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Jérémie Voix

LETTER TO THE EDITOR AND PRESIDENT'S RESPONSE

As I have not been attending CAA meetings the last couple of years, I appreciate that Canadian Acoustics publishes the minutes of meetings of the Board of Directors and the Annual General Meetings. From the October 1998 meetings, I note that the CAA has managed to turn around what was advertised as a precarious financial situation two-and-a-half years ago in Calgary. This was the meeting where we (1) raised the membership fees and (2) removed the second award year for the Shaw Prize, based on the perception that there was insufficient money in the kitty to pay for all the good things we wanted to do. I also see that in the past year the CAA made a "profit" exceeding $35 per member, despite the fact that membership has dropped since we raised the fees.

It would appear that the CAA has overshot the mark by compounding a positive correction to revenues and a negative correction to expenses at the same time, where perhaps one of the two corrections might have sufficed on its own. Thankfully, a surplus is much easier to deal with than a deficit!

Part of the decrease in expenses can be attributed to the non-award of student and other prizes. My own experience as Awards Coordinator (in the past) and Fessenden Award Coordinator (current) has taught me that people don't apply for these awards if they are not vigorously promoted by the CAA. We used to send out a booklet with the awards rules and forms along with the December issue of Canadian Acoustics; this did not happen in 1997 or 1998.

Now that we have turned things around to the better--at least financially speaking--I hope the Executive and Directors will be discussing how to apply the surplus. I have some suggestions:

1. Vigorously promote our student and postgraduate awards;
2. Lower the fees and try to get back some of the members we lost; or
3. Generate some new membership benefits.

I agree that the CAA must maintain a solid financial footing; however, let us not lose sight of the goals of the Association.

Sincerely

David M.F. Chapman
Past President, CAA

I am happy to reply to Dave Chapman's letter as part of our editor's efforts to stimulate our journal. I have to say that I agree with many of Dave's sentiments and that I was one of those opposed to the large increase in membership fees in 1998. However, I think it is necessary to look a little deeper to find the real cause of our problem. At the 1998 meeting the executive supported the treasurer's recommendation for a modest $5. fee increase. However, the perhaps overly enthusiastic, group of members at the annual general meeting insisted on a $15 increase. This was probably not necessary to balance our books and was probably not in accord with the wishes of the majority of the members. The bigger issue is therefore, not so much how much money we may have, but how do we manage an organisation where the typically very small group of members at the annual general meeting can send us of in all directions? I think the answer is that major issues such as fee increases and perhaps voting for the executive and board members should be decided by mail vote.

This would involve changes to our bylaws but even a cursory reading of our bylaws suggests that they are not ideally matched to our current mode of operation. This would be a big job requiring some legal advice but I think it is time to take it on. What do you think?

John Bradley
President, CAA

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BEHAVIOURAL SPEAKER IDENTIFICATION A FORENSIC APPLICATION

(Application de l'identification d'un interlocuteur par son comportement)

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ABSTRACT

Behavioural speaker identification refers to the process of identifying an individual as the speaker of a given utterance, based solely on auditory perception. The present study applied behavioural speaker identification to evaluate the hypothesis that a particular individual had produced a set of utterances recorded in a police telephone tap. The individual admitted producing some of these utterances but denied producing others. Forty voice samples were extracted from 16 telephone calls recorded by the police, and one call with the individual, recorded by the experimenters. Two listeners rated the similarity of these samples in a paired-comparison task. Utterance pairs were grouped into pairs of potential speakers. An ANOVA was performed on the paired-comparison ratings with potential speaker pair and rater as factors. The effect of potential speaker pair was significant, suggesting that at least some of the utterances had been produced by different speakers. Utterance pairs in which both utterances were denied by the individual were rated as most similar, while utterance pairs in which only one utterance was denied by the individual were rated as least similar. A cluster analysis revealed two distinct clusters. All utterances denied by the individual fell into one cluster, while the other cluster was comprised of all utterances which the individual admitted producing, along with the recording of the individual's voice obtained by the experimenters. Overall, the evidence suggested that the individual was accurate in identifying which utterances he had produced.

SOMMAIRE

Identifier un locuteur par son comportement réfère au processus d'identification d'un individu qui dit un énoncé et ce, basé seulement sur l'information auditive. Dans la présente étude, l'identification d'un locuteur par son comportement a été appliquée afin de déterminer si un individu en particulier avait prononcé un énoncé potentiellement incriminant sur des enregistrements effectués par la police. Le suspect en question a admis avoir prononcé certains énoncés, mais nié en avoir produit d'autres. Quarante échantillons de voix ont été extraits de seize conversations téléphoniques enregistrées par la police et un appel au suspect a été enregistré par le chercheur. Des auditeurs ont noté les similarités de ces échantillons en effectuant des comparaisons par paires. Les paires d'énoncés ont ainsi été groupées en paires de locuteurs potentiels, en supposant que les énoncés d'un seula ppel ont été produits par un seul interlocuteur potentiel. Un ANOVA a ensuite été exécuté sur la comparaison des paires notées selon les paires de locuteurs potentiels, avec les évaluateurs comme facteurs. L'effet du locuteur potentiel s'est avéré significatif, ce qui suggère que certains des énoncés ont été produits par des locuteurs différents. Les paires d'énoncés comprenant deux énoncés niés par le suspect ont été notés de façon plus similaire que les paires où seulement un des deux énoncés avait été nié par ce dernier. Ainsi, une analyse de groupe a révélé deux groupes distincts. Tous les énoncés niés par le suspect se sont retrouvés dans un groupe, tandis que l'autre groupe se composait de tous les énoncés que le suspect avait admis avoir produits et ce , selon l'enregistrement du suspect obtenu par le chercheur. En somme, les résultats suggèrent que le suspect avait correctement identifié les énoncés qu'il avait lui-même produits.

