences reflect the intentional effort of the performer to produce a variety of aesthetic effects. Another is musical context. Terhardt and Zick (1975) found that, for melodic passages, listeners preferred a physical intonation that was stretched as opposed to normal (in this case, equal-tempered) or contracted intonation. For harmonically rich passages involving complex spectral patterns, however, stretched tuning was judged to be the poorest of the three types studied. To account for these results, Terhardt and Zick suggested that interaction patterns between simultaneous harmonic components produce a subjective stretch (a concept included in later theoretical developments, e.g., Terhardt, 1979). Thus, adding a physical stretch would result in a percept that was "out-of-tune".

Specifically with respect to the octave, Ward (1954) reported that simultaneous (harmonic) presentation of component tones yielded a narrower estimate of the subjective octave than did successive (melodic) presentation of tones. Terhardt (1978) also noted this effect, and recent unpublished results in our laboratory were consistent: the harmonic frequency ratio 2:1 was judged a reasonably "correct" octave by listeners, while the melodic presentation of the same ratio sounded "flat" by comparison.

The musical implication is that there may be two standards for the subjective octave, both capable of exerting an influence on preferred tuning in musical contexts. When melodic judgments are made with reference to harmonic standards, a preference for stretched tuning will result. A wider melodic interval is needed to match, perceptually, a harmonic interval of the same physical ratio. If, on the other hand, melodic judgments are made with reference to melodic standards, they will be stretched to a lesser extent, or not at all. It is difficult, of course, to predict which standard will prevail in any given instance, but it seems reasonable to expect that the choice will be influenced by the availability of specific harmonic or melodic cues in the musical context itself.

The present experiment was an exploration of some of these musical notions within the experimental control and abstraction of a psychoacoustical paradigm. The purpose of the present experiment was to examine octave judgment in the presence of musically related tones--the tones of the well-tempered major triad. The melodic triad is a salient cue to tonal structure (Cuddy & Badertscher, 1987). It was thought that these tones, presented melodically, might therefore cue a melodic standard of judgment for the octave.

The psychophysical method was the method of constant stimuli and the method of parameter estimation was adapted from a solution proposed by Olson & Ogilvie (I972) and verified for the octave discrimination paradigm (Dobbins & Cuddy, I982). Two performance measures were estimated: the difference threshold, reflecting sensitivity of octave resolution; and the magnitude of the subjective octave, or that tuning equally likely to be judged sharp or flat. The Olson and Ogilvie model incorporates the traditional assumptions of signal detection theory as well as the assumption that the subjective metric is linearly related to the physical scale. The psychophysical function can be used to estimate the difference threshold and point of subjective equality in physical units (Dobbins & Cuddy, 1982). Another point made in our previous report is that a good fit of the model to the data implies a continuous function relating psychophysical and physical dimensions; thus a categorical model of musical interval perception (e.g., Siegel & Siegel, 1977) was not supported.

There were four experimental conditions. On each trial for each condition two test tones approximating the physical octave were presented, and the listener was asked to rate the sharpness or flatness of tuning. In the first condition, the two tones were presented in immediate succession as in our earlier study. In the second condition, the two test tones were separated by two interpolated tones. The interpolated tones, along with the first test tone, formed an equal-tempered major triad. The third and fourth conditions were experimental controls. In the third condition, the test tones were separated by a silent delay equal in duration to that of the interpolated tones of the second condition. In the fourth condition, the interpolated tones occurring between the test tones were mistuned with respect to the equal-tempered scale.

An example of the sequence of events for each of the four conditions is given in musical notation in Figure I. The example is given with the octave C5 to C6 as the test octave in all conditions (one octave below the actual frequency range used in the experiment). The first row of notation represents the events of a trial for Condition 1. The second row shows the interpolation of a descending major triad, in its first inversion, between test tones (Condition 2). The third row shows a silent delay, or musical rests, between test tones (Condition 3). The fourth row shows mistuned auditory material between test tones (Condition 4). Mistuning is represented by crosses over the notes.

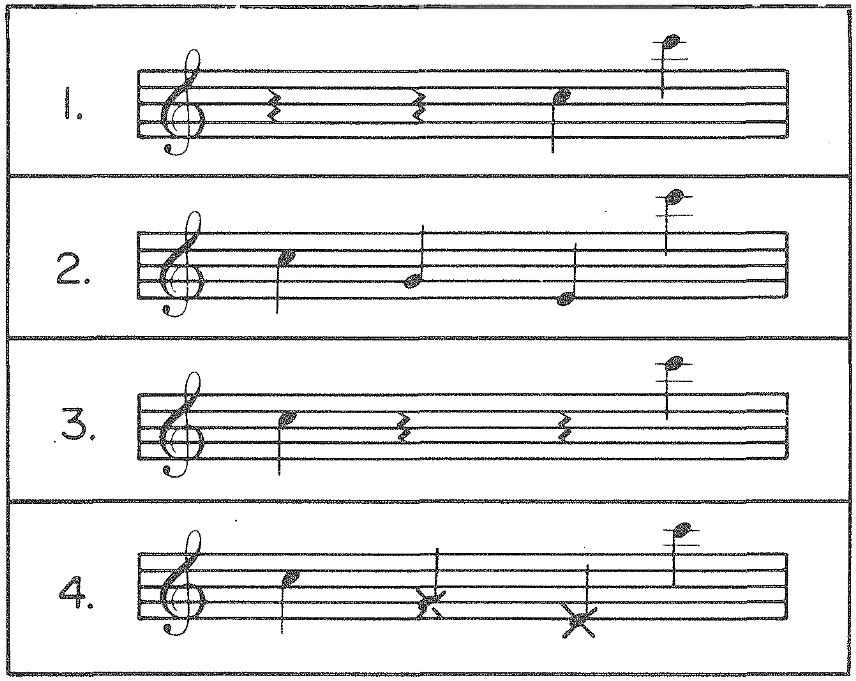

FIGURE 1. The sequence of events for each of the four experimental conditions. The musical notation is given one octave below the actual frequency range used.

METHOD

1. Listeners

The listeners were ten undergraduate students ranging from 20 to 24 years of age. All were either Bachelor of Music students or had taken university-level music courses, and all had achieved the Grade VI level of piano performance for the Royal Conservatory of Music, Toronto. Most were also equally proficient in at least one other instrument. Listeners were paid for their voluntary participation.

2. Apparatus

Stimulus tones were produced by a General Radio 1161-A coherent decade frequency synthesizer under the control of a Digital PDP8/I computer. All tones were sinusoidal with linear rise and fall times of 30 msec. The output signal was attenuated to 50 dB SPL by a Hewlett-Packard 350B attenuator set, and in turn fed to a Soundcraftsman 20-12 audio frequency equalizer, where levels were adjusted so that all tones were of equal subjective loudness.

Listeners were tested individually in a sound-isolated booth, and heard the tones binaurally through MB-300 headphones. Listeners made their responses by closing one of four touch-sensitive illuminated switches, which were labelled "very flat", "flat", "sharp", and "very sharp" in their left-to-right order on the response panel.

3. Stimuli

Each trial contained a 1-sec standard tone (S) and a 1-sec comparison tone (C). With the offset of C, a response light was illuminated on the switch panel, at which point listeners had 3 sec to respond before the next trial began.

For each trial, S was assigned one of three frequencies: 987.8 Hz, 1046.5 Hz, and 1108.7 Hz. These values correspond to B5, C6, and C#6, respectively, according to equal temperament rules and with A4 at 440 Hz. Within each block of trials, each value of S was paired with each of 11 different C-values, ranging from 1100 to 1300 cents above S in 20-cent gradations. (A cent is the 100th logarithmic division of an equal-tempered semitone.) Thus, S-C intervals ranged from one semitone below to one semitone above the physical octave (PO).

S-C intervals were presented within four contextual conditions as described in the text above and in Figure 1. The duration of each interpolated tone (Conditions 2 and 4) was 1 sec and the silent delay of Condition 3 was 2 sec. The two interpolated tones of Condition 2 formed along with S an equal-tempered descending interval of five semitones followed by an equal-tempered descending interval of three semitones. The two interpolated tones of Condition 4 were tuned 130 cents sharp and 160 cents flat from their respective counterparts in Condition 2.

A visual metronome was employed to eliminate temporal uncertainty on the part of the listeners. During each trial, a 0.5-sec light on the response panel flashed four times at 1-sec intervals, so that for Conditions 2, 3, and 4 the onsets of S and C would coincide with the onsets of the first and fourth flashes respectively. However, in Condition 1 trials, S and C onsets coincided with the third and fourth flashes, so that listeners would expect C immediately to follow S when the first two flashes were not accompanied by tones.

Each of the 33 S-C pairs (3 S frequencies by 11 S-C intervals) was presented three times under each of the four contextual conditions for a total of l32 trials per block. A basic block was permuted to produce three blocks of randomly ordered trials.

4. Procedure

All listeners were instructed to evaluate each S-C interval with respect to an octave, selecting the most appropriate response from the four available alternatives. No "correct" or reference octave was demonstrated to the listeners before or during the experiment.

Each session began with a practice block of 24 trials. This block contained all four contextual conditions, all three S frequencies, and six (1100, 1140, 1180, 1220, 1260, and 1300 cents) of the 11 S-C intervals. After their assurance that the instructions were understood, listeners heard the three experimental blocks in an order randomized for each listener, with 5-min breaks between blocks.

RESULTS

The data for each condition within each block for each listener were entered into a 11 x 4 confusion matrix (11 C-values by 4 response alternatives). A maximum-likelihood solution for parameter estimation was derived from a model proposed by Olson and Ogilvie (l972) for the method of constant stimuli with two or more response categories and implemented through the program MALCOS. The solution provides two theoretically independent measures of each listener's performance, reported in physical units of cents. The measures are the difference limen (DL), based upon one-half of the interquartile range of the response distribution, and the subjective octave (SO), or that tuning judged equally likely to be flat or sharp.

The data averaged across blocks and across listeners are given in Table 1. Table 1 shows for each contextual condition the DL in cents, the discrepancy in cents between the subjective octave and the physical octave, and the between-subjects standard error for each measure.

TABLE I. Mean DL and SO-PO in cents and between-subject standard errors (SE) for both means.

	Contextual Condition			
	1	2	3	4
Mean DL	42.1	29.3	32.5	44.7
Mean SO-PO	22.2	1.9	4.4	22.3
SE between-subjects for DL	4.6	3.9	5.0	4.4
SE between-subjects for SO-PO	8.4	4.6	6.2	9.1

The data show similar results for Conditions 1 and 4, and similar results for Conditions 2 and 3. Analysis of variance confirmed this observation. The main effect of condition was significant for both the DL ($F(3,24) = 8.17$, $p < .001$) and SO ($F(3,24) = 4.57$, $p < .025$) measures. Orthogonal contrasts within the effect of contextual condition indicated that the conditions in which S and C tones were presented in immediate succession or were separated by two mistempered tones did not differ significantly, nor was there a significant difference between conditions where well-tempered tones or a 2-sec delay separated S and C tones. But the latter two conditions, compared with the former, produced greater sensitivity of discrimination and less bias in favour of a stretched octave (for DL, $F(1,6) = 24.43$, $p < .005$; for SO, $F(1,6) = 15.57$, $p < .01$). Between-subjects standard error for the SO measure was also reduced in the latter conditions compared to the former. The main effect of blocks was significant, indicating a slight but significant linear trend towards greater sensitivity and reduced bias (for DL, $F(1,6) = 28.87$, $p < .005$; for SO, $F(1,6) = 6.32$, $p < .05$). There was no significant interaction, however, between blocks and conditions; the differences attributable to contextual condition held for each block of trials.

Condition 1 used the temporal parameters of earlier studies. The mean discrepancy of 22.2 cents in favour of a stretched SO in Condition 1 is close to the estimate of 22.5 cents for musically trained listeners with the method of constant stimuli (Dobbins and Cuddy, l982) and the estimate of 21.4 cents reported by Ward (l954) for a fixed S tone at 1180 Hz with the method of adjustment. In Condition 1, eight of the ten listeners were consistently biased toward a stretched SO ($p < .05$), and a ninth listener was similarly biased on two of the three experimental blocks.

Of the 120 matrices computed, 110 were found to fit the Olson and Ogilvie (l972) model according to a chi-square test of the difference between expected and observed response proportions, with p set at .01. Only three pairs of DL and SO estimates could not be obtained, due to response inconsistencies that occurred in the more difficult conditions. (Because of these missing values, degrees of freedom for the statistical tests reported above were reduced accordingly.) Inspection of the rejected confusion matrices revealed that listeners occasionally made reversal errors along the decision axis, e.g., would use the "very sharp" category for a comparison that was physically very flat. Such errors could be evidence of categorical perception: the listener detects the mistuning but the direction of mistuning is not discriminated (Siegel & Siegel, 1977). However, the reversal errors were relatively infrequent and could just as easily be attributed to lapses of attention.

ADDITIONAL EXPERIMENTS

Additional tests yielded the following supplementary information:

1. Three highly practiced listeners (the musically trained listeners from Dobbins and Cuddy (1982)) were also tested under all conditions of the main experiment. Discrimination was slightly more sensitive than the main experiment (average DL = 32.1 cents) and showed less variation with condition. The SO-PO discrepancy was 31.2 cents for the average of Conditions 1 and 4, but only 11.4 cents for the average of for Conditions 2 and 3. This pattern of results for SO-PO discrepancy replicates the pattern of the main experiment.

2. Four highly practiced listeners (different from the above) were tested under conditions where the S-C delay varied between 0 and 8 sec. No conditions involving interpolated tones were included. For three listeners, there was some evidence of improved sensitivity or reduced bias with delays of 1 or 2 sec. The effects were smaller and less reliable than in the main experiment, however. Ward (1954) earlier reported no effect from interpolation of a 1-sec silent delay between tones. These results suggest that the magnitude of the delay effect in the main experiment was due, at least in part, to the embedding of the delay condition with the condition containing the major triad.

   In a subsequent group discussion, the listeners from the main experiment agreed that the presence of the major triad seemed to make judgment easier. Many suggested that during the silent delay, therefore, they attempted to recreate a triadic structure from memory. In the presence of mistuned tones it was difficult to produce this auditory image. What the listeners emphasized was that the silent delay was accompanied by an active attempt to retrieve a musical cue.

3. Two listeners, highly trained both in music performance and with the psychophysical task, were asked to tune the subjective melodic octave with the psychophysical method of adjustment. The physical parameters were as in the main experiment, but here, on each trial, the listener adjusted a variable comparison tone to be one octave above the standard. On preliminary cuing trials, listeners heard a standard PO presented either harmonically or melodically and attempted to tune a melodic octave to match the standard. The octave to be tuned was located six semitones above the standard. Then, on half the experimental trials, listeners were asked to use the memory for a harmonic octave as the standard for tuning the melodic octave; on the remaining half, to use the memory for a melodic octave. For the first listener, the mean SO-PO discrepancy was 36.7 cents and 15.1 cents for harmonic and melodic standards respectively. For the second listener, the mean SO-PO discrepancy was 16.5 cents and -5.7 cents for harmonic and melodic standards respectively. Although the absolute values of the

discrepancy were quite different for the two listeners, the difference between the two conditions was about 20 cents for both listeners.

DISCUSSION

Our results suggest that listeners are capable of adopting two different criteria for the subjective melodic octave, criteria that differ by about 20 cents. The main experiment showed that for two temporally contiguous tones in the frequency region studied, the subjective octave was stretched from the physical octave. However, octave discrimination was enhanced and bias in favour of a stretched octave was reduced when the octave was presented in a tone sequence forming a well-tempered major triad. Listeners also tended to be in greater agreement when the triad was present, as evidenced by the lowered between-subject variability. These results suggest that it was the pattern of the major triad that influenced judgment. Had listeners merely tried to judge the interval between the third and fourth note presented in Condition 2, the preferred stretch for an interval of 20 semitones should have been obtained.

Convergence to the physical octave was also obtained in the main experiment when the two tones of the octave were separated by a 2-sec silent gap. The alteration in performance cannot be attributed merely to the temporal separation of the octave tones; with the gap filled with mistuned tones, there was no change in discrimination or bias. The results for the silent-delay condition, in conjunction with listeners' self-reports and the results of a supplementary experiment, suggest that listeners adopted a strategy of rehearsing the major triad during the silent interval. Such rehearsal was prevented, however, by the presence of mistuned interpolated tones.

In the main experiment, therefore, the equal-tempered major triad appears to have cued a reference standard for the subjective octave that was applied locally on specific trials (those generated from Conditions 2 and 3). Supplementary experiments suggested that such a standard was unlikely to be adopted, even during a silent delay, unless the listener was especially instructed to try to match a remembered melodic octave. It appears that a stretched subjective octave is the natural standard to adopt. However, it may be replaced by other standards in a rather flexible manner.

The good fit of the Olson and Ogilvie (1972) model again implies a continuous function for octave discrimination. Consequently, we reject categorical models that suggest musicians are unable to distinguish flat tuning from sharp. However, the concept of an octave category is useful where it defines a range of physical values that are acceptable members of the category. For individual listeners, there is probably a best or prototypic member of the category, exemplified by natural tuning preferences. (See Krumhansl (1983) for a similar description applied to the the tonal organization of musical pitches.)

Two contemporary models of pitch perception have incorporated the phenomenon of octave enlargement. Both models locate the origin of the stretch in the auditory system itself, not in familiarity with physically stretched intervals. For Terhardt (1978, 1979) octave enlargement is a by-product of speech perception. Due to nonlinearities in the auditory system, the harmonics present in voiced speech sounds are stretched, and these stretched percepts become the standards for judging musical intervals, including the octave. For Ohgushi (1983) the stretched octave is the result of systematic bias in the temporal pattern of firing in auditory neurons. Of the two, Terhardt explicitly attributes the stretch to the auditory processing of simultaneous harmonic components, and argues that successive tones provide an unaffected, direct, measure of pitch (Terhardt, 1978). Thus, though the stretch may arise through primary auditory processes, there is also a plausible basis for a second reference standard for the subjective octave.

The musical implications of our data must be approached with caution, because we need to know much more about how perception of isolated intervals applies to larger musical contexts of phrases and other musical structures. Nevertheless, some interesting ideas emerge. First, our data, and those of other investigators, suggest that a natural preference for a stretched interval will usually prevail. But, second, these preferences may be modified by context or by strategy. Certain musical texts may elicit these secondary preferences, as Terhardt and Zick (1975) have suggested. There are, as well, musical instances where maintaining consistent intonation may require special strategies. For example, suppose a melody in an unaccompanied soprano voice is followed by a voice in a different register taking its pitch cue from the soprano. Singers may prefer to preserve a stretched scale, but the idiosyncratic nature of the stretch will create difficulties with overall consistency. Therefore, a choirmaster/organist of our acquaintance, John Gallienne of St. George's Cathedral, Kingston, insists on training choristers to adopt a standard for tuning the subjective octave that, in his words, is "hard, cold and narrow". This percept arises from the melodic presentation of the frequency ratio 2:1, and Gallienne argues that it produces a more reliable standard than the naturally preferred stretch.

In conclusion, listeners are capable of modifying judgment of the subjective octave in the direction of the physical octave under appropriate cuing or rehearsal. Under such conditions, agreement among listeners is increased. Where convergence of intonation is a musical goal, it may make sense to emphasize listening to, and matching, melodic intervals. Generally, the results support the musical notion that, where feasible, a flexible but systematic choice of tuning criteria is desirable.

ACKNOWLEDGMENTS

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SOME COMMENTARY ON THE EVALUATION OF MUFF STYLE HEARING PROTECTION UNDER THE CANADIAN STANDARD

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ABSTRACT

The results of a comprehensive study on the evaluation of hearing protection devices are discussed with respect to the Canadian standard. Overall the Canadian standard is more realistic in its philosophy than are other standard rating schemes.

SOMMAIRE

Les résultats d'une étude extensive concernant l'évaluation des protecteurs individuels contre le bruit sont discutés en regard des dispositions de la norme canadienne. D'une manière générale, la norme canadienne comporte une approche plus réaliste que d'autres procédures normatives d'évaluation.