1. INTRODUCTION

The present study focused on the role of acoustic evidence in a recent criminal investigation regarding the trafficking of narcotics. Under court order, a suspect's telephone line was tapped, and numerous telephone conversations were recorded. Based on perceptual judgements, a police analyst identified another person as being the specific individual in conversation with this suspect, during a number of telephone conversations, including several that were potentially incriminating. This person acknowledged participating in some calls, but denied that he was the speaker in most of the calls, contending that these other calls had been made by another individual. In order to provide evidence for this claim, the defense lawyer contacted the second author (D.G.J.) to request a voice analysis. The present study was undertaken to determine the likelihood that the police hypothesis was correct, and that the individual was in fact the speaker on all the recorded calls, including those that were incriminating.

1.1 Issues in Speaker Identification

Two basic approaches to speaker identification are distinguished: "technical" and "naive" (Nolan, 1983). The first category includes all methods that involve informed analysis, such as visual comparison of spectrograms, acoustic analyses (e.g., comparison of fundamental frequency, formant frequency, formant bandwidth, etc.), and comparison via phonetically trained listening. The second category includes those methods in which no specialized training is required for analysis. The identification is achieved behaviourally (through perceptual judgements), with listeners who are not phonetically trained. "Earwitness" testimony falls into this category.

In the present case, the quality of the recordings complicated definitive acoustic analysis, as many of the telephone calls had been made from cellular telephones, and the spectral characteristics of the signal and the noise varied widely from call to call. Visual spectrographic inspection was also rejected, since this method has been shown to be less accurate than naive perceptual judgement (Nolan, 1983). In view of these limitations, the current study employed naive behavioural speaker identification[1].

Legal evidence based on naive behavioural speaker identification (earwitness testimony), has been surrounded by controversy through its entire history of usage (McGehee, 1937). The legal value of such evidence remains in question (Van Wallendael, Surace, Parsons & Brown, 1994). Earwitness judgments are subject to the effects of expectancy bias (Orchard & Yarmey, 1995), limited attention (Armstrong & McKelvie, 1996; Hammersley & Read, 1985; Saslove & Yarmey, 1980), and memory inaccuracy (Clifford, Rathborn & Bull, 1981; McGehee, 1937; Palmeri, Goldinger & Pisoni, 1993; Saslove & Yarmey, 1980). Interestingly, the psychological literature is replete with studies expressing similar limitations and failings with respect to eyewitness testimony (e.g., Lipscomb, McAllister & Bregman, 1985; Rantzen & Roslyn, 1992), although eyewitness testimony remains an important and valued form of legal evidence.

In part, concerns over earwitness testimony stem from the fact that the testimony is based on acoustic events, which are transient and intangible. While an eyewitness can usually identify a perpetrator with little difficulty, an earwitness has the difficult task of inferring the identity of a perpetrator on the basis of voice information (Hollien et al., 1983; Legge et al. 1984). One aspect of the challenge of speaker identification is the absence of any means of generating a comparative stimulus from witness descriptions. While forensic sketch artists are often able to generate a picture of a perpetrator on the basis of a witness description, they are not similarly able to generate a sample of a perpetrator's voice. Voice information lacks a static representation which can be easily drawn or described, and thus speaker identification is extremely vulnerable to error (Hollien, 1990; Saslove & Yarmey, 1980). Nevertheless, speaker identification is necessary for valuable earwitness testimony, just as visual identification is necessary for eyewitness testimony. This is a negative implication for earwitness testimony, and contributes to its uncertain status. However, regardless of the difficulties with speaker identification, earwitness testimony relating to a recorded or remembered voice may constitute critical evidence in a case.

Given that speaker identification requires the use of recorded voice samples, an important consideration in such identification tasks concerns the length of the voice sample required for accurate identification. Research indicates that sample duration does affect identification performance, but not in a straightforward manner. Yarmey and Matthys (1992) found that hit rate did not reliably increase, and false alarm rate did not reliably decrease as voice sample duration increased from 18 seconds to six minutes. However, in other work, hit rate was reported to increase when voice sample duration was increased from 30 seconds to eight minutes

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1. An alternative, using phonetically trained listeners, lacks supportive research (Nolan, 1983), and its potential superiority over naive speaker identification has not been established. Also, unlike naive identification, the influence of various factors on phonetically-based identification is unknown. Moreover, research has demonstrated that listeners are able to identify speakers accurately without any special training (Armstrong & McKelvie, 1996; Bull, Rathborn & Clifford, 1984; Goggin, Thompson, Strube & Simental, 1991; Hollien, Bennet & Gelfer, 1983; Kreiman & Papcun, 1991; Legge, Grosmann & Pieper, 1984; Palmeri et al., 1993; Yarmey, 1994).

(Orchard & Yarmey, 1995). In contrast, smaller increases in sample duration have not reliably resulted in superior speaker identification (Bull & Clifford, 1984). In one study (Haggard, & Summerfield, 1982, cited in Bull & Clifford, 1984) speech samples of less than two seconds produced poor recognition accuracy. It has been shown, however, that speaker identification can be performed with high accuracy rates on the basis of a single syllable. Bricker and Pruzansky (1966) demonstrated that naive listeners were 84% accurate when identifying familiar speakers on the basis of a syllable. Similarly, Williams (1964, cited in Bull & Clifford, 1984) found that listeners could identify a speaker with 93% accuracy in a same-different task with one-syllable utterances, although error rates were lower for two and three-syllable utterances. Pollack, Pickett, and Sumby (1954) found that recognition accuracy for voice improved little with increases in duration beyond one second. While the literature is by no means unanimous, we concluded that identification based on a single word had good prospects for success.

In the current experiment, each voice sample was a token of the word 'okay', extracted from one of the recorded telephone conversations. This selection was motivated by the assumption that speaker identification would be facilitated in a text-dependent context (i.e. with phonemically identical samples), and 'okay' was the largest common phonemic element across the utterances. Comparing (potentially) different voices within the structure of a single word permitted direct phonemic contrasts (e.g., comparing /k/ to /k/) as opposed to non-phonemic contrasts (e.g., comparing /k/ to /n/). Moreover, in accordance with research demonstrating successful speaker identification with one syllable (Bricker & Pruzansky, 1966; Williams, 1964, cited in Bull & Clifford, 1984), the length of the sample was deemed sufficient.

1.2 Objectives

The objective of the study was to test the police hypothesis that the suspect had spoken on each of a particular set of calls. This hypothesis was tested by determining the likelihood of there being more than one voice in the set of attributed utterances, on the basis of same/different listener ratings. A high likelihood of there being more than one voice in the set would constitute evidence against the police hypothesis. Conversely, given that the individual had admitted to producing some of the utterances, a high likelihood of there being only one voice in the set would constitute evidence in favour of the police hypothesis.

Subsequent evaluation of the police hypothesis was accomplished in relation to the suspect's contention. Prior to the experiment, an interview was conducted in which the suspect identified all of the calls in which he had participated. On this basis, the utterances were divided into two categories: utterances from calls in which the suspect admitted participating, and utterances from calls in which the suspect denied participating. Mean similarity ratings were then determined for calls within and between these categories. Higher similarity ratings for calls within categories than between categories would support the suspect's contention, and provide evidence against the police hypothesis. Lack of any differences in similarity ratings would support the police hypothesis.

2. METHOD

2.1 Stimuli

Twenty-four samples of the word 'okay' were selected from the utterances recorded by the police. These samples were taken from 16 separate telephone calls, and thus represented 16 potential speakers. The distribution of the 24 samples was as follows; 10 of the calls contained a single sample, 5 calls contained two samples, and 1call contained four samples. An additional 16 samples were obtained during a subsequent telephone conversation with the suspect, and recorded to tape with the suspect's full consent. In total, 40 samples were extracted from 17 telephone calls, and thus 17 potential speakers were represented in these samples. Samples were selected from calls in which the suspect admitted participating and from calls in which the suspect denied participating.

All conversations had initially been recorded on audio cassette tape. The utterances were digitized with 16-bit resolution at a frequency of 22 kHz, low- pass filtered at 10 kHz., and edited using CSRE (Avaaz, 1996). Editing isolated the word 'okay' from the surrounding acoustic information, and saved each utterance to an audiodata format (.adf, Avaaz, 1996) file.

2.2 Procedure

Two subjects who reported normal hearing ability rated pairs of samples of 'okay' as same or different (i.e., same or different speaker), and indicated the certainty of their response. There were four response alternatives: same-certain, same-uncertain, different-certain, and different-uncertain. Subjects were informed as the nature of the task, and were aware that the number of voices present in the sample was unknown.

Samples were presented to the raters monaurally, at a comfortable listening level. All samples were presented via ER-3A insert earphones, using the ECoS/Win experiment controller (Avaaz, 1997). Samples in each pair were played successively, and could be repeated as many times as desired by the listener. After each response, the computer recorded the response, and cycled to the next trial. The next pair was presented automatically, following a 500 ms interval.