I. INTRODUCTION

The CSA Z94.2-1984 standard [1] for the evaluation of personal hearing protection devices (PHPDs) is a further attempt to produce a rating scheme which reflects the acoustic protection a user should expect from a particular PHPD. This standard, like the majority of others used in North America, Europe and Australia, is based on the Real Ear Attenuation at Threshold (REAT) technique. While there has been and continues to be a determined effort to develop an acoustic test fixture which would replace the subjective REAT tests, REAT is still believed to be the most representative of the actual situation. This is because it uses subjective testing. The results are the optimum expected because the highly controlled lab evaluations will not be duplicated in field use. It is believed that because of this subjective testing, with all its inherent difficulties, results obtained from different labs show wide variation [2,3,4]. While some variation is to be expected because of differences in the subjects and variations in the PHPD quality, it is also believed that ambiguities in the standard can allow biased results to be obtained while supposedly following the procedures given [5].

The CSA standard relies on the REAT test methodologies prescribed in ANSI S12.6-1984 [6]. However, there are several differences in the overall standards and the schemes used to rate PHPD effectiveness. Two major differences are:

1. The CSA requires that PHPDs undergo extensive preconditioning before being subjectively tested using the REAT technique. This preconditioning involves mechanical flexing, vibration and impact tests, thermal and pressure cycling as well as repeated soiling and cleaning of the head/protector interface seal. This is an attempt, for PHPDs which are reusable, to approximate the effects of a certain amount of field use as well as a durability test. This approach was adopted by CSA in an effort to help account for the fact that field attenuations do not approach the higher average values found in the laboratory

test situation [7].

2. The CSA attenuation rating of protectors uses a coarser classification system (A,B or C) compared to the Noise Reduction Rating (NRR) used for U.S. labelling. The ABC scheme is based solely on the mean laboratory values while the NRR derates this mean by two standard deviations. CSA derating is done by including correction factors in the selection of a PHPD for a particular noise environment. The CSA allows changes to be easily implemented in the derating while the NRR derating is locked-in to the standard deviations obtained in the laboratory. Should a lab find techniques which reduce its standard deviations, the NRR values would rise, however, the actual protection afforded in practice would not change [5].

A study on the evaluation of PHPDs applying CSA Z94.2-M1984 was conducted by Faulkner, Gough and Kiss [8]. No tests using this standard had been carried out on PHPDs in Canada prior to this study. Previously, CSA ratings were derived by reinterpreting the data collected elsewhere. The Mechanical Engineering Acoustics and Noise Unit (MEANU) study evaluated a cross section of commonly used muffs under the CSA standard and compared the results with the means and deviations reported by the manufacturers. In general these results were obtained following ANSI procedures. The study also evaluated several additional variables not specifically covered in the standard. These included (a) details of the psychophysical methods used to obtain REAT data, (b) specific procedures for the selection of the listening jury for the REAT data, and (c) the comparison of the REAT subjective data with objective data obtained on a acoustic test fixture (ATF) in accordance with specifications obtained in an earlier ANSI standard [9].

II. METHODS, EQUIPMENT AND SUBJECTS

A. Test Facilities

The REAT testing was done in a hearing research chamber with the audio stimuli provided by a computer driven audiometer. The entire installation, shown schematically in Figure 1, was designed to offer the maximum flexibility possible for the testing procedures. The system shown was used for screening potential subjects, performing pure tone audiometric studies of subjects and also programmed to measure binaural threshold using two different techniques.

The hearing research chamber was designed to meet the requirements of both ANSI standards [6,9]. This meant that the volume must be large enough to allow reverberation times (RTs) from 0.5 to 1.6 seconds depending on the frequency band. The actual results showed a maximum RT of 1.54 seconds at 500 Hz and a minimum of 0.50 at 8000 Hz. This chamber was operated inside the confines of a large (311 cubic meters) reverberation room so that the background noise inside the hearing research chamber would meet those required by ANSI. In fact the background noise was well below the minimums with a sound pressure level of 14 dB in the 125 Hz octave band which decreased to -7 dB at 1000 Hz and -3 at 8000 Hz.

These two binaural techniques, which presented filtered 1/3 octave band noise through loudspeakers, was completely carried out by computer prompting [10]. The first method was a modified version of the Hughson-Westlake method [11] where the ascending/descending increments were changed from 5/10 dB to 2/4 dB. The second method was a modified version of automatic audiometry. The

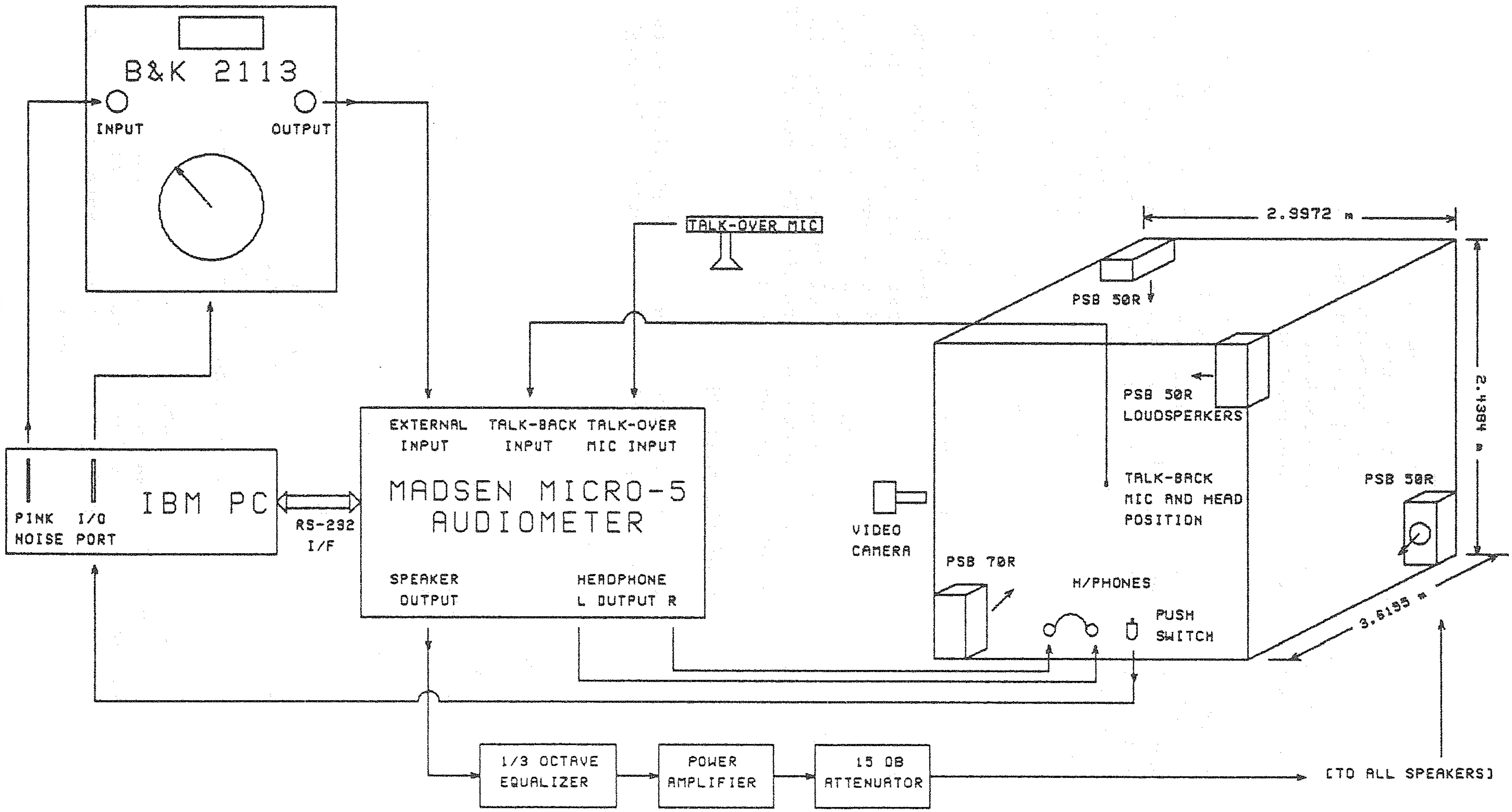

Fig. 1 Hearing Research Chamber Equipment Arrangement

pulsed tones were continuously presented and the sound level varied continuously in one dB steps (at a rate of 1 dB/second) either up or down depending on the subjects response to hearing the tones. Each test began with the 1000 Hz 1/3 octave band and then evaluated successively higher bands before beginning at the lowest band and increasing until the 1000 Hz band was repeated. This repetition of the 1000 Hz band allowed a check of the subject's response at the beginning and end of each threshold determination.

The resulting saw-tooth traces produced were interpreted according to the requirements in ANSI S12.6 [6]. In the case of the automatic method interpretations of the trace were made more restrictive than required by ANSI in two ways. First the range of excursions allowed (any peak to valley difference) was decreased from 20 to 12 dB. Second, the stipulation that any peak not be lower than any valley was further restricted so that any peak could not be within 2 dB of any valley. It is believed that these restrictions were possible because of the use of a lower rate of change in level (1 dB/second) compared with the CSA standard (5 dB/second) [see CSA Z107.4-M86].

The objective tests were done using an ATF built to ANSI specifications [9]. The ATF was installed in a large reverberation chamber 230 m^3 rather than the hearing research chamber. This was done because the sound reinforcement system was capable of producing the higher sound pressure levels required by ANSI. The physical attenuating properties of each cup of the muffs was measured by measuring the open (unoccluded) sound pressure level of the microphone compared to the level with the cup in position on the ATF. In order to evaluate the variations in attenuation measured on the ATF, several different measurements were made on one cup of several protectors.

B. Preconditioning of the Muff PHPDs

The CSA standard outlines a series of physical tests that muff-type PHPDs must be subjected to prior to REAT evaluation. The eight physical tests are:

1. temperature cycling
2. leakage
3. high temperature storage
4. low temperature impact
5. cleanability
6. vibration
7. suspension system durability
8. cold weather handling

A specialized vacuum chamber was constructed with a sealed removable lid. This chamber was placed inside an oven for heating and the oven inside a cold room which allowed all the temperature and vacuum tests to be done. Impact tests were done at -7°C (normal temperature applications) and did not include tests at -29°C which is specified for cold applications (cold weather handling).

The vibration tests were done on an electrodynamic shaker table, while the suspension durability was done on a servo-hydraulic testing machine. Cleanability involved ten cycles of first soiling and then cleaning the surfaces of the muffs of a vaseline/graphite mixture. More complete details of the extensive preconditioning are given by Faulkner et al [8].

C. Subject Selection and Testing

From an original group of 18 candidates, ten subjects were eventually selected on the basis of:

(a) achieving hearing threshold levels no better than -10 dB HL and no worse than 20 dB HL at all frequencies (in accordance with ANSI Standard S12.6) and,

(b) providing experimenter approved performance on a set of definitive criteria based upon the general descriptions for the selection of subjects in accordance with ANSI Standard S12.6 (3.4.2.2).

The criteria referred to in item (b) above were intended to provide a more definitive approach to the selection of subjects for REAT testing under laboratory conditions than those referred to in the ANSI Standard and alluded to in the Canadian Standard. Figure 2 presents a scheme for the selection criteria employed in this study. Our selection criteria were directed toward describing the behaviours of subjects at each of three phases of the REAT procedures; (a) initial screening of subjects, (b) conditions for participation in the project, and (c) monitoring of performance during the testing situation. As our intent in arriving at descriptions of subject behaviours was to be as objective as practically feasible under the three phases of the REAT procedures, we referred to our criteria as "pragmatic descriptors" of the subjects' behaviours. A rationale for this approach to subject selection, training, and monitoring under REAT testing procedures has been presented previously [12].

Under the testing schedule two subjects were alternated on each test day, providing a substantial rest period for each subject between test procedures. Each individual subject wore the same protector for the entire test. The attenuation threshold for each listener was based on measures of open thresholds made on three separate trials and on measures of occluded thresholds made on the same number of trials. The occluded and unoccluded trials were alternated. On each separate trial the hearing protector under test was refitted by the subjects under the supervision of the experimenter. All muff-type PHPDs were worn in the over-the-head position.

III. RESULTS AND DISCUSSION

A summary of the overall results obtained from the REAT evaluation of the PHPDs is shown in Table 1. Included are the NRR and CSA ratings given by the manufacturer or inferred from the data supplied by them. The data obtained during this study is broken down to indicate whether (a) the PHPD had been preconditioned (PC) or was as received (new) (b) the data was collected using the Hughson-Westlake (HW) method or the automatic (auto) procedure. For the Safeco 290, the PHPD was also retested after the subjects gained experience and the results are shown for both tests. As outlined above, the Canadian standard includes an extensive preconditioning procedure which is to be done before the REAT tests. This preconditioning, which in some respects is similar to the British standard [13], is not done in the ANSI procedure. The comments in Table 1 summarize the physical changes in the protectors which were noted after the preconditioning. For the PHPDs tested two of them showed minor damage which could lower their effectiveness. The other three were virtually undamaged as noted by visual inspections.

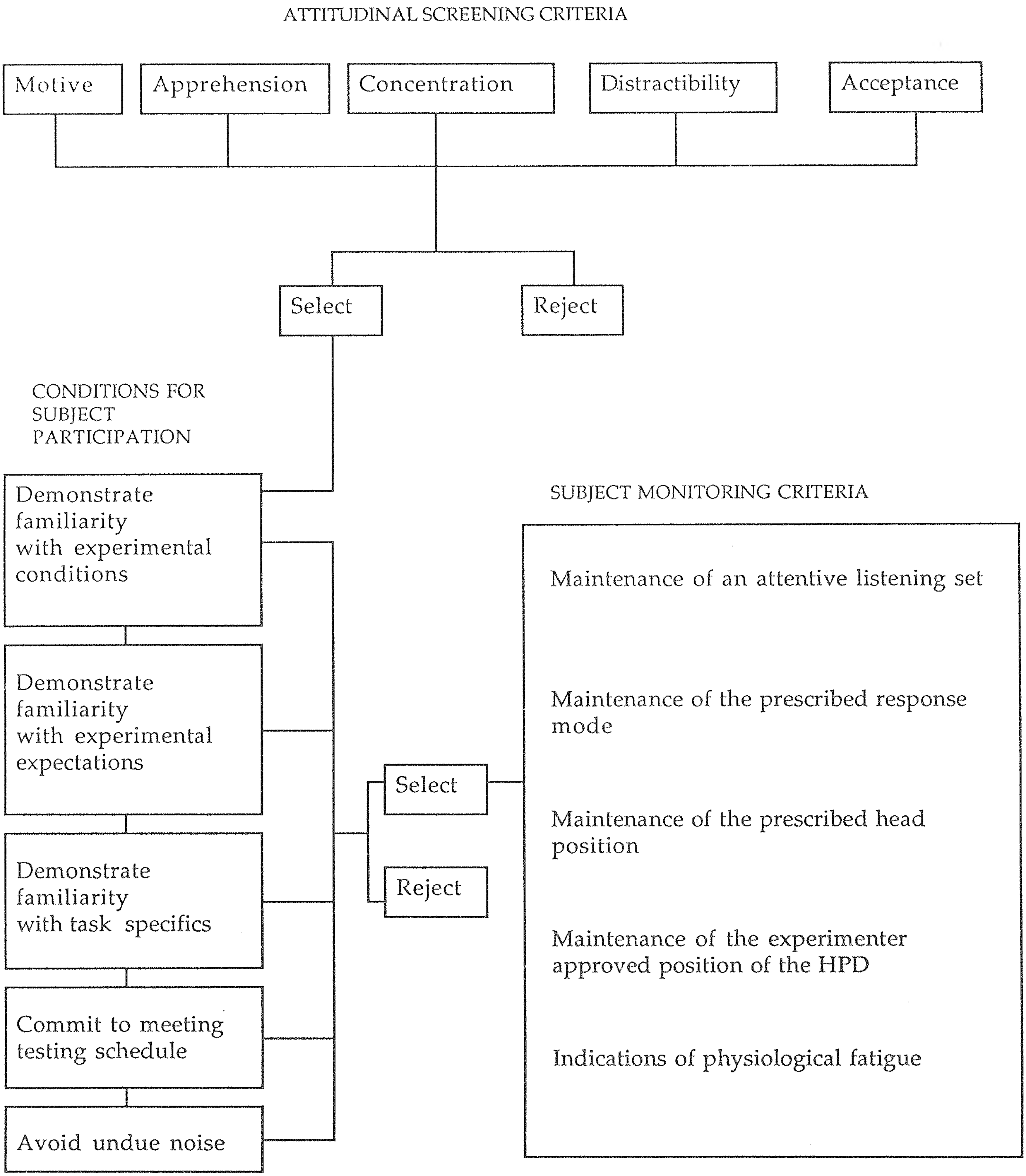

Fig. 2 Pragmatic Descriptors of Subject Behaviors

Table 1

Summary of Comparisons of REAT Test Data for PHPDs

PHPD	Manufacturer	REAT Data NRR	REAT Data CSA	MEANU REAT Data NRR	MEANU REAT Data CSA	Preconditioning Effects
Safeco 290	Safeco Manfrg	23	A			
PC/Inexp. Listen				22	A	Negligible
PC/Exp. Listener		23	A			
EAR 1000	Cabot Corp	24	B			
PC/H-W Method				20	B	Cushions wrinkled
PC/Auto Method				21	B	and slightly deformed
Bilsom 2315	Bilsom Int'l	24	A			
PC/H-W Method				19/20	B	Negligible-
New/H-W Method				19/20	B	headband
New/Auto Method				20	B	cushion became loose
Peltor H7A	Peltor Inc	27	A			
PC/Auto Method				25/26	A	One cushion
New/Auto Method				25	A	split
Hellberg No	Hellberg	24	AL			
PC/Auto Method				25	A	Negligible inner cup foam yellowed

All muffs tested in the over-the-head position

The results of the REAT data which compare new versus preconditioned muffs are shown in Figures 3 and 4 for two different muff manufacturers. Figure 3 was obtained using the Hughson-Westlake method while Figure 4 used the automatic procedure. The four points (2 for each test) which are shown at 1000 Hz are a result of the repeat of 1000 Hz 1/3 octave threshold at the conclusion of each subjective evaluation (see section II, subsection A). For both these PHPDs there is no clear indication of the new protector having either higher or lower attenuation than the preconditioned one. Even though at lower frequencies the new PHPD is generally slightly higher in attenuation than the preconditioned, this difference is well within the variations expected from the standard deviations of the data (see the lower curves in Figures 3 and 4). At the medium to high frequencies the data cross several times so that no trend as to which of the protectors exhibits better attenuation characteristics is shown. Overall there is no significant difference in the results.