All possible pairs of the 40 stimuli were used in the task, except that no stimulus was ever paired with itself. Thus, each listener rated 1560 pairs of the word 'okay' (780 pairs in both orders). The pairs were randomized across 20 blocks, containing 78 pairs each. Each listener completed the blocks in random order, with a short rest between each block. After completing 10 blocks (780 pairs), the test session stopped, and the remaining 10 blocks were completed on a subsequent day. Subjects required approximately one hour to complete each set of 10 blocks.

3. RESULTS AND DISCUSSION

3.1 Rater Accuracy

An estimate of rater accuracy was generated by comparing the hit rates for pairs in which both samples had been extracted from a single telephone call, as these pairs had to have been produced by the same speaker. Responses of "same" for such pairs were counted as hits without respect to certainty. The samples obtained in our own recordings were not included in this comparison, however, because the quality of these samples was superior to that of the samples obtained by the police. Overall, the average hit rate was 0.89. This estimate is similar to that reported by Williams (1964, cited in Bull & Clifford, 1984), who found that subjects could identify a speaker with 93% accuracy in a same-different task with only one-syllable. This estimate of accuracy should be treated with caution, however, because samples from within a telephone call also shared acoustic information apart from voice spectra (such as specific telephone noise), which could have contributed to the same-different decision, and inflated the accuracy rate.

3.2 Analysis of Variance

The primary goal of the study was to test the police hypothesis that there was but one speaker in the set of imputed utterances. For the purposes of analysis, the utterances were grouped according to the telephone calls from which they had been extracted, such that all utterances extracted from a call were considered to be equivalent (i.e., produced by the same speaker). Since the utterances from the police recordings were extracted from 16 different telephone conversations, 16 groups of utterances were formed, representing 16 potential speakers. Utterance pairs were accordingly recoded as 126 pairs[2] of potential speakers. The utterance pair ratings were then subjected to an ANOVA with potential speaker pair and rater as factors.

The effect of potential speaker pair was significant ($F(125,251) = 14.15, p < 0.001$), indicating that the ratings (i.e., same-certain, same-uncertain, different-certain, & different-uncertain) differed significantly with potential speaker pair. This result indicates that there were highly reliable differences in the judged similarity of utterances across recordings, which suggests that the police hypothesis was incorrect, and that the utterances may have involved more than one speaker. However, significant differences in ratings across potential speaker pairs could also have reflected different levels of certainty in the ratings, which would be expected, given the varying quality of the samples obtained by the police. Thus, the data were recoded to collapse across levels of certainty, and a second ANOVA was conducted. The effect of potential speaker pair was highly significant in this analysis ($F(125,251) = 10.80, p < 0.001$), indicating that the significant differences in the same/different ratings could not be attributed to differences in certainty. Moreover, given that the original police hypothesis had also been generated by listening to voice samples of varying quality obtained in the telephone tap, the different conclusion reached by these raters cannot be easily dismissed, and provides sufficient reason to doubt the police hypothesis.

There was also a significant main effect of rater ($F(1,125) = 4.05, p < 0.05$) and a significant interaction between potential speaker pair and rater ($F(125,251) = 1.50, p < 0.005$). This indicates that the two raters were not in complete agreement, or did not share the same degree of certainty regarding their decisions. To evaluate these possibilities, the effect of rater was examined with data recoded to collapse across levels of certainty. There was no significant main effect of rater in this re-analysis, suggesting that the differences between the ratings made by the different raters were based on differences in certainty. However the interaction between rater and call pair was significant ($F(125,251) = 1.32, p < 0.05$), indicating that the raters may have used different factors or weights in their rating decisions[3].

For the next analysis, samples were categorized in accordance with whether they had been extracted from a call in which the suspect admitted participating (A), denied participating (D), or had participated in for the purposes of this experiment (S). On the basis of these types, each potential speaker pair was categorized as one of six possible combinations. The ratings

2. There were only 120 pairs of potentially different speakers. The six remaining pairs were instances where multiple utterances were extracted from the same call.

3. Since short (two-syllable) samples were used in the present study, it might be suggested that the samples were not long enough for the raters to make accurate voice similarity ratings, which would discount the decisions of these raters in relation to the decisions of the police. However, because the raters in the present study were reasonably accurate in their decisions (e.g., hit rate of 0.89), the lack of complete agreement between them does not undermine their challenge to the police hypothesis.

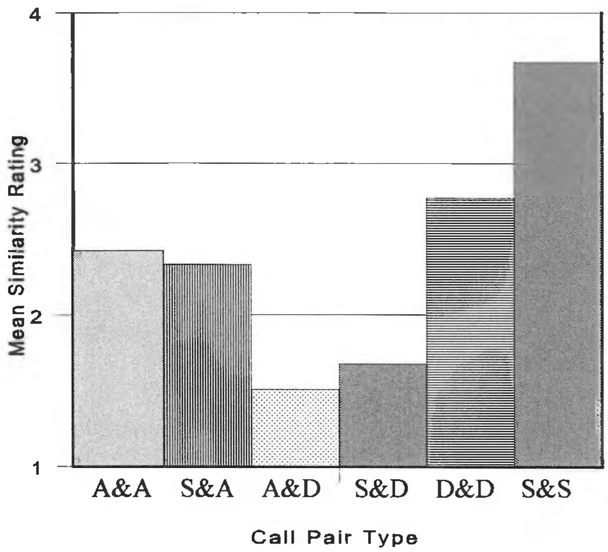

Figure 1: Similarity ratings forpairs of utterances from calls in which the suspect participated (S), admitted participating (A), or denied participating (D).

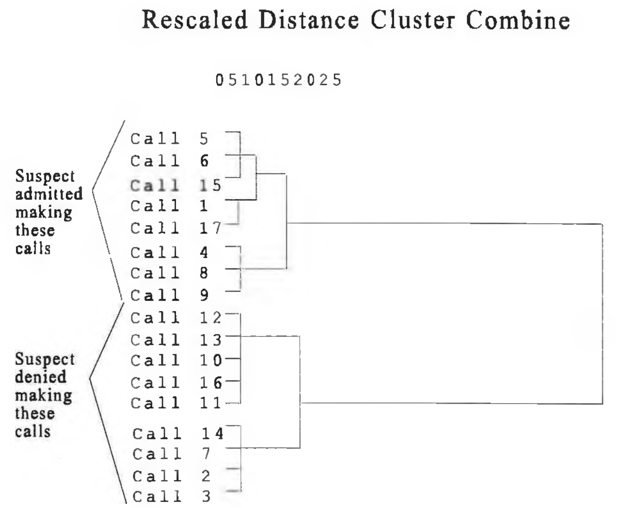

Figure 2: Results of cluster analysis on similarity ratings for all calls

were then subjected to a one-way ANOVA with speaker pair type as the independent variable. The effect of speaker pair type was significant (F (5,3119) = 666.07, p < 0.001), indicating that similarity ratings were different for the various speaker pair types. Mean similarity ratings were calculated for each type of pair[4], and are presented in Figure 1. A Tukey's HSD (Honestly Significant Difference) posthoc test of means indicated that all means were significantly different, except for the means of the first call pair type (A & A), and the second call pair type (S & A). The highest mean similarity ratings were obtained for pairs in which both samples were extracted from the recordings of the suspect obtained by our lab. This is not surprising, as these samples were extracted from a single telephone conversation (thus reflecting voice characteristics at a single point in time), were of relatively high quality, and were free from background and channel noise. Pairs of samples extracted from calls in which the suspect admitted participating were rated as fairly similar to each other, as were pairs involving these samples and samples from our recording of the suspect. However, both of these types of samples were rated as less similar to samples from calls in which the suspect denied participating. Conversely, samples from calls in which the suspect denied participating were rated as highly similar to each other. These results suggest that the suspect had been accurate in identifying calls in which he had and had not participated, and that the police hypothesis is incorrect.

4. A rating of four was equivalent to the decision that samples were certainly from the same speaker (i.e., same-certain). A rating of one was equivalent to the decision that samples were certainly from different speakers (i.e., different-certain).

The high similarity ratings for samples extracted from calls in which the suspect denied participating suggest that these samples likely were produced by another single speaker, and accordingly support the suspect's initial contention that most of these calls were made by another single speaker. Nevertheless, it is also possible that these calls were made by the suspect using a disguised voice, or a number of speakers with highly similar voices. While the latter possibility is unlikely, it is difficult to rule out the possibility that the suspect successfully disguised his voice.

3.3 Cluster Analysis

In order to gain a better understanding of the relationships between the samples, a cluster analysis was performed, using Ward's method of agglomeration (Ward, 1963). The analysis was performed on a matrix in which each of the 17 calls was treated as both a distinct case and a unique variable. The value for each of the cases on each of the variables was accordingly defined as the mean similarity rating for that call pair[5]. Clusters were thus formed on the basis of perceived voice similarity, as coded by the ratings of the unique pairs[6].

5. Prior to computing the mean similarity ratings for each call pair for the cluster analysis, the data was recoded such that higher similarity ratings were represented by lower numbers. Thus, for this analysis, a rating of one was equivalent to the decision that samples were certainly from the same speaker, and a rating of four was equivalent to the decision that samples were certainly from different speakers. Mean similarity ratings could then be treated as distances between call pairs.

6. Using Ward's method of agglomeration, cases or clusters are combined in sequential order based on squared Euclidean

The samples extracted from our own recording were included in this analysis, in order to determine the perceptual relationship between the suspect's voice and the other voice samples. Thus, 143 pairs of potential speakers, based on 17 different calls, were subjected to the cluster analysis. From this analysis, two distinct clusters emerged (see figure 2). These distinct clusters clearly suggested the presence of two strong voice percepts in the set of samples, and supported the suspect's contention that the police hypothesis was incorrect.