A more detailed comparison of the new versus preconditioned muffs was done using the ATF. Shown in Figures 5 and 6 are the results when each side of two pairs of the preconditioned and two of the new protectors were evaluated. For each of the PHPDs, each of the two cups was evaluated 3 times for a total of twelve tests. Figure 5 shows the results for the Bilsom 2315 while Figure 6 is for the Peltor H7A. For the Bilsom the only statistically significant variations occurred at the high frequencies (3150-8000 Hz) as the variation between new and preconditioned was up to twice the standard deviation of the results. The Peltor H7A (Figure 6) showed less variation as all the differences were well within the experimental error. With the small differences between new and preconditioned

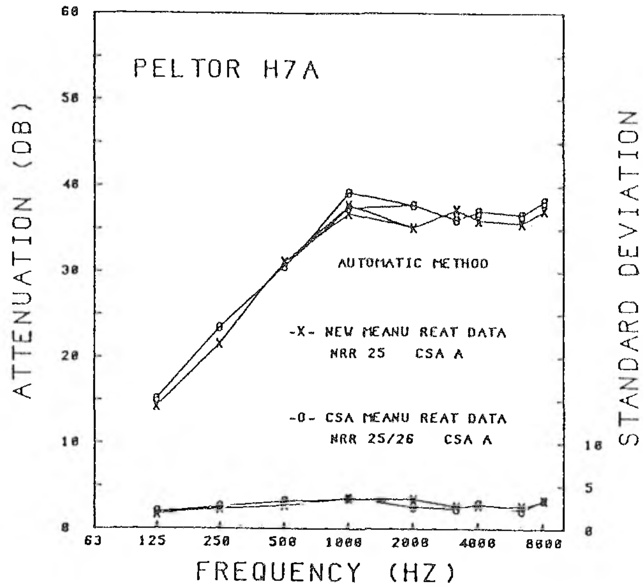

Fig. 3 Comparison of New Versus Pre-Conditioned Muffs by MEANU - Bilsom 2315

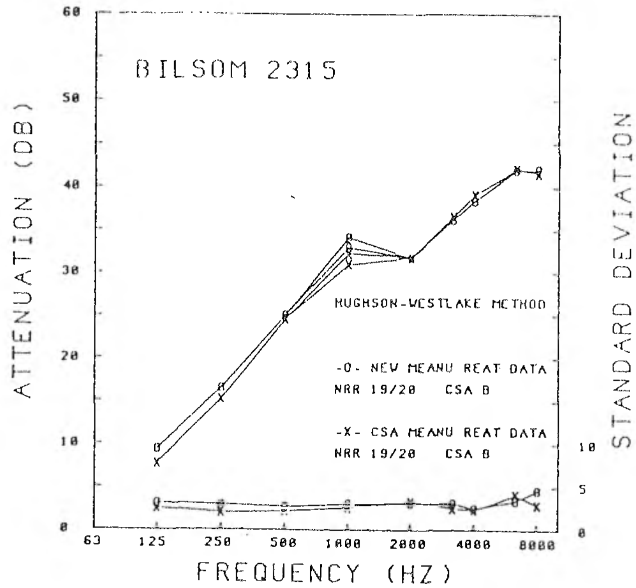

Fig. 4 Comparison of New Versus Pre-Conditioned Muffs by MEANU - Peltor H7A

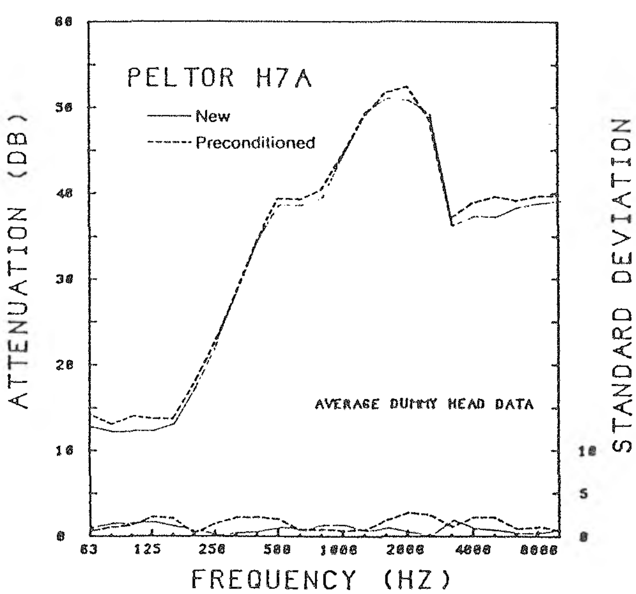

Fig. 5 Dummy Head Data - Bilsom 2315

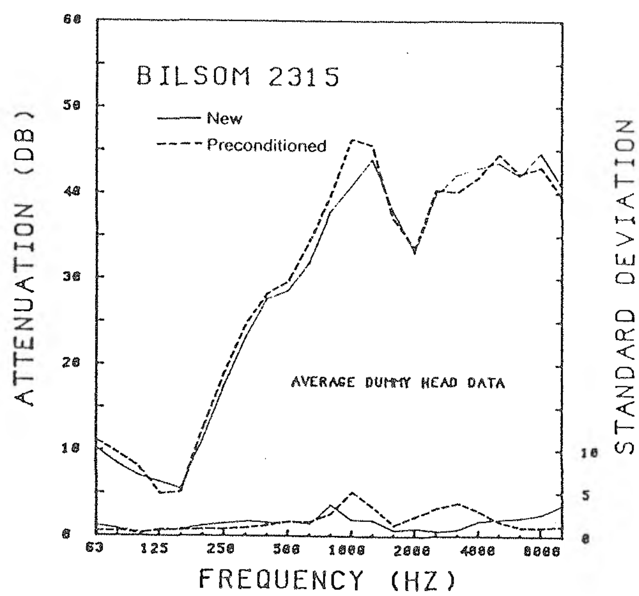

Fig. 6 Dummy Head Data - Peltor H7A

PHPDs shown on the ATF, it is not surprising that the REAT data is also quite consistent. The small physical changes which had bee noted during the preconditioning did not appear to cause any overall degradation of the subjective attenuation properties.

It is thought that the selection of subjects and the procedures used in determining their thresholds is responsible for much of the variations seen between labs evaluating the same PHPDs. In order to reduce certain of the variables associated with subject selection, the procedures outlined in section IIC were implemented. As a further check on consistency of each subject all threshold data began and ended with an evaluation at 1000 Hz. This was an attempt to ensure that the subject remained consistent over at least the one test. This retesting showed the subjects mean variation at the 1000 Hz band was 1 dB using the Hughson-Westlake procedure and 1/2 dB when using the automatic procedure. Even with this small variation in the REAT data there could be an overall change in a protector's NRR rating. (This is the reason that there are sometimes two NRR values given in Table 1).

A further check on the consistency of the subjects was done by retesting the first protector evaluated in the program. This meant that the same subjects evaluated the same PHPD after evaluating 4 additional protectors. The subjects were now more experienced since none had any previous experience as listeners prior to the first tests. The results of this test are shown in Figure 7 and indicate relatively little change in either the average attenuation shown or in the standard deviations of the results. It appears that the added experience did not affect the results under the testing procedures used.

A second variable, the audiometric procedure, was also investigated. The use of both the Hughson-Westlake and the automatic procedures with the same PHPD allowed a direct comparison of results obtained using the two techniques. Figure 8 shows no consistent variation in either the average values or the standard deviations obtained. This is true even though the subjects preferred the automatic procedure and it was consistently faster to administer. The subjects reported that they felt more involved in the testing when the automatic procedure was implemented. As mentioned previously, the retesting at 1000 Hz showed an increase of precision when the automatic procedure was used.

While it is easy to calculate the various ratings of PHPDs after the data is collected, it is important to appreciate what level of precision is actually possible. Figure 9 shows the mean of the standard deviations for 8 of the subjects used for the REAT tests and includes their individual results for all the protectors they evaluated. In general, this indicates that a standard deviation of less than 2 dB was not obtained except for a limited number of subjects. To attempt more precision than is indicated by these results would seem fruitless. PHPD rating schemes such as NRR using a 1 dB resolution are somewhat misleading.

To compare the variability of the REAT tests with those in the ATF measurements, a series of 10 measurements were made using one cup of a particular protector. The results of this test are shown in Figures 10 and 11 for two protectors. Overall the standard deviation is somewhat less than 1 dB but shows some frequencies which consistently have larger variations than others. This appears to occur when there are rapid changes in slope of the attenuation curve and are thought to be due to slight shifts in resonances in the muff/ATF cavity

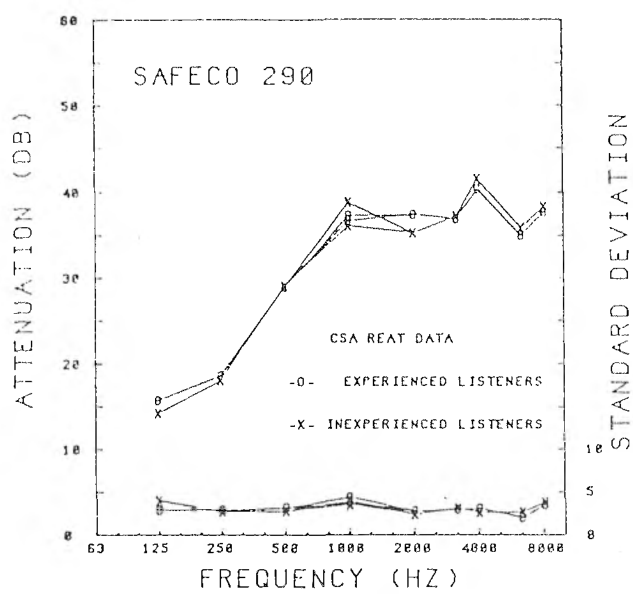

Fig. 7 Comparison of Experienced and Inexperienced Listeners for the SAFECO 290

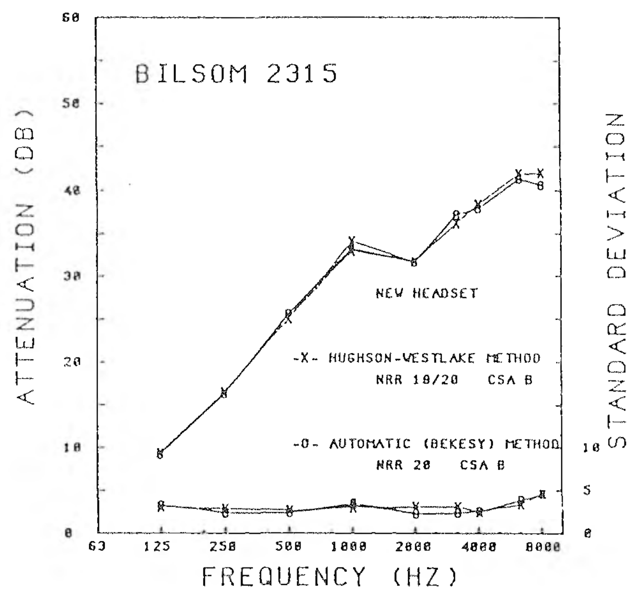

Fig. 8 Comparison of Testing Procedures for the Bilsom 2315

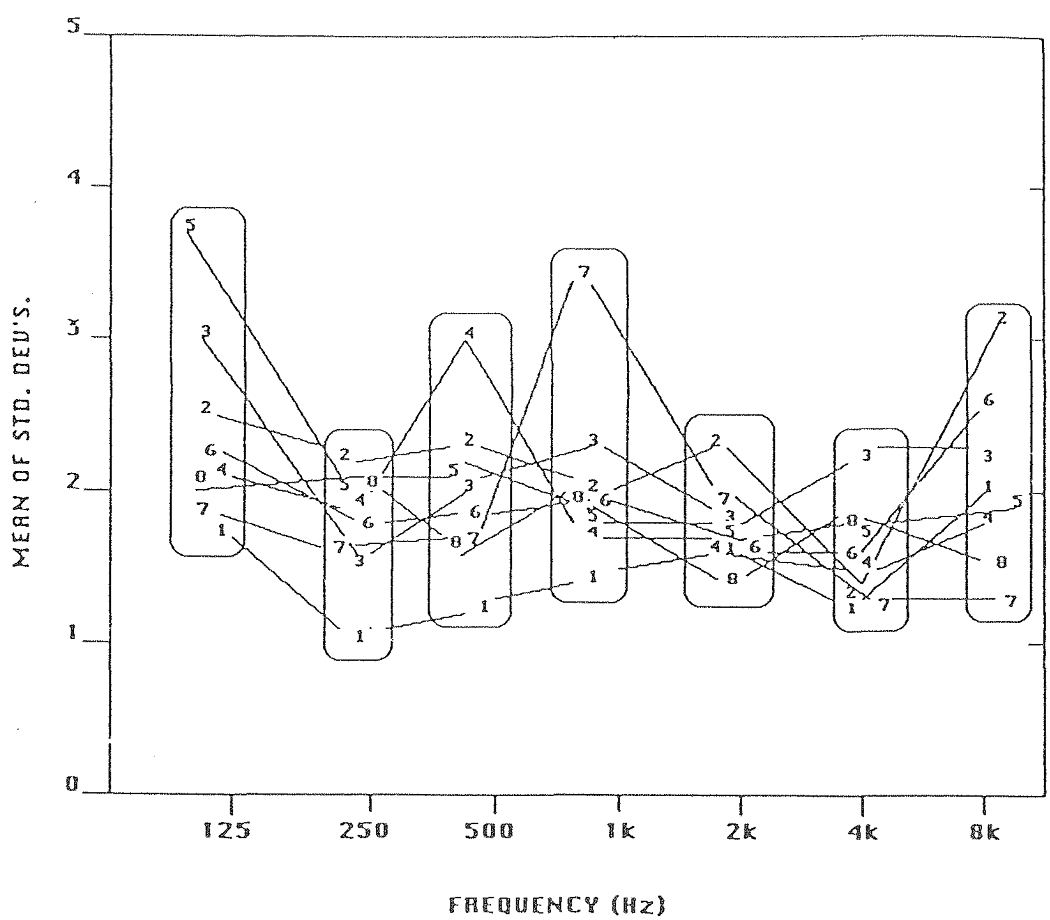

Fig. 9 Mean Standard Deviations for REAT Results for Eight Subjects Over Ten Hearing Protectors

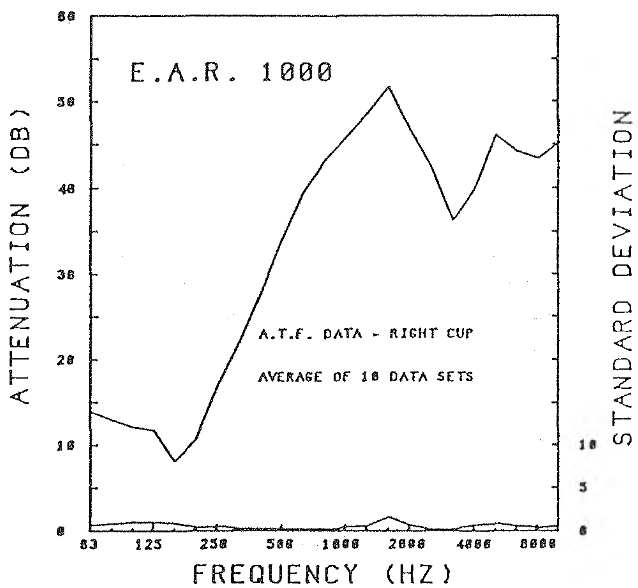

Fig. 10 Summary of ATF Data for E.A.R. 1000

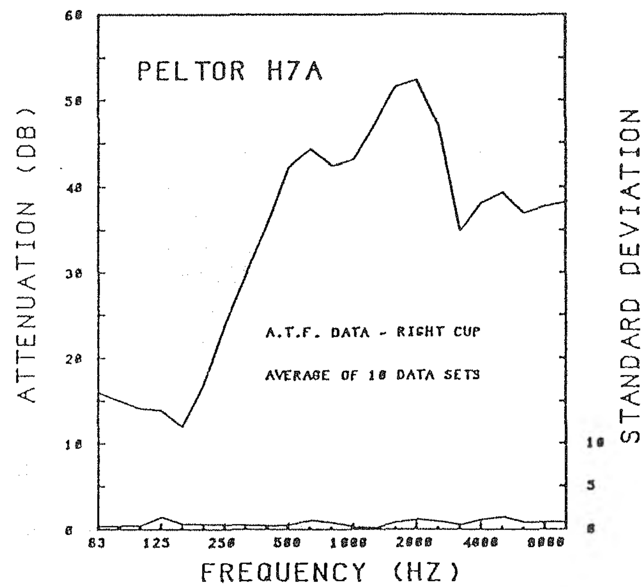

Fig. 11 Summary of ATF Data for Peltor H7A

which occur when the muff is repositioned before each measurement.

IV. SUMMARY AND CONCLUSIONS

This article describes the results of a study conducted to evaluate muff-type PHPDs in accordance with the Canadian standard CSA Z94.2-M1984, and its references to the ANSI standard S12.6-1984. Five PHPDs were pre-conditioned following CSA requirements and tested under REAT procedures described under ANSI S12.6-1984. The attenuation results for the pre-conditioned PHPDs under REAT conditions were compared with new units of the same makes and models of PHPDs in an "as-received" condition from the supplier. Ten subjects participated in the REAT testing procedures and were selected in accordance with a paradigm developed for the study and reported in detailed elsewhere [12].

Of the five PHPDs subjected to the CSA pre-conditioning procedures, two suffered damage which could impair the effectiveness of the units, while the remaining three PHPDs showed only negligible effects from the procedures.

To demonstrate the attenuation differences which might occur between "new" vs pre-conditioned PHPDs under REAT procedures, the results obtained for two different PHPDs were presented. No trend was apparent for the slight differences obtained for the "new" vs pre-conditioned versions for the two PHPDs tested.

A further comparison of the new vs pre-conditioned versions of the same PHPDs was carried out using the ATF described in ANSI S3.19-1974 (R1979). The results for two pairs of new and pre-conditioned versions of the same makes and models of PHPDs showed differences between the two versions which were generally within the experimental error expected for the tests.

Aside from the definitive approach to subject selection, referred to as pragmatic descriptors of subject behaviours, other procedures were introduced which were intended to reduce subject variability during the REAT testing conditions. These included retesting each subject at 1000 Hz during the REAT procedures to determine the reliability of the subjects' responses; retesting the first PHPD evaluated in the study after the subjects had acquired experience under the REAT conditions; and testing all subjects under two audiometric procedures (Hughson-Westlake and automatic audiometry) for one PHPD. The results for each of these procedures indicated no consistent variation in either the average values or the standard deviations obtained. However, the subjects' preference under REAT conditions was for the automatic audiometric procedure.

The mean of the standard deviations obtained for each of 8 subjects over all ten PHPDs under REAT conditions, was in the order of 2dB. This result indicates that the NRR use of a 1 dB resolution could be somewhat misleading.

The following conclusions may be drawn from the study:

1. Pre-conditioning muff-style PHPDs accordidng to CSA Z94.2 does not degrade the acoustic performance of the PHPDs.

2. It does not seem reasonable to use a rating scheme which differentiates between PHPDs on standard deviation values of less than 2-3 dB.

3. Automatic audiometric procedures should be standardized for REAT testing procedures.

4. Computer prompting in REAT testing permits increased precision in obtaining auditory thresholds.

V. ACKNOWLEDGMENTS

The authors wish to acknowledge the support of the Alberta Department of Community and Occupational Health who funded this project under the Occupational Health and Safety Heritage Grant Program (Grant 85-60R). Copies of the study report [8] can be obtained from this agency at 5th Floor, 10709 Jasper Avenue, Edmonton, Alberta, T5J 3N3.

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Point of View

A Network of Centres of Excellence in Acoustics? The Importance of Regional Chapters

Of possible interest to members of the Canadian Acoustical Association is the new federal program for the establishment of Networks of Centres of Excellence. The stated purpose of the program is to support leading-edge, fundamental, and long-term applied research of importance to Canada. As many as 20 "world-class initiatives" will be selected through a competition "administered by the Inter-Council staff acting on behalf of the Medical Research Council (MRC), the Natural Sciences and Engineering Research Council (NSERC) and the Social Sciences and Humanities Research Council (SSHRC) assisted by a panel of experts of international stature." Federal contributions to the program as a whole will be as much as 10 million dollars a year for four years.

The formal announcement of the program is dated June 30, 1988. The deadline for a letter of intent to apply is three months after that, and of the final proposal, only two months after that, November 30. One is struck by the short time between the announcement and the proposal, but it must be appreciated the program is designed to help existing Canadian strengths achieve even greater potential.

How many people working in acoustics will take advantage of this program? How many might have taken advantage? How many will be able to should similar opportunities arise in the future?

Previously, under the leadership of Dr. Edgar Shaw, members of the Canadian acoustics community joined forces coast-to-coast for a period of a few years to host an outstanding 12th International Congress on Acoustics in August, 1986. The Canadian research effort also at that time showed its international calibre in many fields. These precedents for cooperation and research excellence indicate to me the feasibility of a network of Canadian centres of excellence in acoustics.

The Canadian Acoustical Association aims to foster education, research, applications and employment in acoustics in Canada. I see the establishment of a network of Centres of Excellence in Acoustics overlapping in large part with the goals of the Canadian Acoustical Association. One stepping stone to reaching these goals is the development of regional chapters of the Canadian Acoustical Association.

Presently, there is a well-established regional Chapter in Toronto. A group has started to meet in Halifax. But what of Victoria, Vancouver, Calgary, Edmonton, Saskatoon, Winnipeg, London, Kingston, Ottawa, Montreal, Sherbrooke, Fredricton, Charlottetown and St. Johns? Do these regions have experts concerned with noise control, hearing impairment, audio engineering, physical and architectural acoustics? Are there students in these regions with similar interests? And in these regions are there unique acoustical strengths and problems found nowhere else in Canada? Could the people here involved in acoustics learn something from or teach something to their colleagues? Do they have mutual concerns? And do they have a few hours to give to a stimulating evening? Are addresses available of Association members in each region who could form a nucleus for a regional chapter? Positive answers to these questions provide the basis for regional chapters of the Canadian Acoustical Association.

Knowledge of the capabilities and needs of acousticians in one's own community, which would come about through a regional chapter, can have far-reaching implications. For example, suppose two professionals, A and B, working respectively in the areas of audiology and sound recording could well use the half-time assistance of a bright new graduate in engineering acoustics. Student C, a senior student in engineering acoustics, is unaware of A and B but knows that he can obtain a full-time position in engineering unrelated to acoustics in the region, or he can move to the United States for a position in an acoustics field there. He would prefer to work in acoustics where he is. Suppose A, B, and C, encounter each other at a regional chapter meeting. The consequence might be a full-time position for C and a decision not to change career, a collaborative project among ABC leading to a patentable application, local publicity drawing attention of the community at large to the importance of acoustics, a new interdisciplinary course in acoustics at the local university, increased municipal interest in noise control and hearing health, and so on.

Flourishing activity within a region generates the need to contact colleagues throughout Canada for advice and consultation. Returning to A, B, and C, they have new questions to ask and important original information to share. What they have discovered can assist D and E in other regions, and they need to purchase new instrumentation from X in Mississauga and Y in Vancouver and consult with Z in Winnipeg. The above scenario is one of any number of possibilities in which links established through a regional chapter might enhance local, and, perhaps ironically, national progress in acoustics.

Such a scheme of regional chapters might well help the acoustics community to prepare for large-scale federal funding programs in the future. With a system of regional chapters as a foundation, the Canadian Acoustical Association can begin to establish its own Network of Centres of Excellence program in acoustics.

This is the first year for a Canadian Network of Centres of Excellence program. It may not be the last. I understand that in the United States such a program is annual, and having begun, perhaps the Canadian government will continue its new program in some way. Regardless, we have only to benefit by further developing networks in Canada within the different branches of acoustics and within our major geographical centres[2].

Annabel J. Cohen

[1]For more information on the Centres program write Inter-Council Program Directorate, Networks of Centres or Excellence, 200 Kent St., Ottawa, Canada K1A 1H5 613-995-6010.

[2]Should you wish to establish a local chapter in your region please contact Annabel J. Cohen, CAA Membership Chair, Department of Psychology, Dalhousie University, Halifax, N.S. B3H 4J1 for materials that may be of assistance. Professor John McNulty, Department of Psychology, Dalhousie is thanked for comments on an earlier draft of this manuscript.

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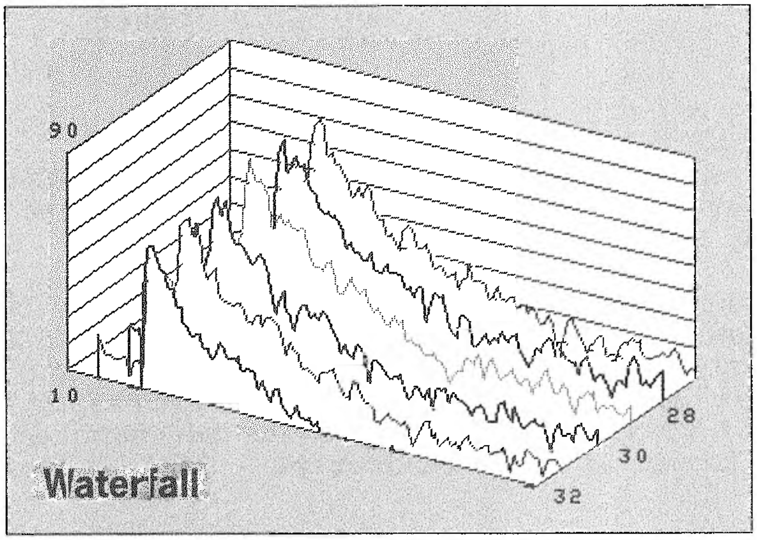

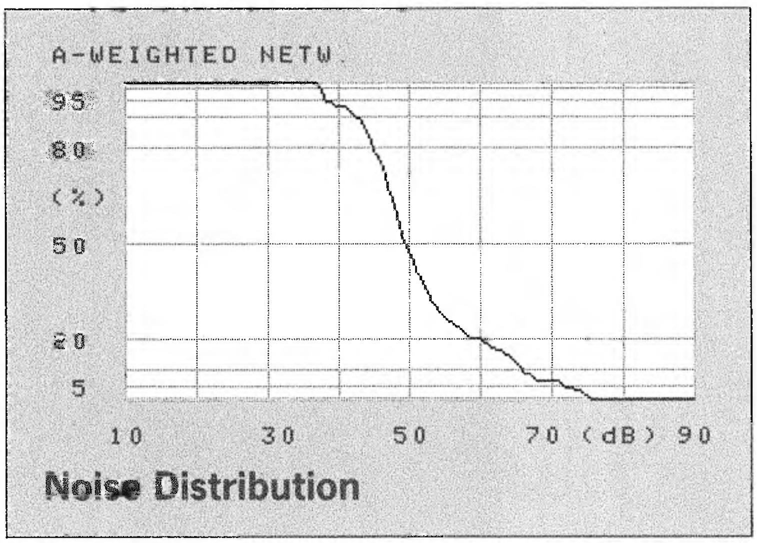

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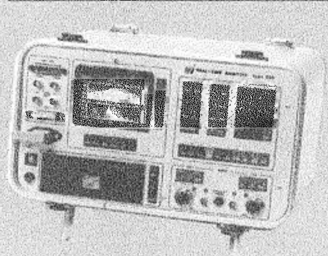

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DIRECTORS AWARDS - 1986

In order to promote submission of scientific papers in Canadian Acoustics, the Directors of the Association have decided to offer two $500 prices for the best paper published in the Journal in 1986.

The student prize has been given to **Mrs. Chantal Laroche** for her paper titled "Etude de l'effet du contenu spectral des bruits impulsionnels sur l'acquisition de la fatigue auditive".

The professional prize has been awarded to **Dr. Murray Hodgson** for his paper on "Factory sound fields - Their characteristics and prediction".

We are pleased to offer our congratulations to the winners. The 1987 awards will be given at the Acoustics Week next October. Good luck to all authors.

PRIX DES DIRECTEURS - 1986

Dans le but de promouvoir la soumission d'articles scientifiques dans l'Acoustique canadienne, les Directeurs de l'Association ont décidé d'accorder deux prix d'une valeur respective de 500$ pour le meilleur article paru en 1986.

Le prix étudiant a été décerné à **Madame Chantal Laroche** pour son article intitulé "Etude de l'effet du contenu spectral des bruits impulsionnels sur l'acquisition de la fatigue auditive".

Le **Dr. Murray Hodgson** a reçu le prix de la catégorie professionnelle pour l'article intitulé "Factory sound fields - Their characteristics and prediction".

Nous offrons toues nos félicitations aux deux gagnants. Les prix pour 1987 seront remis lors de la Semaine de l'acoustique en octobre prochain. Bonne chance à tous les auteurs.

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Report on the Inaugural Meeting
HALIFAX/DARTMOUTH REGIONAL CHAPTER
of the Canadian Acoustical Association
April 6, 1988

The inaugural meeting of the Halifax/Dartmouth Regional Chapter of the Canadian Acoustical Association took place April 6, in the MacAloney Room of the Dalhousie Arts Centre. The meeting coincided with the visit to Canada of Dr. Judy Edworthy from Britain. She reported her work on the Perceived Urgency of Advanced Auditory Warnings, demonstrating many "alarming" auditory examples. Linda Weilgart, of the Department of Biology at Dalhousie University, made a fascinating presentation on her dissertation research concerning sperm whale vocalizations. The acoustic material was gathered in her field work in the Galapogos Islands and her presentation was brought to life with slides accompanied by whale sounds. Finally, Dr. Larry Hendrickson, an engineer and audiologist in the School of Human Communication Disorders at Dalhousie, discussed New Developments on Hearing Aid Technology, including auditory prosthesis projects and novel compression amplification systems. (A summary of the presentations follows.) The occasion brought together people from the fields of music composition, physics, engineering, psychology, and medicine, and a lively discussion followed each talk and continued into the two coffee periods. The meeting was convened by Peter Terroux and Annabel Cohen. Another meeting is planned for September.

SUMMARY OF PRESENTATIONS AT THE HALIFAX/DARTMOUTH CHAPTER, APRIL

The Perceived Urgency of Advanced Warnings

Judy Edworthy, Ph.D.
Department of Psychology, Plymouth Polytechnic, Devon, UK

The effectiveness of a visual display depends not only upon the way the information is displayed, but on the simple requirement that the operator must be looking at it at the critical moment. Auditory warning signals, however, are routed through to the brain on a priority line regardless of the current activity of the operator. For this reason, auditory warnings are used throughout industry, hospitals, and transport vehicles to signal danger, or potential danger. Unfortunately, many auditory warnings have been installed on a 'better safe than sorry' principle which has resulted in them being too loud, too numerous, and confusing.

Scientists at the Medical Research Council's Applied Psychology Unit, Cambridge, and the University of Southampton's Institute of Sound and Vibration Research, headed by Dr. Roy Patterson, have designed sets of warnings for civil aircraft, military helicopters, and hospitals which largely overcome the commonly reported problems. These advanced auditory warnings are very different from the well-known horns, bells, and buzzers commonly in use, and the design of an auditory warning falls into three stages. In the first stage, the masked threshold of the environment is calculated, and the appropriate level for auditory warnings is predicted; in the second stage, a distinctive pulse of sound, lasting 100 - 300 ms in length and with at least four harmonic components weighted according to the background noise levels, is generated; in the third stage, a burst of sound is generated by playing the pulse several times at different pitches and amplitudes, and with varying time intervals between pulses. The burst thus resembles an atonal melody with a distinctive rhythm. The complete warning consists of several bursts with silent intervals between them to allow communication. The design process is controlled by a digital computer.

Part of the design process is to rationalise the warning system as well as improving the actual warnings. For example, the set of warnings designed for hospitals were designed under the auspices of the British Standards Institute, and are the warnings proposed in a draft British Standard on medical alarms. This draft standard attempts to reduce the number of auditory warnings in intensive care wards and operating theatres, and to make the warnings standard from hospital to hospital.

Warnings constructed according to Dr. Patterson's principles allow a wide range of warnings to be generated, because of the large number of parameters available at both the pulse, and the burst, level. This allows warnings to be tailored to the specific environment for which they are intended. In particular, warnings can be made as urgent, or as non-urgent, as required. A research programme in the perceived urgency of auditory warnings is being carried out at the Department of Psychology, Plymouth Polytechnic, headed by Dr. Judy Edworthy. The results of this programme should allow the designer of future auditory warnings systems to generate warnings varying in their levels of subjective ('perceived') urgency, and to generate distinctive warnings with approximately the same levels of subjective urgency.

The aim of the research programme is to find out which of the parameters available in generating auditory warnings (e.g. harmonic content of the pulse, or speed of the burst) affect the perceived urgency of the warning, how strong the effects are for each of the parameters, and the interactions between parameters. The paradigm being used is as follows: Two, or three, parameters are selected; as an example, the two parameters speed and pitch may be chosen. Two or three levels of each parameter are selected, and all possible stimuli are generated. The stimuli are presented to the subjects in a paired-comparison design based on the Youden square. The results reveal the rankings from the most to the least urgent of the stimuli, the consistency of within-subject and between-subject responses, and the spread of responses to individual stimuli. Subjects are also asked to estimate the urgency of each stimulus on a scale of 0-100, and these responses are subjected to analysis of variance.

A number of experiments investigating perceived urgency at both the pulse and the burst level have been carried out. Parameters investigated at the pulse level include envelope shape, regularity of the harmonic content of the pulse, fundamental frequency and the presence of delayed harmonics. Parameters investigated at the burst level include speed, rhythm, pitch, pitch range, pitch contour, musical structure and number of repetitions.

The results obtained thus far indicate that most of these parameters have strong and consistent effects on perceived urgency of both pulses and bursts. Some parameters produce more consistent effects than others, and some produce results that are counter-intuitive and surprising. The findings from this series of experiments will be used to produce a set of design principles intended for advanced auditory warning design in which the urgency of the warning is appropriate to the urgency of the situation being signalled. The research is supported by a contract from the Royal Aircraft Establishment, Farnborough.

Acoustics of Whale Vocalizations

Linda Weilgart, M.Sc.
Department of Biology, Dalhousie University

Sperm whales produce "clicks", and stereotyped patterns of clicks known as "codas". The clicks sperm whales constantly produce when not at the surface can be used, with the aid of a directional hydrophone, to follow whales day and night in a sailboat. The intricate sound production mechanism and system of the sperm whale was discussed, as well as the considerable sexual dimorphism seen in this species. Mature males produce distinctive-sounding clicks called "slow clicks" which are different from those of females and immatures. The repetition rate of these clicks is much slower than that of the usual clicks heard from groups of females and immature males. The pattern of emphasized frequencies as well as the repetition rate of slow clicks showed some individual differences between clicks of particular males, though these differences did not allow for positive identification of males by sound alone. All mature males emphasized frequencies of 1.8 and 2.8 kHz which were thought to represent resonance frequencies of the sound production organ. Finally, the social sounds of sperm whales ("codas") were compared to those of pilot whales, which emit whistles. The question was raised as to why sperm whales are the only social cetacean to emit clicks rather than whistles.

Developments in Hearing Aid Technology

Dr. Larry Hendrickson, Ph.D.
School of Human Communication Disorders, Dalhousie University

First, the speaker reviewed new developments in auditory prosthetic devices including conventional hearing aids and cochlear implants. Research was then summarized on the aspect of hearing aids known as amplitude compression or automatic gain control. Previous research by Braida and associates at MIT in the early 1980s had shown disappointing results with multichannel systems. The speaker's early work, conducted at Stanford University, included computer simulation of several compression systems. This work demonstrated the enchancement of speech intelligibility with single channel systems incorporating severe amplitude compression. A wearable, hard-wired unit was subsequently implemented and has also been evaluated on hearing-impaired individuals. The degree of benefit depended in part on the bandwidth of the transducers in the hearing aid. This unit has been applied to cochlear implants and the enhancement of telephone signals. Current research on compression systems at Dalhousie University, supported by NSERC, includes the evaluation of these devices on a KEMAR acoustic manikin with Zwislocki ear simulators in a non-reverberant chamber.

CAA - MEMBERSHIP UPDATE

Sharon M. Abel, Ph.D.
President, CAA

This past year your Board of Directors has implemented many changes for CAA. Our Journal has a brand new look, thanks to Raymond Hetu and the number of submissions is on the increase. We also have a number of new awards, due to the success of the 12th ICA and its satellite symposia.

Application forms for our first new award, the CAA Edgar and Milliscent Shaw Postdoctoral Prize in Acoustics, will be available by January 1989. Bruce Dunn and Lola Cuddy are currently working out the details but we expect that the value will be $6000, given in two equal annual installments of $3000. The second new award is the Bell Prize for graduate work in speech related research. Paul Mermelstein and Raymond Hetu have agreed to draw up the guidelines. As you are aware we already have in place two Directors' Awards of $500 each. These are for best papers published in the Journal each year by a full member and student of the Association. Nicole Lalande chairs a subcommittee to select the winners. Finally, three prizes of $500 each are given at our annual meeting for the best papers presented by students. The choice is made by the Local Planning Committee.

Our total membership is growing gradually in spite of the suggestion of our Executive Secretary, Moustafa Osman, to raise the fee to $20. As shown in Table 1 the total count is 392, an increase of 19 from May of last year. Of this increase, the breakdown in gain across categories is 12 for Members, -10 for Students, 5 for Subscription and 12 for Sustaining. Table 2 shows the distribution of Canadian members by Province. Five new members joined us in Alberta, 9 in Ontario and 8 in Nova Scotia. The last of these no doubt reflects the presence of our Membership Chairman Annabel Cohen. The distribution of non-Canadian members shown in Table 3 has remained about the same, although we have lost our representation in Hong Kong, China, Brasil and Australia. To some extent these have been offset by gains in France, Norway and Sweden.

On our annual renewal form we try to elicit some indication of area of interest. Ten areas are named and all members irrespective of membership category are asked to select three. Several people had a hard time with this, either choosing none or all ten. The results of the survey are presented in Table 4, which gives the area together with the number of times it was selected. The four most popular areas are Noise, Architectural Acoustics, Shock and Vibration and Psychological and Physiological Acoustics.

CAAs goal is to encourage interaction among individuals with interests in all areas of Acoustics. While the Board of Directors understands that many of you owe your primary allegiance to societies which are dedicated to particular target areas, we feel that CAA provides a unique opportunity to discuss your interests in a broader forum and to attract interdisciplinary contacts which might change your perspective in a positive way. CAA is <u>your</u> Association. Tell us what you're doing; let us hear your views. Phone me, contact your nearest representative on the Board, publish a paper, present a paper or write a letter to the Editor. The choice is yours!

Acknowledgement

I wish to express my sincere appreciation to Mrs. Dolly Razack for database management and for her considerable help with the membership analysis.

TABLE 1

CANADIAN VS NON-CANADIAN CAA MEMBERSHIP (04/29/88)

	Member	Student	Subscription	Sustaining	Sub-Total
Canadian	256	11	51	25	343
Non-Canadian	30	2	16	1	49
Sub-Total	286	13	67	26	392

TABLE 2

DISTRIBUTION OF CAA MEMBERSHIP BY PROVINCE (04/29/88

	Member	Student	Subscription	Sustaining	Sub-Total
British Columbia	18	-	6	1	25
Alberta	25	-	5	2	32
Saskatchewan	1	-	-	-	1
Manitoba	13	-	2	-	15
Ontario	141	4	25	13	183
Quebec	41	4	9	7	61
New Brunswick	4	-	1	-	5
Nova Scotia	13	3	3	2	21
P.E.I	-	-	-	-	-
New-Foundland	-	-	-	-	-
Sub-Total	256	11	51	25	343

TABLE 3

DISTRIBUTION OF NON-CANADIAN MEMBERSHIP (04/29/88)

	Member	Student	Subscription	Sustaining	Sub-Total
Britain	1	-	3	-	4
France	2	-	3	-	5
Germany	-	-	2	-	2
Norway	1	-	1	-	2
Sweden	1	-	-	-	1
The Netherlands	1	-	-	-	1
U.S.A.	24	2	6	1	33
U.S.S.R	-	-	1	-	1
Sub-Total	30	2	16	1	49

TABLE 4

DISTRIBUTION OF MEMBERSHIP BY INTEREST

Areas of interest	Total
Noise	234
Architectural acoustics	169
Shock and vibration	122
Psycho & physiol. acoustics	91
Electroacoustics	66
Speech communication	59
Musical acoustics	54
Underwater acoustics	51
Physical Acoustics	39
Ultrasonics	31

Membership Directory / Annuaire 1988

The numbers that follows each entry refer to the areas of interest as coded below.
Les nombres juxtaposés à chaque inscription réfèrent aux champs d'intérêt tels que codifiés ci-après.