The clusters could also be explained, however, on the basis of telephone channel noise or spectral distortion resulting from the use of certain telephones, or background noise specific to particular calling locations. It could be argued that all of the calls had been made by a single speaker, but the voice characteristics on the calls in each cluster differed due to the use of different cellular telephones, each effecting a particular distortion of the voice and adding specific channel noise. While this argument is tenable, it seems more likely that the clusters represent two different voices. The suspect's voice, obtained in a staged telephone tap for the purposes of the experiment, fell neatly into one of the clusters. Unlike the 16 calls recorded by the police, this call (coded as call number 17- see figure 2) had very little channel noise, and very little spectral distortion. If the clusters were based on similarities of channel noise and spectral distortion, call number 17 would not have clustered with any of the police calls. The fact that this call fell into a cluster strongly suggests that the clusters were not based on telephone channel noise and spectral distortion, but rather on voice characteristics.

Another feature of the analysis provides support for the suspect's contention. When the results of the cluster analysis are compared with the suspect's claims regarding his participation in each of the calls, an interesting pattern emerges. Every call in which the suspect admitted participating (1, 4, 5, 6, 8, 9 & 15) fell into the first cluster, and every call in which the suspect denied participating (2, 3, 7, 10, 11, 12, 13, 14, & 16) fell into the second cluster. Moreover, the recording of the suspect's voice (call 17) fell into the first cluster (i.e., with all the other calls to which he admitted). This is strong evidence in support of the suspect's testimony, and in opposition to the police hypothesis.

4. GENERAL DISCUSSION

The results of the experiment suggest that the suspect did not produce all of the utterances attributed to him by the police. The analysis of variance indicates that similarity ratings were not uniform for all paired-comparisons. And while the raters in this experiment were not in total agreement, the relatively high degree of accuracy that they achieved indicates that their decisions cannot be easily dismissed in favour of the decision of the police. Most importantly, the results of the cluster analysis clearly indicate the presence of more than one voice in the set of utterances attributed to the suspect. The cluster analysis also supported the suspect's claims in regard to the specific calls in which he did and did not participate. Thus, the present experiment provides numerous lines of evidence in support of the suspect's contention that the police hypothesis was incorrect.

As is common in forensic investigations, the results of the present study do not provide conclusive evidence regarding the innocence or guilt of the suspect. In fact, it is quite possible that the all of the utterances were produced by the same speaker, in spite of the evidence to the contrary. For example, there remains the possibility that the suspect disguised his voice on certain calls (e.g., calls relating to criminal activity, which he would later not admit to making), intentionally creating a false voice percept. Such a disguise, if performed convincingly, could have produced the results of the present study, given that listeners may have difficulty distinguishing a disguised voice from a different voice (Hollien, 1990). In the present case, the likelihood of attempted voice disguise is supported by evidence that speakers suspected that their telephone conversations were being monitored, in that the speakers discussed potentially incriminating matters only indirectly. Thus, although the results of the study suggest that the police hypothesis is incorrect, they clearly do not establish the innocence or guilt of the suspect.

However, the value of such research can be found in the various ways in which it improves the process of forensic investigation. This study sought to quantify the degree to which the voice samples were similar or different, via paired-comparison ratings. In contrast, the police hypothesis was based on the conjecture of officers transcribing audio tapes, and the likelihood of its veracity could not be established quantitatively. This has important implications for the admission of such evidence in the legal system. The value of any evidence in the legal system must be weighed carefully according to the likelihood that the evidence is accurate. Thus, providing statistics which can reasonably quantify the value of evidence may assist the legal process.

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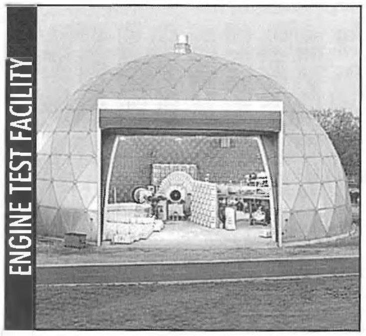

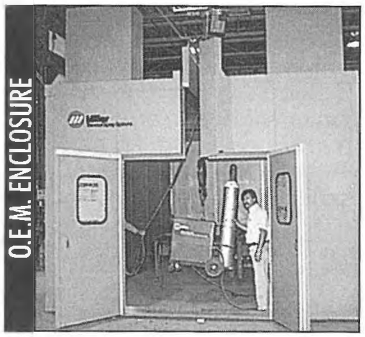

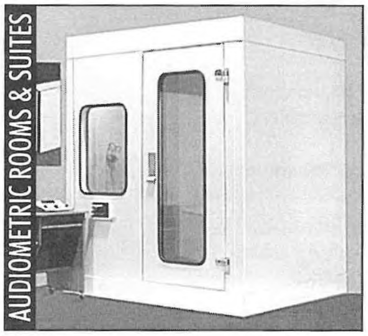

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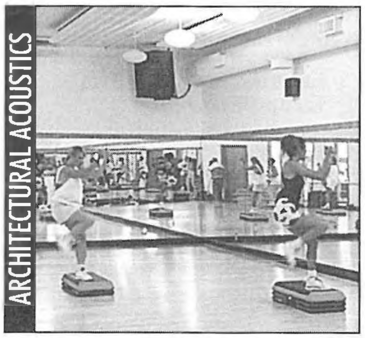