Areas of interest		Champs d'intérêts
Architectural acoustics	1	Acoustique architecturale
Electroacoustics	2	Electroacoustique
Ultrasonics	3	Ultrasons
Musical acoustics	4	Acoustique musicale
Noise	5	Bruit
Psycho and pysio- acousitcs	6	Psycho et physio-acoustique
Shock and vibration	7	Chocs et vibrations
Speech communication	8	Communication parlée
Underwater acoustics	9	Acoustique sous-marine
Other	10	Autre

Duplicate entries means that more than one issue
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Jan. 18-20	Vancouver, B.C.	Machine Health Monitoring
Jan. 20-21	Toronto, Ont.	Noise Measurements
Jan. 27-28	Ottawa, Ont.	Noise Measurements
Feb. 9-10	St. John's, Nfld.	Machine Health Monitoring
Feb. 10-11	Thunder Bay, Ont.	Noise Measurements
Feb. 17-19	Edmonton, Alta.	Machine Health Monitoring
Feb. 24-25	Toronto, Ont.	Intensity Measurements
Feb. 24-25	Sherbrooke, Qué.	Mesures de vibration pour la maintenance prévisionnelle
Mar. 9-10	Cambridge, Ont.	Noise Measurements
Mar. 10-11	Prince George, B.C.	Noise Measurements
Mar. 15-16	Winnipeg, Man.	Noise Measurements
Mar. 22-24	Toronto, Ont.	Vibration Testing/Structural Analysis
Apr. 5-6	Vancouver, B.C.	Paper Machine Monitoring/Structural Analysis
Apr. 6-7	Ottawa, Ont.	Machine Health Monitoring
Apr. 6-7	St. John, N.B.	Machine Health Monitoring
Apr. 13-14	Timmins, Ont.	Machine Health Monitoring
Apr. 19-20	Montréal, Qué.	Essai aux vibrations et analyse modale
Apr. 21-22	Montréal, Qué.	Vibration Testing/Modal Analysis
Apr. 21-22	Edmonton, Alta.	Human Environment
Apr. 27-28	Toronto, Ont.	Advanced Acoustics
Apr. 28-29	Trois-Rivières, Qué.	Mesures de vibration pour la maintenance prévisionnelle
May 4-5	Ottawa, Ont.	Advanced Acoustics
May 4-5	Edmonton, Alta.	Noise Measurements
May 4-5	Val d'Or, Qué.	Mesures de vibration pour la maintenance prévisionnelle
May 10	Baie Comeau, Qué.	Mesures des nuisances de l'environnement
May 11	Québec, Qué.	Mesures des nuisances de l'environnement
May 13	Jonquière, Qué.	Mesures des nuisances de l'environnement
May 11-12	Thunder Bay, Ont.	Machine Health Monitoring

DATE	PLACE	TITLE
May 24-25	Montréal, Qué.	Intensity Measurements
May 26-27	St. John's, Nfld.	Intensity Measurements
May 25-26	Toronto, Ont.	Signal Processing
May 31 – June 2	Winnipeg, Man.	Machine Health Monitoring
June 1-2	Ottawa, Ont.	Signal Processing
July 6-8	Fort St. John, B.C.	Machine Health Monitoring
July 18-19	Vancouver, B.C.	Noise Measurements
Aug. 10-12	Edmonton, Alta.	Intensity Measurements
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CANADIAN ACOUSTICAL ASSOCIATION

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SEMINARS

MONDAY, OCTOBER 3
9:00 to 4:30
Lunch provided

Hearing Conservation and "Right to Know"
1-day seminar co-sponsored by
Industrial Accident Prevention Association

The seminar will consist of presentations describing the effects of occupational noise in the work place, hearing protection and testing, noise measurements, noise control, and the impact of proposed legislation.

Cost: $100 Member, $120 Non-Member Will attend _____

TUESDAY, OCTOBER 4
9:00 to 4:30
Lunch provided

Blasting Vibration and Noise
1-day seminar presented by
U.S. Bureau of Mines
and VME Associates Ltd.

Seminar focuses on research conducted by the Bureau of Mines into the generation, propagation, structural impacts, measurement and analysis of both ground vibration and air-blast from surface mine production blasts. VME Associates will describe monitoring case histories, problems encountered by explosive users, and solutions provided by advances in the explosive industry.

Cost: $100 Member, $120 Non-Member Will attend _____

OR

TUESDAY, OCTOBER 4
9:00 to 4:30
Lunch provided

Noise Control in Buildings
1-day seminar presented by
National Research Council of Canada
Institute for Research in Construction
Acoustics Section

The material to be discussed should be of particular interest to architects and others involved in the construction process who must deal with controlling noise within spaces and limiting noise transmission through floors, walls and other building envelope components.

Cost: $100 Member, $120 Non-Member Will attend _____

WEDNESDAY, OCTOBER 5
9:00 to 12:30
Traffic Noise Barriers
1/2-day seminar presented by
Ontario Ministry of Transportation

The purpose of the seminar is to present the principles relating to noise barrier requirements, construction and maintenance. Topics will include barrier design, material specification, barrier installation, and contractual and legal issues.

Cost: $ 50 Member, $50 Non-Member Will attend _____

For further information on seminars, please contact:
Victor Schroter
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135 St. Clair Ave. W.
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WORKSHOP/TECHNICAL TOUR

WEDNESDAY, OCTOBER 5
Transportation provided

8:00 a.m. Bus leaves Hotel for York University

9:00 a.m. **Sound Level Measurement Workshop**
1/2 day workshop sponsored by
Larson Davies Laboratories

The workshop will provide hands-on demonstration of a wide range of sound level measuring instrumentation, ranging from dosimeters to real time analyzers.

12:30 p.m. Tour and demonstration DACARY Hall
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LUNCHTIME CONCERT
Spouses are Welcome.

Cost: Nil Will attend ______

For further information on Workshop and Concert, contact:
John Hemingway
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1:30 p.m. Bus leaves York University and Westbury Hotel for Ontario Hydro Research Laboratory

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Cost: Nil Will attend ______

Any inquiries regarding this tour should be addressed to:

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1988 SYMPOSIUM

Thursday, October 6
9:00 - 12:00 a.m.

Auditory Neurophysiology
Industrial Noise
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Will attend ______

12:00 Lunch

1:00 - 4:00 p.m.

Mechanical Vibration
Hearing Conservation
Environmental Noise
Studio Audio Room Acoustics

Will attend ______

Friday, October 7
9:00 - 12:00 a.m.

Building Acoustics
Hearing Protection
Clinical Management of the Hearing Impaired
Musical and Psychological Acoustics

Will attend ______

Cost: Members $100. Non Members 120.
This fee covers both Thursday and Friday.

Papers will be given on all areas of acoustics, speech and hearing sciences, and may be of an applied nature or be the results from basic research.
Any enquiries regarding the technical programme or workshops should be made to:

Alberto Behar	OR	Tim Kelsall
Chairman, Technical Programmes		HATCH ASSOCIATES
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Three awards of $500 each will be given for the best formal papers presented by students. In addition, the best papers, with permission of the author(s), will be published in "Canadian Acoustics'. Those who desire this should submit a letter giving permission at the time they send in their complete paper.

EXHIBITION

Thursday	9:00 to 5:00
Friday	9:00 to 12:30

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For enquiries re availability, access to, etc. of exhibition space at the Westbury, please contact:

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CAA ANNUAL MEETING, RECEPTION & BANQUET

THURSDAY, OCTOBER 6	Westbury Hall
4:00 to 6:00 p.m.	CAA General Meeting
6:00 to 7:45 p.m.	Reception
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Number attending _____

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Wednesday a.m.			
Traffic Noise Barriers	$ 50.	$ 50.	_____
or			
Sound Level Measurement Workshop	N/C	N/C	
Wednesday p.m.			
Dobson Research Laboratory	N/C	N/C	
Thursday a.m. & p.m. plus Friday a.m.			
Symposium	$100.	$120.	_____
Thursday			
Banquet (per person)	$ 40.	$ 40.	_____
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CONFERENCE ACCOMMODATION
Delegates are responsible for making their own arrangements or hotel accommodation and travel arrangements. Reservation request forms are enclosed for those residing outside of Toronto. If you reside in Toronto and would like Hotel accommodation, please contact Francine Parry. All conference activities will be held at the Westbury Hotel with buses provided for visits to off-location sessions.

THE CANADIAN ACOUSTICAL ASSOCIATION/
L'ASSOCIATION CANADIENNE DE L'ACOUSTIQUE

ACOUSTICAL WEEK/
SEMAINE DE L'ACOUSTIQUE

3 - 8 OCTOBER, 1988

PROGRAM OF THE SYMPOSIUM/
PROGRAMME DU SYMPOSIUM

THURSDAY MORNING, 6 OCTOBER 1988

SESSION: **AUDITORY NEUROPHYSIOLOGY**

Chairperson

Robert V. Harrison
Otological Research, Hospital for Sick Children and Department of Otolaryngology and Physiology, University of Toronto

Intensity coding in the auditory midbrain of the leopard frog.

Jos J. Eggermont, Department of Psychology, University of Calgary, Calgary, Alberta

Thresholds and rate-intensity functions were studied from tone-pip stimulation in 69 units recorded from the torus semicircularis of the leopard frog. Thresholds varied widely within and across animals (range 26-90 dB SPL, mean 63 dB, SD 15 dB): it was not uncommon to record from two units simultaneously and find thresholds differing by 30 dB. Rate-intensity functions were obtained at all frequencies within the response area. Some units had a best intensity, other units had a monotonically increasing rate-intensity function. Dynamic ranges also varied widely between units (but not within). Thresholds and rate-intensity functions were especially compared at the two characteristic frequencies of double tuned neurons. Differences with findings in mammals will be discussed. The intensity behavior for tone pips will be compared to that for "Wiener-kernels" obtained for random click stimulation, permitting an analysis of the intensity coding differences between narrow band and broad band signals.

The effects of total deafness on the cellular structure of the cochlear nucleus.

C.E. Fleckeisen, R.V. Harrison, Hospital for Sick Children Department of Otolaryngology and Physiology, University of Toronto

To determine the effects of total sound deprivation on the cochlear nucleus we are measuring various morphological parameters in an animal model of profound deafness. New born and adult chinchillas weere treatedd with high doses of amikacin (aminoglycoside antibiotic that destroys all or most coclhear hair cells) to produce models of adulthood. Total deeafness is confirmed by the disappearance microscope studies confirm extensive hair cell degeneration. The brainstems of the experimental animals are sectioned sagittally and prepared according to the Nessl method. Slides are coded to avoid observer bias. Regions of specific cell types are outlined on specimen photomicrographs using a digitizing pen and tablet. Multiplying these area results by intersection intervals yields regional volum measurements. Counts of the major cell types are made on selectedsections and cell densities are calculated. High magnification photomicrographs are made of typical examples of the cell types from which cellular cross-sectional areas are measured. The morphological changes observed which result from total deafness will be discussed.

The distribution of FM sweep selectivity within cat primary auditory cortex (AI).

J.R. Mendelson (1), C.E. Schreiner (2), L.L. Grasse(3), and M. Sutter (2). (1) Dept. of Physiology, University of Toronto, Toronto, Ontario, (2) Coleman Laboratory, Dept. of Otolaryngology, UCSF, San Francisco, CA, (3) Dept. of Psychology, York University, North York, Ontario.

Previous studies have shown that cells in cat AI are sensitive to the direction and/or speed of FM sweeps. In the present study we determined how these response properties were distributed across the cortical surface. FM responses were investigated in 9 anaesthetized cats using computer-controlled exponential FM sweeps changing from low to high (upward-directed) or from high to low (downward-directed) frequencies betwwe 0.2 and 64.0 kHz presented at 3 different rates of frequency change (speed). In dorsal and ventral subregions of AI, units preferred upward-directed FM sweeps, while in central AI units preferred downward-directedd FM sweeps. Speed selectivity also showed a distinct spatial distribution such that cells preferring faster speeds (F) were encountered in the most dorsal and ventral aspects of AI while cells preferring slower speeds (S) were found in the central region. Medium speed (M) selective cells were found in between the fast and slow subregions along the dorso-ventral axis (i.e., in the following sequence; F-M-S-M-F). The spatial distribution of FM response properties appeared to be orthogonal to that of characteristic frequency. The orderly arrangement of FM responses suggests that sensitivity of FM sweeps is an important aspect of the functional organization of AI.

Human evoked potentials to changes in the lateralization of a noise

Terence W. Picton, Linda K. McEvoy, Adrian J.C. Kellett, S.C. Champagne and J.B. Kelly (Human Neurosciences Research Unit, University of Ottawa, Ottawa, Canada, K1H 8M5)

A continuous noise was generated by running a sequence of random numbers through a digital-analog converter and connecting the output through an amplifier and filter to an earphone. Two channels were programmed to generate identical noise-stimuli with one channel delayed relative to the other. When these stimuli were presented through earphones, the subject heard a noise that was lateralized to the side receiving the leading stimulus. Changes in the relative timing of the two stimuli caused the noise to shift its lateralization. These shifts occured without any detectable change in the ongoing monaural noise. Any potentials evoked by these shifts were therefore specifically related to binaural interaction. The response recorded from the vertex contained a negative-positive complex with peak latencies of 140 and 225 ms. The amplitude of this response increased with increasing the interval between the shifts in much the same way as the N1-P2 response to the onset of a sound. The response increased in amplitude with increasing shifts in the interaural delay, and decreased if the intensity of the stimulus in one ear was 40 dB less than the intensity in the other ear.

Contralaterally stimulated oto-acoustic emissions.

K. Tough and H. Kunov, Institute of Biomedical Engineering, University of Toronto

The detection of ipsilateral stimulus frequency oto-acoustic emissions has typically invloved assumptions about the acoustic linearity of the ear impedance, the nonlinearity of the emissions, and of the phase relationship of the emissions to the stimulus. An experiment was designed for detecting the existence of an active physiological source at the contralateral acoustic stimulus frequency. This novel method relies of the principle of acoustic reciprocity and avoids the problems inherent in the above assumptions. The results of the experiment carried out on normal subjects is discussed, with specific reference to the relationship between spontaneous oto-acoustic emissions and contralaterally stimulated emission effects.

The Effects of Central Auditory Nervous System Lesions on Patients' Auditory Processing of Frequency and Duration.

Thompson, M.E. (1), Abel, S.M. (1), & Freedman, M. (2)
(1) Department of Otolarngology, Mount Sinai Hospital, Toronto, Ontario (2) Baycrest Centre for Geriatric Car, Toronto, Ontario

The performance of four groups of patients with lesions localized to the right temporal lobe, left temporal lobe, brain stem, and eighth nerve was compared using three psychophysical tasks. These included detection, frequency discrimination, and duration discrimination. Speech perception was measured using the Four Alternative Auditory Feature Test. All subjects with the exception of patients with acoustic neuromas had normal hearing acuity. The patients were compared to a group of age-matched normal control subjects and hospitalized control subjects. Performance deficits demonstrated by patients with lesions in the central auditory nervous system were dependent on site of brain lesion, verified by CT and/or MRI scans. The relationship between nonlinguistic auditory processing of frequency and duration and these patients' speech percetion will be discussed.

Neural Machanisms of Auditory Localization In The Saw-Whet Owl

L.Z. Wise, B.J. Frost, S.W. Shaver and M.L. Csizy, Departments of Psychology and Biology, Queen's University, Kingston

Behavioural studies of the saw-whet owl have revealed exceptional sound localization accuracy in this species. Mean errors of head orientation, measured using the magnetic search-coil technique, are less than 1 degree in azimuth, and somewhat larger in elevation. Greatest accuracy is exhibited for sounds within + 20 degrees of the visual line of regard. We have also studied the frequency and spatial tuning of cells in the midbrain nucleus MLD of anesthetized saw-whet owls electrophysiologically. In the central region of this nucleus, cells were sharply tuned to frequencies from 200 Hz represented dorsally through to 7kHz represented ventrally, and showed little selectivity for sound source location. However, cells in the lateral and frontal zones of the nucleus were broadly-tuned or unresponsive to pure tones, but responded vigorously to noise and were spatially selective. As electrode penetrations moved from medial to lateral across the frontal aspect of MLD, spatial receptive fields moved from ipsilateral to contralateral locations, becoming increasingly more eccentric in the contralateral field as more caudo-lateral regions were explored. Azimuthal spatial tuning was quite sharp for these cells, whereas elevational tuning was more broad. We are currently examing the coding of interaural time and intensity disparities underlying sound localization ability, using both behavioural and electrophysiological techniques.

Session: **INDUSTRIAL NOISE**

Chairperson:

Tim Kelsall
Hatch Associates Ltd.

Radiation of Sound from a Vibrating Rectangular Plate with General Boundary Conditions

A.C. Berry, Groupe d'acoustique, Université de Sherbrooke
Sherbrooke (Québec), Canada, J1K 2R1
J.L. GUYANDER
Laboratoire de vibration-acoustique, Bâtiment 303, INSA Lyon
69621 Villeurbanne, Cedex, France

The sound radiation from baffled, thin, rectangular plates has generally been restricted to the simply-supported plate analysis, for which simple relations hold. This paper investigates the influence on the acoustic radiation, of a more general type of boundary conditions, namely, edges presenting arbitrary translation and rotation stiffness. For such structures, the in-vacuo modal basis is not known a-priori. Thus, the in-vacuo vibrationnal response of the structure is determined using a polynomial expansion of the transverse displacement; the constant coefficients of the expansion are obtained from the extremalization of the Hamilton functionnal of the plate, assuming a harmonic transverse point-force excitation. In the limit of a low fluid-structure coupling (Air loading), the in-vacuo vibrationnal response may be used to calculate the acoustical perturbation generated in the fluid. Results are shown in terms of quadratic velocity of the plate, far-field acoustic pressure, acoustic power and radiation efficiency of the plate. The influence of the boundary conditions is examined, and the limiting cases of simply-supported, calmped, and free plates are presented. Finally, in the perspective of a reduction of the radiated power, the effecct of edge damping is studied, as well as the addition of a plate-attached, concentrated mass. Further improvement of this work include a more adequate characteristization of the mechanical excitation, in order to model practical situations encountered in industry.

Methodological approach to the acoustical project of "Parc de la Villette" in Paris

Vick J. Chvojka, ACOUVIB Experts-Conseils, C.P. 307, Beaconsfield, P.Q., Canada, H9W 5T8

A well-known acoustical project for Parc de la Villette was achieved with help of a systematical engineering approach. A large noisy area in Paris was studied in details before being converted to the recreation area surrounding a new National Science Museum. The really complex acoustical environment is created by six busy boulvards, Metropolitain highway as well as about 27 railway tracks. The success of this project

was assured using sophisticated methods such as correlation techniques, mathematical modelling techniques, simultaneous measurements of short-term Leq series and other pertinent noise and traffic assessments.

Noise control at source applied to a 32t punch press.

Vick J. Chvojka, ACOUVIB Experts-Conseils, C.P. 307, Beaconsfield, P.Q., Canada, H9W 5T8

Precise diagnostics undertaken within a turn-key project for the noise control of the 32T punch press allowed us to discretized the events happening during the operation process. The operation cycle having a period of 555 ms consists of 40 punches in 3 sequences, stamping, cutting and feeding. The pertinent identification and quantification of the impact noise sources were achieved with help of mathematical model of the mechanical motion. Such a matter, the peak levels belonging to each series of impacts were classified and the optimal attenuations determined for the components originating those impacts in order to meet the objective of noise control by efficient and economical means. Each element of noise and vibration control was consequently specified, fabricated and installed. The results of this project have shown that the objective was met with a margin of more than 3 dB Peak.

Noise exposure survey at a large construction site

Z. Filip, Ontario Hydro, 757 McKay Rd., Pickering, Ontario

A noise assessment was conducted at a large Ontarion Hydro construction site to identify noise hazards and noise exposed workers, and to quantify trade group noise exposure levels.The assessment was conducted in two phases. The first phase was to identify site shops that are noisy (>85 dBA) due to noise exposure levels in these shops. The second phase was to quantify the noise exposure levels for the trade groups on site found to be noise exposed due to the equipment used and activities performed. A total of 212 workers were monitored: 26 in six of eleven shops, and 186 from fourteen trade groups. It was recommended that the first priority should be to engineering controls with emphasis given to the noise producing trade groups: Pipefitters, Painters, Ironworkers, Boilermakers, Cement Masons and Sheetmetal Workers.

Guideline for regulatory control of occupational noise exposurre and hearing conservation.

S. Gewurtz, Policy and Regulations Branch, Ontario Ministry of Labour, 400 University Avenue, 9th Floor,Toronto, Ontario M7A 1T7

Under the auspices of the Canadian Federal/Provincial Advisory Committee on Environmental and Occupational Health, a working group was established in December, 1982 to develop guidelines on occupational noise exposure and hearing conservation regulations. The objective is to assist Canadian agencies to develop and/or update their occupational

noise regulations, and to promote uniformity in such regulations across Canada. The guideline which has been developed is designed so that it can be adopted in its entirety, or if necessary, be modified and adopted in part to satisfy the requirements of specific agencies. This paper describes the contents of the guideline in general terms.

Experimental validation of ray-tracing model for predicting factory noise levels.

Murray Hodgson and Roland Woodcock, Acoustics Group (GAUS), University of Sherbrooke (Québec), Canada J1K 2R1

While many theoretical approaches have been used to predict factory noise levels, ray-tracing techniques have proven to be the most accurate and flexible. Such a ray-tracing model has been used extensively by the GAUS. Clearly it is important to demonstrate its accuracy in comparison with controlled experiment. With respect to such validation, and the general use of the model, one serious problem exists; that of the accurate a priori estimation of certain input parameters - in particular, the surface absorption coefficients and the fitting density. This paper reports the results of comparisons made between prediction and measurement for a machine shop, aimed at validating the model. Absorption coefficients were estimated from reverberation time measurements in empty factories of construction similar to that of the workshop. The fitting density was estimated by fitting prediction with the measured factory sound propagation. The acoustic powers of 10 machines were measured. Noise levels due to these sources were predicted and compared to those measured. The excellent agreement demonstrates the accuracy of the technique if values for the input parameters are accurately known.

SESSION: **TRANSPORTATION NOISE**

Chairperson

Soren Pedersen
Ontario Ministry of Transportation

A new noise barrier benefit/cost formula for Ontario

Chris Blaney, Ministry of Transportation, Research and Development, Central Building, 3rd Floor, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8

Since 1978 the Province of Ontario, Ministry of Transportation has evaluated its Retrofit Noise Barrier Program with the use of a Benefit/Cost formula. Recently, some problems were found with the original formula and an update was required. The update included a change in the required minimum amount of barrier attenuation to at least 3dBA. In addition there is now no minimum number of homes required

before consideration of placement of a new noise barrier.

Measurement of noise inside truck cabins

J. Desormeaux, Ontario Hydro, 757 McKay Road, Pickering, Ontario L1W 3C8

The measurement of noise inside truck cabins presents a series of problems due to several factors such as changes in the vehicle's speed, changes in the external environment, variation in the noise level with the microphone location inside the cabin, the window condition (open or closed), etc. This paper will discuss the only existing American standard on the subject and present guidelines for another, more comprehensive standard, which takes into account several of the variables mentioned above. Real-life situations where those guidelines were applied is described and the results discussed. The measurement techniques applied were found to be relatively simple to cary out and the results correspond to users' everyday experience, thus validating the proposed method.

Residential development of rural lands

Cathlyn Kaufman, J.L. Richards & Associates Limited, Consulting Engineers & Planners, 864 Lady Ellen Place, Ottawa, Ontario K1Z 5M2

Residential development of rural land must acknowledge and respect the impact of various noise sources. Noise generation intensity and its source can be wholly different from suburban to urban environments and settings. It is the intent of this paper to provide an awareness to these differences and offer various methods to minimize their effects. It is also the intention to identify probable problem areas that will play an ever increasing role as the population profile matures. In closing, this paper will pursue the inter-relationships between noise abatement techniques and "sound" planning principles (established planning principles and planning principles that recognize "sound").

Analyse des bruits de circulation provoqués par les camions lourds, évaluation de l'impact en fonction de la hauteur du point de mesure.

Jean-Gabriel Migneron et Marc Asselineau, Laboratoire d'acoustique
Centre de recherchess en amémagement et en développement (CRAD),1624 pavillon Félix-Antoine-Savard, Université Laval, Ste-Foy, Québec G1K 7P4

Après une courte révision des principaux paramètres susceptibles de caractériser le bruit du camionnage et un aperçu de l'importance de cet impact sur certains secteurs résidentiels particulièrement perturbés, l'exposé rapportera une série d'expériences relatives à la génération du bruit lors du passage de camions lourds, en fonction de la hauteur du point de mesure. On constate en effet des différences très significatives entre les signatures relevées à 0.30, 2.4 et 5 mètres du sol au voisinage de l'axe de roulement. Ces différences affectent la

composition spectrale, du fait de la proximité ou de l'élolignement des pneumatiques, mais aussi le comportement temporel. Il est ainsi possible de mettre en évidence la part prise par le bruit des pneumatiques sur l'impact coustique, la modification notable du spectre avant et après le passage d'un camion et surtout, les différences entre les temps de montée et de décroissance des niveaux de pression et les phénomènes de traînage associés.

Discussion of the draft CSA standard on highway noise barriers

Soren Pederson, Ontario Ministry of Transportation.

(Summary not available at the time of printing)

Transportation noise problem in the Province of Quebec

Jean-Pierre Panet, Gouvernement du Québec,Ministère des Transports, Service de l'environement, 255 boul. Crémazie est, 8è étage, Montréal, Québec H2M 1L5

A summary of the existing provincial (Quebec) legislation concerning noise pollution and environmental impact assessment will be presented. The approach used by the Ministry of Transporation of Quebec concerning noise problems will be described with some real case description.

Session: **LEGISLATION**

Chairperson

Shal Gewurtz,
Ontario Ministry of Labour

1988 update on regulating occupational exposure to noise in Canada

D.A. Benwell-Morison, Head, Non-Ionizing Radiation Section, Bureau of Radiation and Medical Devices, National Health and Welfare, Room233, Environmental Health Centre, Tunney's Pasture, Ottawa, Ontario, K1A 0L2

Recent Canadian activities concerning occupational noise standards, guidelines and background documents are described. A summary of existing and proposed Canadian occupational noise regulations and voluntary guidelines are presented. Noise limits and other noise control measures are outlined. Pertinent international activities are noted and possible future activities in the field are suggested.

Regulatory issues involved in the measurement of varying and impulse noise

John Earchen, Metrosonics Ltd.,P.O. Box 23075, Rochester, New York, USA 14692

Various regulatory bodies are concerned with the measurement of varying and impulse noise. In this paper, the technical issues involved in such measurement will be reviewed and discussed.

Occupational noise regulation in Ontario

Jamie Henderson, Hazard Analyst, Development Unit, Ontario Ministry of Labour, 400 University Ave., 9th Floor. Toronto, Onario M7A 1T7

The Ontario Ministry of Labour has had a proposed occupational noise regulation under development for more than eight years. In this paper, the current noise regulation is compared with the proposed regulation and the regulation development process is discussed to shed some light on why the development of a new noise regulation has taken so long.

The role of C.S.A. standards in canadian noise regulation

Tim Kelsall, Hatch Associates Limited, 21 St. Clair Avenue East, Toronto, Ontario M4T 1L9

In theory, regulators should set limits on noise, and standards writing

organisations should prescribe measuremenet procedures. In practice, Canadian experience in occupational, environmental and transportation noise has been that standards are written and rarely used for regulation while regulations are written which do not use established standards. This paper reviews the history of the relationship between noise standards and regulations in these areas and discusses some recent initiatives which may improve cooperation in the future.

The OSHA noise standard

R.G. Kunicki, USA Department of Labour

A discussion is presented on the origins of the U.S. Occupational Safety and Health Administration (OSHA) 29 CFR 1910.95 General Industry noise exposure standard. The interpretation of the standard's history as explained by the Occupational Safety and Health Review Commission in its April 6, 1987, decision on Docket No. 80-2848, Secretary of Labour vs. Collier-Keyworth Co., is also discussed. Finally, issues raised during the course of the Collier-Keyworth hearings and implication of potential findings on OSHA enforcement of the standard are addressed.

Manitoba's hearing conservation regulation

Jim F.W. MacKay, Environment and Workplace Safety and Health, Manitoba

Over the past few years, several Provincial and Federal agencies have adopted hearing conservation and noise control legislation. This paper discusses the steps taken in drafting and implementing Manitoba's Hearing Conservation and Noise Control Regulation (Manitoba Regulation 116/85). The regulation became effective on November 18, 1985 and includes requirements for assessment of worker exposure to noise, exposure controls, worker education, hearing surveillance, and record keeping. These requirements are based largely upon draft guidelines recently published by the Federal/Provincial Advisory Committee on Environmental and Occupational Health. In Manitoba, few technical resources were available to enable employers to establish hearing conservation programs in their workplaces in compliance with the requiremetns of the regulation. To facilitate implementation of the regulation, the Province adopted a "Compliance Schedule" approach to enforcement, whereby employers were given reasonable time to establish hearing conservation programs. Also the Workplace Safety and Health Division provided sound level meters and noise dosimeters, on short-term loan, to assist smaller employers. A course presented by Manitoba Health trains and certifies Industrial Audiometric Technicians. These policies and activities enabled many employers to establish effective hearing conservation programs in their workplace.

Federal regulation on levels of sound - the process and the results

B.V. Seshagiri, Labour Canada

Labour Canada is carrying out a thorough technical review of the Canada Occupational Safety and Health Regulations. For this purpose, a Review Committee has been established with equal representation from employer and employee groups under federal jurisdiction. The uniqueness of Labour Canada's approach to regulation making lies in the fact that the stake-holders, i.e. employers and employees, have been given almost complete freedom to propose the changes they wish to see brought about to the regulations. The only limitations are those placed by the existing enabling legislation, i.e. Part IV of the Canada Labour Code, and problems of enforcement. This paper discusses the regulatory process, particularly as it applies to the federal regulation on noise in the workplace.

A New Noise Level for the Energy Idustry in Alberta: The Energy Resources Conservation Board (ERCB) Interim Noise Directive and Handbook

R. Wright, ERCB - Alberta

The ERCB is responsible for the safe and efficient development of energy resources in the Province of Alberta. A Noise Directive has been developed to deal with noise from all facilities that fall under the ERCB's jurisdiction. Examples of the facilities that would be subject to this directive are natural gas compressor stations, pipeline pumping stations, drilling and servicing rigs, and gas plants. This is the only noise legislation in Alberta that regulates industrial noise impacts on the environment other than any municipal bylaws that may be in place. The directive was developed by a committee composed of members from the acoustical consulting community, industry, universites, rural land owners, governmental agencies and ERCB staff. The resulting documents represent the consensus opinion of the committee, rather than unanimous approval, and took three years to develop from the start of meetings to final issuance.This paper highlights the interim directive, including the maximum permissible sound levels and how those sound levels are determined.

THURSDAY AFTERNON, 6 OCTOBER 1988

SESSION: **INDUSTRIAL NOISE II**

Chairperson

Tim Kelsall, Chairperson
Hatch Associates

Intermittent and impulsive noise exposure evaluation

Kerr, A.A., Dofasco Inc., P.O. Box 2460, Hamilton, Ontario, Canada, L8N 3J5

Current noise regulations in the United States and Canada are based on epidemiological studies that were conducted in the sixties and early seventies. The noise levels were considered continuous and were easy to accurately calculate personel noise exposures using hand held noise level matera and time studies. The noise levels of many industries vary widely over relatively short periods. Current or proposed noise regulations require that steady, intermittent, varying and impulsive noise should all be integrated to determine the true noise exposure.This paper will discuss the results of quantifying the noise exposure in an industrial impulsive environment using:

- -a sound level meter and time studies
- -an integrating noise level meter
- -a noise dosimeter with - crest factor of thirty
  - \- fast response
  - \- slow response
- -the 3 dB and 5 dB trading relationship

The frequency distribution and the waveform analysis of the impulsive noise environment will also be discussed.

A Study of the Relationship Between Noise Levels, Annoyance and Work Performance within Offices

Lynne Molinari, Ontario Hydro

This study attempts to identify sound levels that are associated with work performance and annoyance. Noise measurements were performed on typical workdays. Six sampling intervals of 5 and 15 minutes duration, distributed throughout each day, as well as continuous measurements, were obtained at each location. The measured parameters were Leq, L1, L5, L50, L90, Lmin, Lmax, and Lpeak. In addition, two questionnaires were completed by the employees in each location to define the job demands placed upon them their evaluation of various environmental conditions. Subsequently, two timed tasks requiring concertration were completed, one with and the other without hearing protectors. The results showed significant correlations between annoyance, task performance, L5 and L10 for sound levels in the 50-60 dBA range. Performance on the tasks was improved for the low noise condition. In addition, a reliable noise monitoring sampling strategy was established.

Fluid induced pulsations: A case study

R. Ramakrishnan, and B. Howe, Vibron Limited, 1720 Meyerside Drive, Mississauga, Ontario L5T 1A3

The use of Natural Gas as an alternate fuel to propel I.C. Engines has been the vogue for the past few years. The application in automobiles and intra-city vehicles has been on the rise due to the apparent saving in fuel costs. Unfortunately, one of the safety features attached to the fuel tank has been producing a high level of vibrations. The present case study describes the mechanism that causes the pulsations within the fluid line. The pulsations have sufficient energy to excite any connected membranes such as the fluid meters and set them into

oscillatory motion. One of the major consequences of the fluid pulsations is the high level vibrations of the entire metering system. The distrubance of the system is sufficient to impede the metering mechanism. A simple reactive muffler [Beranek, L.L., Noise and Vibration Control, McGraw-Hill, Toronto, 1971. Chap. 12.] was designed to reduce the pulsations. The details of the system will be presented. The vibration levels before and after the installation of the muffler will be presented. The experimental results will be compared to the theoretical predictions of the muffler performance.

PC. Baffle: Duct Silencer Performance Prediction Software for a Personal Computer

R. Ramakrishnan, 41 Watson Avenue, Toronto, Ontario M6S 4C9
N. Ball, 224 St. Andrew Street, Ottawa, Ontario K1N 5G6

A Personal Computer (IBM-XT or compatible) based software has been developed to predict the insertion loss and pressure drop of a conventional duct silencer system. The acoustic performances were evaluated for any duct-liner configuration (2-D System) using a cubic finite element model to solve the wave equations with no flow. The duct silencer is lined on two opposite sides with acoustic material. The coupled wave equation [Scott, R.A "The Propagation of Sound between Walls of Porous Materials",Proceedings, Physical Society, London, Vol. 58 (1946) 358-368.] includes the propagation in the free space as well as in the material. The equation is solved for the wave number along the axis of the silencer. The real part of the wave number is proportional to the decay rate of the sound. The solution matrix includes higher order modes in the liner axis. The full solution program is written in FORTRAN with a Cubic Finite Element [Watson, W. and Lansing, D.L. "A Comparison of Matrix Methods forCalculating Eigenvalues in Acoustically Lined Ducts."NASA Technical Note, TN D-1886, 1976] subroutine and a Complex Matrix Equation Solver subroutine. The run time is approximately 4 hours on a XT with a 8088 processor to evaluate 18 third octave band frequencies from 100 Hz to 5000 Hz. Design curves are then generated for a given set of normalized parameters. Design curves are limited to conventional full-unit and half-unit silencers. The curves cover the extreme ranges of conventional duct silencers. The design curves are then used to interpolate for any full-unit and half-unit configurations through a bi-polar cubic spline routine.The revised interpolation program is also written in FORTRAN. Both metric and imperial units can be used. The design curves with the interpolation routines constitute the software called PC. BAFFLE. The run time to predict insertion loss at six octave bands (18 third octave bands are still used) is about a minute.The other part of the program generates the absorptive components of the silencer for a minimum pressure loss. The total pressure loss through the silencer is evaluated including the losses due to flow acceleration, diffusion and frictional loss. Standard loss parameters are used for various portions of the baffle to evaluate the complete drop in the static pressure for a given face velocity.A screen by screen description of the program will be presented.

Noise control of single facers in corrugating plants

Cameron W. Sherry, DOMTAR Inc., P.O. Box 300/Exit 40. Transcanada HWY, Senneville, PQ, H9X 3L7

The high noise levels of the single facers in a corrugating plant are well known. There have been a few attempts to reduce the noise by redesigning the components of the single facer. These have met with modest success because each new generation of machine has also been required to go faster. Each time the speed of the unit is increased in Domtar is that the use of enlclosures around the single facers has substantially decreased the noise level even with significant increases in the operating speeds.

Noise exposure in woodlands operations

Cameron W. Sherry, DOMTAR Inc., P.O. Box 300/Exit 40. Transcanada HWY, Senneville, PQ, H9X 3L7

Over the past several years within the Canadian Pulp and Paper Association and the Canadian Standards Association there has been considerable discussion about the exposures of woodland workers to noise. In Domtar using Metrosonic dosimeter we have measured the exposures of several groups of woodland workers. Of particular interest will be the noise exposures of chainsaw operators that are several decibels higher than previous studies would have lead one to believe. In addition exposures of skidder operators, feller buncher operators and truck drivers will be discussed.

Session: ***NEW TECHNOLOGY FOR THE SPEECH AND HEARING SCIENCES***

Chairperson

Krista Riko
Mount Sinai Hospital/Toronto General Hospital
Otologic Function Unit

CSRE: The canadian speech research environment

Donald G. Jamieson*, Terrance M. Neary** and Ketan Ramji*
*Speech Communication Laboratory, Department of Communicative Disorders, University of Western Ontario, London
**Department of Linguistics, University of Alberta, Edmonton

CSRE - The Canadian Speech Research Evironment - is a comprehensive, integrated, microcomputer-based facility of support speech research. CSRE includes facilities (a) to record and edit natural speech; (b) to analyse and/or compare speech tokens; (c) to parametrically synthesize speech sounds; and (d) to control experiments requiring the presentation of speech signals for perceptual testing. The system requires an IBM/AT clone (eg. Zenith Model 386 or 248, with math coprocessor and EGA or VGA graphics), a data acquisition system (e.g., ARIEL DSP-16, or Data

Translation DT2821/2801A plus filters) and a Mouse. The presentation will provide an overview and demontration of CRSE, followed by an opportunity of hands on use of the facility.[The development of CRSE is being supported by grants from the Strategic Program of the Natural Sciences and Engineering Research Council of Canada, and from Bell Northern Research]

A general-purpose hearing aid prescription, simulation, and testing system.

Donald G. Jamieson, Richard Seewald, and E. Raftery, Amplification Laboratory, Department of Communicaive Disorders, University of Western Ontario

This paper describes a comprehensive, integrated, microcomputer-based facility for research on hearing aid fitting, and for clinical use. The facilty permits one (a) to enter audiometric measures from a patient in a computer database; (b) to use those measures in formal prescription rules, in order to predict which hearing aid amplification function is likely to provide the optimal benefit for a hearing impaired listener; (c) to design and implement a (digital) filter in a digital-signal processing (DSP) board, which precisely implements the gain function specified in b), above so that speech intelligibility can be measured with the prescribed hearing aid gain function; (d) to measure speech intelligibility directly, using computer-based testing procedures. The system requires an IBM/AT clone (eg. Zenith Model 386 or 248, with math coprocessor and EGA or VGA graphics), an ARIEL DSP-16 digital signal processing board, plus filters and associated analog audio equipment, and a Mouse. The presentation will provide an overview and demonstration of the system. [This work is being supported by a grant from Unitron Industriels Ltd; previous work on the project was supported by Health and Welfare Canada, through the National Health Research Development Program.]

A survey of new facilties for the measurement of speech movements

Kevin Munhall, Speech Motor Laboratory, Department of Communicative Disorders, University of Western Ontario

The measurement of articulation and the changes in the shape of the vocal tract during speech has been a persistent problem for speech scientists. In recent years a number of new techniques have become available for measuring these. Included will be a description of the National Intritute of Health/ University of Wisconsin X-ray microbeam project, alternating magnetic field systems for tracking speech movements, ultrasonic imaging, and optoelectric tracking systems such as the WatSmart 3-D motion analysis system. Strengths and limitations of the various approaches will be discussed. Dr. Munhall is a member of the User's Committee of the N.I.H. X-ray microbeam project and has considerable experience with other techniques such as ultrasonics and optoelectric tracking systems.

A digitally-programmable hearing aid

William A. Cole and James A. Jonkman, Etymonic Design Incorporated, Dorchester, Ontario

This paper will describe the development, beginning in 1984, of the world's first, wearable, digitally-programmable, hearing aid. The presentation will summarize both the electronic design of the unit and the human engineering aspects of the hearing aid and the programming unit. The unit is now in production in Canada.