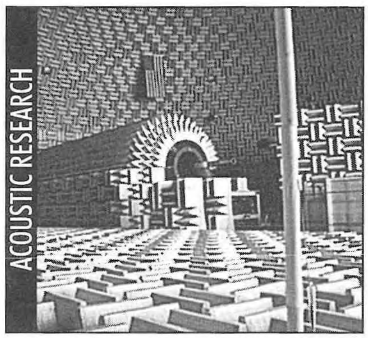

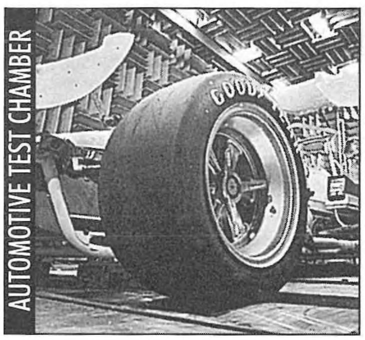

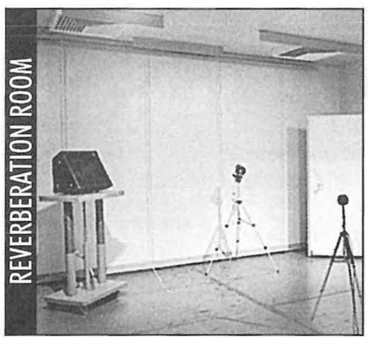

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NOISE CONTROL TECHNOLOGIES

STUDY OF NOISE LEVELS IN A NEONATAL INTENSIVE CARE UNIT

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ABSTRACT

The integrated care approach has been a focal point of interest for the past few years. In this approach, noise is viewed as a compromising element in the normal development of newborns in neonatal intensive care units. The objective of this study was to develop a methodology that could evaluate the impact of a training program designed for nurses regarding existing noise levels within a neonatal intensive unit. This method entails measurements of noise levels and their sources. The method's development was based on a continuous evaluation of noise levels in a neonatal intensive care unit (NICU), using a computer (type 1 sound-level metre) before the nurses' training. In order to evaluate the impact of the nurses' training, noise level measurements obtained before training at described locations are to be repeated after training. LAeq,1sec, as well as audio samples were recorded throughout 8 work shifts. The project was conducted in an Ottawa regional hospital that specializes in the treatment of sick children. The average pre-training noise levels were 53 dBA, 61 dBA and 65 dBA, for the night, day, and evening shifts respectively. These levels largely exceed the maximum sound level of 40 dBA recommended by the World Health Organization to avoid negative effects on sleep in hospitals. On the basis of this study, the training of nurses likely contributes to the reduction of noise levels in NICUs, but interventions concerning noise control are also necessary in order to ensure an acceptable sound environment for neonates requiring intensive care. (Project supported by the University of Ottawa)

SOMMAIRE

Au cours des dernières années, l'approche de soins intégrés a retenu l'attention. Entre autres, le bruit est considéré comme un élément qui peut compromettre le développement normal des nouveau-nés dans les unités de soins intensifs (NICU). L'objectif de cette étude était de développer une méthodologie qui permettrait d'évaluer éventuellement l'impact d'une formation des infirmières sur les niveaux de bruit prévalant dans les unités de soins intensifs. La méthode porte sur les mesures de bruit et leur source. L'élaboration de la méthode a été basée sur une évaluation continue des niveaux de bruit dans un NICU, avant la formation des infirmières, en utilisant un ordinateur (sonomètre, classe 1). Dans le but d'évaluer l'impact d'une formation des infirmières, les mesures des niveaux de bruit obtenus avant la formation devront être reprises après la formation. Des LAeq,1sec., ainsi que des échantillons audionumériques, ont été enregistrés lors de 8 périodes de travail. Le projet a été mené dans un hôpital pédiatrique de la région d'Ottawa. Les niveaux moyens de bruit pré-formation étaient de 53 dBA, 61 dBA et 65 dBA, pour la nuit, le jour et la soirée, respectivement. Ces niveaux dépassent largement le maximum de 40 dBA recommandé par l'Organisation Mondiale de la Santé afin d'éviter les effets négatifs sur le sommeil. Sur la base de cette étude, il est prévu que la formation des infirmières devrait contribuer à réduire les niveaux de bruit, mais que des interventions de contrôle du bruit à la source devront aussi être menées afin d'assurer une ambiance sonore acceptable pour les nouveau-nés qui requièrent des soins intensifs. (Projet financé par l'Université d'Ottawa)

1. INTRODUCTION

In the past few years, efforts have been made to improve the physical and psychological environments of neonates within neonatal intensive care units (NICUs) (Als, Lawhon, Duffy, McAnulty, Gibes-Grossman & Bicikman, 1994; Merenstein, 1994; Oehler, 1993; Tucker Blackburn & VandenBerg, 1993). The impetus for this study came from caregivers based at Children Hospital of Eastern Ontario (CHEO), who were interested in applying and assessing the benefits of individualized care. In particular, they wished to measure the effect on physiological outcome and length of stay in the neonatal intensive care unit, of training nurses in this methodology. For this reason, it was crucial to assess the validity and reliability of the evaluation method, in order to assess the outcome of the training program. Above all, the caregivers at CHEO wanted to focus on the aspect of noise in NICUs.