SESSION: **HEARING CONSERVATION**

Chairperson

Marylin Pike
MDS Health Group Ltd

The Ontario Hydro noise control and hearing conservation program

Alberto Behar, Ontario Hydro, 757 McKay Road, Pickering, Ontario L1W 3C8

The need to protect workers' hearing prompted Ontario Hydro Management to set up a Noise Control and Hearing Conservation program. That was done beginning 1984. Some elements of the program (e.g. use of hearing protectors, noise control measures, hearing tests) were already in place since the early 70's. However, there was an identified need for a comprehensive package where requirements and responsibilities would be listed. The program strarts by defining basic terms such as noise, noise-exposed worker, etc. Then it lists the steps to be taken to assess the risk from noise: noise level survey and noise exposure survey. Noisy areas are to be posted and workers performing their duties in those areas have to wear approved hearing protectors. Engineering noise controls are also decided at this point. Noise-exposed workers undergo a hearing test every two years. Results are reviewed by a committee created ad hoc that decide the need for a follow-up, Workers Compensation claim or clinical intervention. Management is responsible for running the program. However, employees' intervention is also insured through the local Health and Safety Committees. Application of the Program resulted in an increase of workers' awareness regarding risk from excessive noise, extensive and proper use of hearing protectors, and the institution of a system for early detection of hearing losses.

The Stelco noise control and hearing conservation program

Gary Bucholz,Staff Specialist - Industrial Hygienist, Industial Hygiene

Department, Stelco Inc., Wilcox Office, Hamilton, Ontario L8M 3T1

Stelco has had an active noise control and hearing conservation program for many years. This paper will present a review of the program and its development over the years. The key elements of the program that are presently in place will be discussed in terms of their effectiveness in protecting workers from noise-induced hearing loss.

Hearing conservation at Du Pont Canada inc. Kingston site.

D. T. Dickson, Du Pont Canada Inc., Environmental Affairs, Kingston, Ontario

Since the mid-1960's, Du Pont Canada Inc. has utilized a comprehensive hearing conservation program which has been shown to be effective in protecting workers against noise-induced hearing loss. Medical surveillance is an important tool to verify that workers are not being over-exposed to noise. Performance of hearing protection devices are enhanced when used in the context of an effective hearing conservation program.

Development of a questionnaire to screen industrial workers having a hearing handicap

Nicole M. Lalande and Jean Lambert, École d'orthophonie et d'audiologie, University of Montreal, P.O. Box 6128, Station A, Montreal, Quebec, Canada, H3C 3J7

Presently, industrial hearing conservation programs involve mainly the assessment and the control of noise exposure, and the measurement of hearing. Although the objective of such programs is to prevent occupational hearing loss (OHL), this occupational disease is the most prevalent one in the industry. Consequently, a comprehensive hearing conservation program should also include (a) screening of workers having a handicap due to OHL and (b) rehabilitation services adapted to their needs. A pilot study has been conducted to test and develop suitable services for OHL workers and their spouses. A questionnaire was used to assess hearing handicap and to promote self-acknowledgement of a hearing problem. The statistical analyses of the questionnaire (principal components analysis and discriminant analysis) has allowed us to propose a screening tool; this questionnaire will be presented and discussed. (Work supported by Health and Welfare Canada (NHRDP), and "l'Institut de recherche en santé et en sécurité du travail du Québec).

Hearing conservation in industry: Why is it failing?

William D. Ruth, HEARing MEasurements Co., Ltd., 27 Strathearn avenue, unit 2 - Bramalea, Ontario L6T 4V5

Industrial noise induced hearing loss has been a problem for serveral hundred years. Although compensation for this problem has been on the books since around 1919, the first WCB claim was made in 1951. For the

next twenty five years, relatively few claims were submitted. However, this began to change more dramatically aboout ten years ago and now many more claims are submitted with the average cost of just over $10,000.00 On the surface it would appear that companies are taking a greater interest and are trying to prevent the problem. But for the most part, this is only on the surface. The results of ongoing hearing testing as part of the hearing conservation program would suggest that most programs fail. As a matter of fact, if the results were similar with eye injuries, there would be an investigation. With all the information now available, why is this happening? Perhaps it's because of the type of injury noise causes. Since there is no blood, no pain or physical evidence, there does not seem to be any valid reason for the same direct action other hazards demand. While there is concern, there is no real action. And there is no real participation by the various levels of management. The problem can be corrected. The problem has to be corrected. The injury has to be seen for what it really is, a disability that remains with the victim for the rest of his/her life.

Compensation for Occupatinal Noise Induced Hearing Loss In Ontario -- Review and Update

R. Thakur, M.D., Medical Consultant, Industrial Hearing Loss Occupational Disease Department

Noise Induced Hearing Loss was recognized as an Industrial Disease under the Workers' Compensation Act of Ontario in March 1947. Following this amendment, the Compensation Board developed procudures for the adjudication of claims and provision of disability awards for this clinical condition. In March 1952 the first pension award was granted to a boiler maker. Since then, there has been a steady increase in the number of claims submitted to the Compensation Board for assessment. Over the past 3 years approximately 3,500 under claims have been assessed annually. Claims for Industrial Hearing Loss would qualify for acceptance if sufficient noise exposure in the work environment is established and the clinical diagnosis is compatible with acoustic trauma. Based on the Workers' Compensation Board's previous policy governing the adjudicative process of Noise Induced Hearing Loss cases, about 65% of submitted claims were accepted and 70% of these allowed claims received monetary awards, charged to the last liable employer. However, this policy has recently been revised following a detailed comprehensive review of this occupationally related condition. Various clinical aspects, example risk appraisal, progression of hearing loss with exposure etc were studied. A revised, more equitable, hearing impairment scale has also been developed. The new policy on Occupational Noise Induced Hearing Loss became effective June 3, 1988 and will encompass a greater number of cases with established hearing handicap resulting from occupational noise exposure.

SESSION: **ENVIRONMENTAL NOISE**

Chairperson

Leslie G. Kende,
Environment Ontario

Radiation pattern from an interference producing device to control a spherical low frequency noise source

Maurice Amram & Rochdi Lahlou. Ecole Polytechnique, Montreal

(Abstract not available at printing)

Methodological approach to the acoustical project of "Parc de la Villette" in Paris

Vick J. Chvojka, ACOUVIB Experts-Cosils, C.P. 307, Beaconsfield, P.Q., Canada, H9W 5T8

A well-known acoustical project for Parc de la Villette was achieved with help of a systematical engineering approach. A large noisy area in Paris was studied in details before being converted to the recreation area surrounding a new National Science Museum. The really complex acoustical environment is created by six busy boulvards, Metropolitain highway as well as about 27 railway tracks. The success of this project was assured using sophisticated methods such as correlation techniques, mathematical modelling techniques, simultaneous measurements of short term Leq series and other partinent noise and traffic assessments.

Developments in environmental noise control in Ontario

Leslie G. Kende, Environment Ontario, 135 St. Clair Ave. W., Toronto, Ontario, M4V 1P5

(Abstract not available at printing)

* The loudness of narrow-band impulse noise as a function of signal duration and frequency

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In order to isolate the influence of the center frequency of narrow-band impulses on loudness, one has to take into account the effect of decreasing duration with increasing frequency. This can be acheived by calculating the loudness level at different frequencies using a measure of acoustic energy of the impulses. In doing so, one has to assume that the temporal integration of loudness of impulses follows a simple energy rule. To test this assumption, the loudness of narrow-band impulses

which duration varied from 4 to 83 ms, was measured using the method of adjustment. Ten normal hearing subjects adjusted the level of impulses centered at 3150 and at 6300 Hz to equal the loudness of narrow-band noise centered at 1000 Hz. The latter was presented at three peak levels, namely 80, 90, and 100 dB SPL. Its loudness had previously been equaled to that of a 1000 Hz pure tone. Each impulse was tested both as the comparison and as the reference signal. The results show a very good agreement with a negative exponential function of signal duration as proposed by Plomp and Bouman (J. Acoust. Soc. Am., 1959,31: 749-758). The time constant appeared to be smaller at 6300 Hz than at 3150 Hz. It was also smaller at higher than at lower sound pressure levels. For durations well below the time constant, the temporal integration of the loudness of the impulses is very well accounted for by the energy content of these signals.

The impulsive impact of bird scaring devices: A case history

Ramini Ramakrishnan, Ministry of the Environment of the Province of Ontario, Noise Assessment and System Support Unit, 135 St. Clair Avenue West, Toronto, Ontario

Farmers have been dealing with the problem of birds preying on their crops for a long time. The issue is particularly acute for fruit growers during harvest time. In the Niagara Peninsula, the crop loss has been estimated to be between 5% and 10% a year. Such a loss can be disastrous for a small farmer whose break-even margin is usually very thin. It has been the practice for the Niagara Peninsula area farmers to rely mainly on some sort of acoustic devices for scaring the birds. The acoustic devices called bird bangers depend upon producing a short burst of sound similar to a gun shot at a preset repetative rate. The sound level produced is very high and the users believe that the louder the sound, the more effective is the process in scaring the birds. Bird bangers conflict with the Ministry of Environments's Model Municipal Noise Control By-Law which sets 70 decibels, A-weighted Impulse (dBAI), as a permissable noise limit for pest control devices ["Model Municipal Noise Control By-Law," Final Report, Ministry of the Environment of the Province of Ontario, August, 1978;Seshagiri, B.V. "Reaction of Communities to Impulse Noise." Journal of Sound and Vibration 74, 47-60, 1981.]. Bird bangers that were used produced sound levels in excess of 100 dBAI at nearby properties. If there are no conflicting land uses near an orchard, the environmental impact of intence acoustic outputs would be minimal even if the noise levels exceed the preset criteria of the Ministry. However, if a sensitive receptor such as a residence or a hospital is located adjacent to the farm, the noise impact can become substantial. The same acoustic devices which protect the farmers can infringe on the material comfort of residential receptors therby contravening the EPA. In the Niagara area most fruit farms are small and hence the conflict with neighbours is increased. A case history will be presented, where such a conflict is clealy evident. Two parties are trying to exist under conflicting land uses. On the one hand, we have a farmer with an orchard and the right to farm and on the other hand, there are redisents with the right to enjoy their own property. It may be impossible to say that one right has preference over another.The Ministry of the Environment has been attempting to tackle the issue with acceptable solutions. Many of the mitigation measures that were tried will be presented. The varying degrees of success rates in suppressing the acoustic impact will be highlighted. The ongoing measures to resolve the two conflicting rights will also be presented.

FRIDAY MORNING, 7 OCTOBER 1988

SESSION: BUILDING ACOUSTICS

Chairperson

John Hemingway,
Vibron

Measurements of electro-acoustic modification systems

J.S. Bradley, Institute for Research in Construction, National Research Council, Ottawa, Canada, K1A 0R6

Assisted Resonance, Multi-Channel Reverberation (MCR), and the more recent Acoustic Contol System (ACS) are examples of electro-acoustic systems that have been successfully used to modify the reverberation times of auditoria. Some other electro-acoustic modification schemes have been less successful. To evaluate such systems, it is essential to carry out thorough objective tests and it is of particular interest to determine their performance in terms of other newer auditorium acoustics measures than just the classical reverberation time. These newer measures include early decay times, early-to-late sound ratios, and lateral energy fractions as well as the overall sound level due to a known source. The results of tests on simple experimental feed back systems as well as the more sophisticated ACS system at York University are reported. The results of the other measures are seen to give a more complete picture of the operation of these systems.

Optimum location for fire alarms in residential buildings

R.E. Halliwell, Acoustic Section, Institute for Research in Construction, National Research Council of Canada, Ottawa, Canada and M.A. Sultan, Fire Research Section, Institute for Research in Construction, National Research Council of Canada, Ottawa, Canada

Fire alarms can save lives in a fire emergency only if people hear them. If alarm sounding devices are to be used effectively, attention must thus be paid to where they are located in the building. Concerns were expressed about the present requirements in the National Building Code of Canada concerning the audibility of fire alarm systems. An earlier

study on the optimum placement of smoke alarms in singal-family homes has been extended to address those concerns, the results of which show the optimum locations for fire alarms in apartment buildings. Two questions must be answered if an optimum location is to be found; first, what is the minimum alarm level necessary to awaken a sleeping person?, and secondly, what are the causes of sound attenuation of the alarm signal in apartment buildigns?. The answer for the first question is based on published data while the answer to the second is based on IRC studies on the attenuation of fire alarm signals in apartment buildings. From these, a simple model, that can be used to determine sound attenuation within apartment buildings, has been developed. Measurments were made in eleven apartment buildings ranging from older low cost housing for seniors to new luxury condominiums. These showed that if adequate fire safety proteciton is to be provided for sleeping residents, then an alarm sounding device must be located within each apartment. The optimum location of the fire alarm with the residence can then be determined by the use of the model.

Experience with the acoustical control system (ACS)

J.R. Hemingway 2469 Callum Ave., Mississauga, Ontario, L5B 2HB

The Acoustical Control System (ACS) is an electro-acoustical system which produces reverberation enhancement by the simulation of multiple sound reflections following the laws of physics applicable to the propagation of sound. The first major installation ACS in North America was in Decoustic/ACS Centre for Acoustic Research at York University or DACARY. This paper describes experience gained over an 11 month period in installation and fine tuning procedures for ACS, RASTI testing results, sound recording experience and the results of informal research performed with professional musicians in the DACARY facility.

In situ determination of the absorptive properties of multi-layer room surfaces

Murray Hodgson and Roland Woodcock, Acoustics Group (GAUS), University of Sherbrooke, Sherbrooke (Québec), Canada, J1K 2R1

The simulation of sound fields in a room requires not only an accurate knowledge of its geometry, contents and sound sources, but also of the absorptive properties of its surfaces. These may be determined from the acoustic impedance. The surfaces of rooms can be considered as consisting of a single layer (simple partition) or multiple layers (double partitions, partitions with coverings, suspended ceilings). In the case of suspended ceiling, for example, the acoustic impedance is determined from that of the acoustic tiles as modified by the air space and roof. Techniques exist for measuring the acoustic impedance of surfaces. However, these usually require free-field conditions and/or are not accurate at low frequencies. Electro-acoustic analogies, by which each layer of the structure is characterized by a transfer matrix, allow the impedance of such a multi-layer system, for arbitrary and diffuse incidence, to be calculated. Unfortunately certain relevant properties of the structure, such as the flow resistivity of absorbent materials, often cannot be determined a priori. This paper reports on research aimed at the in-situ determination of the acoustic impedance of a room surfaces by a combined theoretical and experimental approach. Impulsive techniques are used to measure in-situ the propagation of sound near the surface. The measurement results are compared to sound propagation predictions, made as a function of the surface impedance, varying the unknown parameters to obtain a best agreement.

Psycho-acoustical research at DACARY

James R. McKay, Chairperson, Director, DACRAY Research Unit, Department of Music, York University, 4700 Keele Street, North York, Ontario, M3J 1P3

An ACS Model 6000 was installed at the Decoustics/ACS centre for Acoustical Research at York University (DACARY). Instantaneous adjustment of the acoustical conditions at DACARY presents an ideal setting for psycho-acoustical research in the Hall. This paper describes the research program initiated at DACARY which investigates the preferred acoustical conditions for the performance of music.The first phase of the research program is described, which investigates the hypothesis that musicians prefer double sloped reverberation decay curves as a means of obtaining both good ensemble conditions on the stage and an acoustical response of the space into which they are playing. Results of this phase of the research are provided.

Analyse acoustique du stade olympique de Montréal

Jean-Gabriel Migneron, Laboratoire d'acoutique, Centre de recherches en aménagement et en développement (CRAD), 1624 pavillon Félix-Antoine-Savard, Université Laval, Ste Foy, Québec, GlK 7P4

Après l'installation de la toile de couverture mobile du Stade olympique de Montréal, de nombreux problèmes acoustiques se sont trouvés aggravés, du fait de l'augmentation très significative des temps de réverbération. La présentation portera sur un résumé des principales caractéristiques acoustiques de cet espace architectural unique, en termes de temps de réverbération (suivant la localisation source/receveur), niveaux et composition spectral du bruit de fond, réponse impulsionnelle, analyse des échos, distribution sonore, indice d'intelligibilité (RASTI), etc. Une attention toute particulière sera apportée sur les phénomènes d'échos provoqués par la toile de couverture, le contrôle du bruit provoqué par les systèmes de ventilation de l'anneau technique (nécessaires en présence de la couverture) et la modélisation de la distribution sonore.

Low-frequency sound absorption in large spaces using the transverse resonant baffle system

Thomas S. Paige, Vibron Limited, 1720 Meyerside Drive, Mississauga, Ontario, L5T 1A3

A new concept is presented for improving the acoustical characteristics of large spaces such as sports arenas to make them more suitable for concert events. These spaces often have excessive reverberation particularly at low frequencies. The method discussed employs a combination of sound absorbing and reflective baffles suspended from the ceiling in a resonant configuration tuned for maximum absorption at the reverberation curve peak. Calculated predictions for the reduction of reveberation time are shown to be in agreement with measured results in a hockey arena retrofitted with such an absorbing system.

Blocking sound transmission above suspended ceilings

J. David Quirt and Robin E. Halliwell, Acoustics Section, Institute for Research in Construction, National Research Council of Canada, Ottawa, K1A 0R6

Suspended ceiling systems are used in most modern office buildings. Inter-office partitions usually do not block the space between the suspended ceiling and the structural ceiling above. This space above the suspended ceiling is used as an air-return plenum for the ventilation system, and sound transmission through this space often limits inter-office speech privacy. This paper presents the first stages of a project to develop practical acoustical solutions, using the laboratory facility at the Institute for Research in Construction. This laboratory simulates a pair of adjacent offices with a common plenum space above the suspended ceiling (and is the only such facility in North America conforming to the pertinent ISO, AMA, and draft ASTM standards).A series of suspended ceiling systems have been tested in this facility, to evaluate the factors limiting noise reduction in typical installation. In conjunction with these ceiling tests, we have performed an extensive laboratory evaluation of a barrier system intended to reduce sound transmission without preventing airflow.A wall of fibrous absorptive material has been used as a barrier system. Dependence of the noise reduction of physical parameters (flow resistance, barrier thickness, density, etc.) and the effect of providing for airflow have been examined. Results of these studies will be presented. Practical installation concerns and preliminary field test data will also be discussed.

Noise control of underground bus stations: A case study

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Passenger are subjected to high levels of noise for a short period of time while waiting for a bus, train or a subway. There are no set standards that can be followed to limit the overall noise levels in a station platform and hence most stations are designed for noise control on an ad-hoc basis. The present case study, however, is an exception to the rule. The case study deals with the design of an underground bus station in Ottawa, which is located adjacent to the Queen's way and a large shopping center. Noise control was included as part of the original design so as to obtain a suitable acoustic environment for the

users. The design goal for noise in the station was chosen to be near 80 dBA (Leq, equivalent energy level), based on guidelines used for train platforms in the USA. Data was collected from similar buses in existing stations to establish the necessary amount of noise reduction. Design alternatives were proposed to achieve the results. The design of two long brick faced wall was modelled and tested in a reveberation room. The tests showed that this slight change of the architect's concepts would allow the noise criteria to be met.Measurements were conducted subsequent to the construction and during the operation of the station. The results show that the noise control measures included in the design performed even better than predicted.

Sound transmission through concrete block walls

A.C.C. Warnock, Institute for Research in Construction, National Research Council of Canada, Montreal Road, Ottawa, K1A 0R6

A recent measurement series at the Institute for Research in Construction, looked at sound transmission through 190 mm normal weight concrete block walls with an extensive variety of methods used to attach drywall. Methods ranged from direct attachment to 75 m steel Z bars. Cases included cavities with and without glass fibre. Sound transmission class ratings in excess of 70 were achieved in some cases. The factors affecting the ratings and possible new designs for multi-family homes will be discussed. Less extensive measurements were also made on other block types, including cavity walls using 100 mm blocks. Sound transmission class ratings for this latter type depended strongly on the details of the installation. These results will also be presented and discussed.

SESSION: **HEARING PROTECTION**

Chairperson

Stan Forshaw,
DCIEM

Vibrational analysis of inset hearing protectors occluding model ear canals

G. Doswell, H. Kunov, D. Racansky, Institute of Biomedical Engineering
University of Toronto

Acoustic transmission loss and vibrational displacement measurements were performed on two versions of a polymer ear plug (stock and mass-loaded), inserted into 4 different model ear canal shapes. Each canal shape consisted of two canal types: one hard-walled acrylic canal and one lined with a vinyl gel material to simulate skin. The transmission loss measurements were made with a two-microphone technique

at sound pressure levels of 90, 100 and 110 dB, and at 20 frequencies from 80 Hz to 9 kHz. The displacement measurements, performed at the same sound pressure levels and frequencies, were made at the centre of each end face of the ear plug using a laser interferometer. Both magnitude and phase information, relative to the acoustic sinusoidal driving force, were obtained for both types of measurements.Results indicate that: (1) The ear plugs are linear with sound pressure level over the range tested in terms of transmission loss and displacement, (2) the ear plug/canal system behaves as a 2nd or 3rd order mechanical system (low pass filter), with changes in mass or compliance reflected predictably in the system behavior, (3) an inverse relationship exists between attenuation, displacement and mechanical resonance with respect to canal cross-sectional area in the case of cylindrical (constant cross-sectional area) canals, (4) the ear plugs appear to dissipate energy through a viscous-shear mechanism at or near the "skin"/canal boundary, since both end face centre displacement amplitudes are the same.

Hearing protector evaluation under CSA Z94.2-M1984 in a new hearing research test facility

Christian Giguère and Sharon M. Abel, Department of Otolaryngology, University of Toronto

Until very recently, there was no facility in Canada meeting the hearing protector testing requirements of CSA Standard A94.2-M1984. A new research facility, recently developed at the Mount Sinai Hospital in Toronto, is the second such Canadian facility. The new facility includes: (1) a multi-purpose hearing test chamber with adjustable acoustical environment via the use of removable sound absorptive panels and stationary diffusers, and (2) computer-controlled signal presentation and subject monitoring instrumentation, allowing various psychoacoustical procedures to be conducted. The test facility can be configured for conformance with ANSI S12.6-1984 and for the sound attenuation test procedure section of CSA Z94.2-M1984. Results from the room qualification tests and from a pilot study aimed at comparing the attenuation of two commercially available earmuffs and two earplugs are presented. Two psychoacoustical methods, a 4-IFC and an adaptive procedure, are compared.

An impulse sound source

T. Gerritsen and H. Kunov, Institute of Biomedical Engineering
Univesity of Toronto

A compact, inexpensive impulse source giving reproductible signals is frequenlty required for acoustic testing. A system was designed, consisting of a pair of electronically equalized speakers in a constant pressure enclosure. The design of the speaker system was based on an electromechanical analogy and previous findings regarding the acoustic properties of speaker enclosures. Separate electronic equalization for both speakers in the system was employed to improve the impulse source's measured responses. The use of separate equalization for each speaker in

a constant pressure system is not restricted to impulse sources, but may be used in the design of compact high-performance home loudspeakers.

Shear mechanical impedance of ear canal skin

H. Kunov, A. Ing, D. Racansky, Institute of Biomedical Engineering
University of Toronto

The attenuation of ear plugs is not only a function of their physical characteristics; it also critically depends on mechanical properties of the intra-aural skin into which they come in contact. An experiment has been designed to measure the shear acousto-mechanical impedance of the ear canal skin with a simulation ear plug in the frequency range 63 Hz to 8 kHz. Three different insertion pressures were used on 40 subjects (20 males and 20 females, half of each group over 40 years of age, and half under 30). Analysis of the results indicate little difference between the four groups. This allows us to formulate a general model of shear mechanical impedance of ear canal skin.

Simulation of intra-aural and circumaural skin

D. Racansky and H. Kunov , Institute of Biomedical Engineering
University of Toronto

Objective measurements of hearing protector attenuation with an artificial head (acoustic test fixture, ATF) depend on the accurate simulation of the mechanical properties of skin and underlying tissues, where the hearing protector comes into contact. Based on measurements of a sample population, we have tuned the acousto-mechanical compliance and resistance of silicone rubber to simulate the skin/flesh in the ear canal and the area surrounding the pinna. This requires two layers of different composition and thickness. The parameters available for manipulation are: mass ratio of silicone rubber to silicone fluid; viscosity of the silicone fluid; thickness of each layer; and, within certain limits, the shape of the surface.

Assessing the benefits of active noise reduction

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Downsview, Ontario M3M 3B9

The passive attenuation afforded by hearing protectors can now be enchanced at low frequencies with active noise reduction (ANR) techniques. These systems can offer up to 30 dB atenuation around 250 Hz with an effective range from 20 to 1000 Hz. The benefits of a reduction of high-intensity low-frequency noise are not always realized when expressing the resulting noise level in dBA. Not only does ANR reduce possible saturation of the ear from low-frequency sound, but also reduces upward spread of masking to improve signal detection and speech intelligibility.

SESSION: **CLINICAL MANAGEMENT OF THE HEARING IMPAIRED**

Chairperson

Krista Riko
Mount Sinai Hospital/Toronto General Hospital, Otologic Function Unit, 600 University Ave. Toronto, Ontario M5G 1X5

Speech perception capability and hearing loss

Sharon M. Abel, Peter W. Alberti and Ellen M. Krever, Department of Otolaryngology, University of Toronto, Toronto, Ontario, M5G 1L7

This research investigates decrements in auditory information processing due to ageing, noise sensitivity and progressive sensorineural hearing loss. The aim is documentation within-subject of performance of ten different tests of auditory function. These quantify the ability to encode parameters of the auditory stimulus and evaluate the effects of variation in speech materials, noise backgorund and speech to noise ratio, as well as the relationship among measures. Preliminary results show that both ageing without concomitant hearing loss, and degree of cochlear pathology are predictive of decrements in frequency encoding. Time perception, affected by ageing alone, likely reflects more central processes. Consonant confusions in speech are critically dependent on the spectrum of the noise background, in addition to its level--parameters which determine the relative importance of subject characteristics. The data support the addition of new clinical tools for the measurement of handicap and suggest new strategies for aural rehabilitations.

Trials and tribulations of fitting very young children with hearing aids

Lynne Brewster, Saskatchewan Pre-School Auditory Rehab Centre, Room 15 Ellis Hall, University Hospital, Saskatoon, Saskatchewan S7N 0X0

The problem associated with aiding young hearing impaired children are many and varied. Frequenlty the electroacoustic characteristics of the hearing aid are not the major limiting factors when fitting very young children. Factors such as size, shape, battery accessibility, durability and case noise are often the determinants of successful hearing aid use. One hundred and ninety-eight children under the age of three from a large geographic area covering a wide range of socio-economic groups were reviewed and the major problems associated with the use of amplification were indentified.These will be examined and discussed.

Advantages and limitations of modern hearing aids

Hollis Corbin, Mount Sinai Hospital/Toronto General Hospital, Otologic

Function Unit, 200 Elizabeth Street, Toronto, Ontario, M5G 1L7

This paper discusses the current state of hearing aid and hearing aid coupling technology. Special attention is given to the advantages and limitations of modern hearing aids in providing amplification while reducing tolerance problems and improving speech discrimination, especially in a background of noise. Examples using case studies with "real ear" measurements will be used to demonstrate specific improvements or problems.

Free field masked thresholds under simulated and real impairment conditions

R.W. Gatehouse, Psychology Department, University of Guelph, Guelph, Ontario, N1H 5C7

In 1986, Gatehouse presented data showing that free-field masked tonal thresholds of normally hearing subjects were dependent upon both the relative azimuthal positions of the masker and signal, and upon the probe tone frequency (see Proc. 12th IGA, paper B2-7). Simply, it had been expected that regardless of probe frequency, the greatest degree of masking would ensue when the masker and probe were coincident or closest to each other, since both would have reduced binaural differnce cues. Instead, or some tones (1.0, 2.5 kHz) the signal was as detectable with the masker and probe emanating from the same position (0°) as it was with their greatest separation of 90°, and greatest effects of masking were observed for positions between 30° and 45° away from 0°. Since, signal detectability under everyday conditions of masking where the signal, and masker are likely to be spatially separated poses particular problems for impaired hearers the present study compared the free-field unmasked, masked, and simulated monaural masked thresholds of normals, and those of real impaired hearers. Because of the problems associated with obtaining specific groups of impaired hearers and the difficulties imposed by the experimental paradigm, not all of the conditions are directly comparable. Nonetheless, it can be stated that impaird herers are much more debilitated than normals in their ability to detect signals that are being masked by signals emanating from other spatial locations. The paper will outline the general and some of the particular problems encountered by specific impairments and levels of impairment

What does it mean to have an occupational hearing loss? Not on an audiogram, but in everyday life

Louise Getty and Raymond Hétu, Groupe d'acoustique de l'Université de Montréal, C.P. 6128, succursale A, Montréal, Québec H3C 3J7

Difficulties associated with occupational hearing loss have been investigated by means of A) qualitative research interview with 61 noise exposed workers and their spouses, and B) sharing of everyday problems within experimental rehabilitation groups with over 50 workers and their spouses. The main problems are associated with listening situations such as television viewing, monitoring warning sounds and tinnitus and

communication in non-ideal environments such as in groups, in the car, in meetings, on the telephone. The consequences for the victim of these difficulties are, increased efforts, anxiety and stress, reduced social involvement, isolation and a negative self-image. The consequences for the spouses are the annoyance and anger raised by the volume of the television, by having to repeat themselves often, by the insecurity of not being heard when calling, by reduced social activities, by feeling responsible for their husband's understanding in social situations. These consequences both for the victims and their spouses result in increased tension in their marital interaction.

High-tech in the elderly: User friendly or intimidating foe?

Brenda Lewsen, Sunnybrook Medical Centre, Sunnybrook Medical Centre, 2075 Bayview Avenue, Toronto, Ontario, M4N 3M5

Of the chronic conditions occuring among elderly people hearing loss ranks second only to arthritis in prevalence. A sizeable segment of the population therefore could potentially benefit from rehabilitation. Currently available hearing aids and assistive listening devices, while being invaluable rehabiliation tools do not as yet solve the amplification problems of the general population. Difficulties hearing in noise or when conversing with large groups are universal. The problems facing the elderly population are compounded by the presence of further auditory and non-auditory difficulties. Declines in central auditory processing manifest in greater difficulties in the presence of a degraded speech signal. Background noise, distortion or interruptions will render speech more difficult to understand than among the younger hearing impaired group. Central auditory factors combine with general feelings of unfamiliarity with devices and physical limitations such as poor vision, memory and learning problems, and poor manual dexterity to produce reduced motivation to perservere with amplification. The usefulness of technically superior devices will be limited unless they can be coupled easily and comfortably to the ear, have large visible remote controls, rough surfaces that can be felt easily and be made of durable materials. They need to be uncomplicated to use and maintain. In addition excellent sound quality at affordable cost is essential. In this presentation examples of the unique requirements of the elderly population will be given.

The comprehensive adult aural rehabilitation program

Dana L. Storms, Mount Sinai Hospital/Toronto General Hospital, Otologic Function Unit, 600 University Avenue, Toronto, Ontario, M5G 1X5

Impaired hearing can have a profound impact vocationally, socially, and emotionally - not only for the hearing impaired individual but also for the people with whom they need to communicate. When an individual reports dificulty communicating due to hearing loss, aural rehabilitation is indicated. A comprehensive aural rehabilitation program consists of a variety of options. These options include: hearing aids, assistive listening devices, speechreading, auditory, training, support groups and coping strategies. Selection of the type of option depends on a number of factors, for example, in recommending a device such criteria as ease of operation, cost, availability, and compatibility should be considered. In this presentation a model program will be presented with case examples.

The benefits of binaural amplification

Davidah Wolf, St. Michael's Hospital, 30 Bond Street, Toronto, Ontario, M5B 1W8

Clinical tests of hearing aid benefit often do not indicate significant advantage of a binaural fitting over a monaural fitting. Nevetheless, it is becoming increasingly apparent to clinical audiologists that there are benefits to the use of two hearing aids. These include the ability to localize, binaural summation and the elimination of the head shadow effect. Binaural amplification is not always possible or appropriate (monaural hearing loss, large threshold differences between ears) but when it is it should be strongly recommended.

SESSION: **MUSIC AND PSYCHOLOGICAL ACOUSTICS**

Chairperson

Lola L. Cuddy
Department of Psychology, Queen's University at Kingston

The independence of scale and serial order information in melodic perception

Annabel Cohen, Dalhousie University, Halifax and Bradley Franklin, Princess Margaret Hospital, Toronto

Listeners indicated the serial order of 8 tones presented in 36 different sequences by completing an 8 X 8 matrix for each sequence representing serial position on the horizontal axis and oridnal position on the vertical axis. In each sequence the order was repeated five times in succession making sequences 40 tones in length. Sequences were generated from one of four 8-note scales or alphabets (major, minor, chromatic, and augmented having the semitone patterns of 2212221, 2122122, 1111111, and 4444444 respectively) and from one of 9 possible serial orders varying in complexity. Accuracy, as measured by number or ordinal positions incorrect and by contour errors, was poorest for the chromatic alphabet and for the most irregular sequential structures. Although some alphabetic effects could be accounted for in terms of familiarity and spacing and some serial effects could be accounted for in terms of rule regularity, effects of alphabet structure and sequential structure were not independent: certain pitch alphabets and sequential structures combined better than others and led to fewer tracking errors. It is suggested that models of music perception must consider congruence between alphabets and serial structures in addition to the respective independent effects on these dimensions.

The perception of structure in music

Lola L. Cuddy, Department of Psychology, Queen's University at Kingston

It has been proposed, both in contemporary music theory and from the results of empirical investigation, that listening to music involves perceptual segmentation of the musical surface and the abstraction of higher-order structural invariants. Segmentation rules are seen to produce perceptual groupings based on proximity and similarity in time and pitch-space. There is evidence that the detection of structural invariants engages pattern-recognition processes that rely upon acoustic regularities present in the surface and, in some instances, familiarity with the musical idiom. The latter invokes knowledge representations which appear to be acquired from exposure to the music, but which are not necessarily the result of formal training in music theory and performance. As a general introduction to this session, this paper will consider some experimental work illustrating the psychological reality of proposed processes, but also suggesting problems that remain to be solved.

Towards the establishment of a neural basis for music cognition

Edwin C. Hantz*, Joseph P. Walton**, Garry C. Crummer***
Kenneth P. Swartz, Robert D. Frisina**
*Department of Music Theory, Eastman School of Music, **Otolaryngology Division of Surgery Department, School of Midicine & Dentistry, ***Department of Music Education, Eastman School, University of Rochester, Rochester, New York

Historically, the study of how we perceive music has been an active area of inquiry. However, experimental investigations of the brain mechanisms that underlie and govern this perception are quite new and cognitive and neurophysiological studies of musical perception will be presented. The most provocative and productive avenues of psychological experimentation will be addressed from the perspective of their potential for enhancing understanding of the neurological foundations of music cognition. Some initial findings about how the brains of musicians may differ from those of non-musicians, as investigated during various musical listening or production situations, will be put forth. Demonstrations of how analysis of auditory event-related potentials can provide insights into neural mechanisms of music cognition will be summarized. They include: 1) differential event-related activity from musicians and non-musicians during timbre discrimination tasks, perception of chord progressions, and discrimination of intervals; 2) Correlation of performance and cognitive strategies for these tasks with brain activity; and 3) Relation of musical background to task performance and neural activity. [Work supported by the Eastman School of Music and the Audiology Clinic, Unversity of Rochester]

Group structure in music processing

Isabelle Peretz, Université de Montréal

Parallel similarity (e.g., repetition of patterns) and internal similarity (e.g., pitch and temporal relationships between tones) were studied as determinants of music grouping structure. These determinants were assessed in three different experiments, each being designed to focus on a different processing stage. In Experiment 1, the listeners were required to divide each tune into its "natural" parts. Their ability to segment the tunes closely matched the boundaries generated by the clustering determinants under study; this consistency was particularly high for musicians. In order to go beyond these introspectionnist judgements, two other experiments were conducted. In Experiment 2, a probe recognition task was used by presenting subjects with a tune fragment followed by a true or false probe; true probes either fell within or across the boudaries generated by the similarity principles studied in Experiment 1. Since the probe was presented after the tune fragment, the differential ease of verifying within and across probes was supposed to reflect the part structure of the melody held in memory. In Experiment 3, the probe was presented prior to the tune fragment and served as a target to be monitored, in order to examine initial perceptual grouping of the melodies. The relative salience of the clustering determinants was found to vary across these last two experimental situations, particularly for the bounday created by a temporal pause. In both of these experiments, musical expertise was found to have little influence on the verification of the excerpts. Thus, the entire set of results argues for the necessity to define grouping determinants differentially in perception, memory, and introspection.

Analytic and synthetic perception of musical triads

John R. Platt, Department of Psychology, McMaster University

Musical chords, such as simple triads, can be perceived either analytically or synthetcally. In the former case, the spectral pitch of one of the component notes dominates. In the latter case, a unitary virtual pitch is heard which is thought to be related to the missing fundamental of the spectral pitches actually present. Two techniques were used to examine what tone chroma subjects hear when listening to isolated triads, how this percept changes with musical training and what the underlying mechanisms might be. When a paired-comparisons task was used to determine which note of a triad sounded most similar to the triad, musically inexperienced subjects showed no systematic preference, moderately experienced subjects consistently preferred the highest note in the triad and professional musicians split equally between preferring the highest note or the root note. Preference for the root note shifted to preference for the highest note as the triad type (major, minor, augmented and diminished) because the root note is based on inference of the missing fundamental. A technique in which subjects were asked to vocally reproduce the pitch they heard when listening to a triad obtained similar results, except that a preference for the root note was detectable in subjects with less musical experience. This suggests that

presenting triads in the context of simple tones may bias subjects to an analytic perceptual mode.

The perception of tonal clarity: How much can be explained by a simple acoustic model

W.F. Thompson, Department of Psychology, University of Queensland

A psychoacoustic model of perceived tonal clarity in music is outlined, and predictions based on the model are compared to judgments of tonal movement by trained musicians. The model tracks the changing correlation between the acoustic structure of music through time and the overall key, where each is represented as a profile of pitch-salience values. The acoustic structure of the music is calculated at each chord or beat in the music using an expanding mathematical box with exponentially greater weighting assigned to more recent events. The influence of overtones is evaluated by using different harmonics in the calculations of the acoustic structure of the music. The model is applied to excerpts from Bach chorales, Mozart sonatas, and jazz. For each excerpt, the changing tonal strength predicted by the model is compared to judgments of changing tonal strength by trained musicians. Where great discrepancies arise, cognitive influences on judgments are considered. The balance of cognitive and acoustic influences in the different styles of music is discussed.

Infants' perception of musical patterns

Sandra E. Trehub, University of Toronto, Erindale Campus, Mississauga, Ontario, Canada L5L 1C6

Adult's recognition of melodies does not depend on specific notes or note durations but rather on global pitch and temporal relations. To what extent does this pattern of processing derive from formal or informal exposure to music? Our extensive research with infants reveals that they also perceive musical patterns in a relational and holistic manner. After relatively little exposure to a melody, infants retain global information at the expense of local detail. For example, they encode the contour (ups and downs in pitch) of a melody, ignoring changes in key and interval size, and they focus on the rhythmic structure of a melody rather than its specific tempo. Are these abilities put to use in early life? There are indications that parental vocalizations to young infants reflect intuitive fine-tuning to infants' perceptual abilities. For example, parents from a wide variety of cultures emphasize musical aspects in their speech (e.g., its contour and rhythm) and de-emphasize semantic or syntactic aspects. It is possible, then, that infants enter the social and linguistic world by a musical route.

The perception of cadence stability: Effects of training, chord components, and tonal context

Margaret Weiser, Psychology Department, McMaster University

Cadences are rule-defined chord sequences. Listeners can rate the stability of simple two-chord cadences without knowledge of music theory. their ratings are affected by the listener's musical training, cadence type (chord progression moving toward or away from the tonic), position of the root (lowest or uppermost not position of the chord), direction of cadence resolution (upward or downward pitch change), and tonal context. The tonal context was an ascending or descending scale in the key of G-major or C-major played before each cadence trial.Musically trained listeners rated G-C cadences most stable in a C-major context, and C-G cadences more stable in a G-major context. Untrained listeners' ratings did not show an effect of key context. All listeners were biased toward cadences ending in the first inversion. This supports a "melody-tracking" interpretation, where listeners follow the uppermost chord voice. Whenever the cadence's root tones were in the uppermost voice, the cadence was rated more stalbe. The effect was strongest for untrained listeners, in particular for downward-resolving cadences. This suggests that untrained listeners can use contextual and chord components to rate cadence stability, although they are unable to express their knowledge verbally.

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