2. LITERATURE REVIEW

The presence of noise in hospitals has become a major concern for both caregivers and researchers alike (Kurdahi Zahr & Balian, 1995; Elander & Hellström, 1995; Strauch et al., 1993; Topf 1992a & b; Hodge & Thompson, 1990; Topf & Dillon, 1988; Webster & Thompson, 1986; Topf, 1985; Aitken, 1982). In a document on community noise prepared for the World Health Organization, Berglund & Lindvall (1995) recommended that the maximum sound level should not exceed 40 dBA in order to maintain an acceptable environment for sleep in hospitals. The most important aspect is to ensure a low background noise level, such as 30 dBA. According to this internationally-used document, efforts should be made to reduce peak noise levels as well as the number of noise events before reducing the background equivalence level.

Anagnostakis, Petmezakis, Messaritakis & Matsaniotis (1980) documented relatively high noise levels (48-56 dBA) in a neonatal intensive care unit. Although these levels are considered safe for adults, these researchers expressed their concerns regarding the physiological and psychological effects of these noise levels on premature neonates. Thomas (1989) commented that, given the immaturity of their central nervous systems, premature neonates cannot inhibit auditory stimulation. In fact, the functional integrity of the central nervous system is very precocious and, as a result, a slight tap or blow to the incubator, which can generate noise levels of 70 dBA or 95 dBpeak, can trigger apnea or bradycardia. Many other negative effects have been associated with noise, including hypoxemia, intraventricular hemorrhage (Long et al., 1980), and reduced sensibility to auditory stimulation (Segall, 1972). Thomas (1989) also stated that noise levels tend to be higher with the complexity of the care/treatment. Consequently, the most vulnerable children were exposed to highest noise levels.

Tucker, Blackburn & VandenBerg (1993) and Oehler (1993) also supported Thomas' findings by reporting the negative effects of the high noise levels in NICUs, insisting that neonates are at risk of neuro-developmental problems when the physical environment is not sufficiently controlled. Deficits, hyperexcitability and language difficulties are some of the problems that were encountered with the development of these children. Moreover, these authors brought attention to the fact that premature neonates spend several weeks to several months in an environment which is far different from that found inside the uterus. Finally, Thomas (1989) listed a number of potential solutions for noise reduction, such as the modification of warning alarms, less abrupt handling of the equipment (e.g. blows to the incubator, closing doors), the purchase of quieter equipment and the modification of caregivers' habits (e.g. limit conversations near the incubators).

A recent study by Als et al. (1994) demonstrated that the developmental approach, which aims to ensure a controlled environment (such as noise) for premature neonates, can provide tangible results. In order to demonstrate this, training based on the "Individualized developmental care for the very low-birth-weight preterm infant" model was given to a group of nurses responsible for the care of an experimental group of neonates. A control group received conventional care specific for this population. The researchers concluded that the neonates in the experimental group warranted less mechanical ventilation and oxygen than those in the control group. Furthermore, the children in the experimental group showed a reduced incidence rate of intraventricular or pneumothorax hemorrhaging, improved daily weight gain and younger age of discharge from the hospital.

During a recent conference, Canadian neonatalogists insisted on the need to study noise levels and characteristics in NICUs, in order to eventually assess the effect of noise reduction on neonates (Walker, 1995). Two studies have demonstrated that this can be done (Elander & Hellström, 1995; Strauch et al., 1993). Both studies insisted on the collaborative efforts of all health care providers within the unit as well as the relative low cost and easy implementation of noise reduction methods. Among the most effective methods were: reducing verbal and radio noises, forwarding telephone calls to a more peripheral site, and coordinating the timing of laboratory procedures. However, there are limits associated with both studies cited.

For example, few details are given about the measurement protocol (identification of noise sources, microphone placement, type of dB used). As a result, the focus of the present study is on the development of a rigorous method of noise level measurements.

3. OBJECTIVES

The objectives of this study included: (1) the development of a valid and reliable method of noise level measurements within a neonatal intensive care unit, in order to eventually evaluate the impact of the training program, (2) the documentation of the principal noise sources in terms of origin and levels, prior to the training of the caregivers, and (3) the drafting of recommendations in regards to the reduction of noise levels in NICUs (where the sources are the caregivers, the instruments and the environment).

4. METHOD

4.1 Instrumentation

The equipment used in this study included a Toshiba T5200 portable computer equipped with 01dB software (dB Trig: equivalent to a Type 1 integrating sound level meter (CEI 804,1985), a 1/2" microphone (Cirrus) with windscreen, and a 1 kHz-94 dB calibrator.

4.2 General Procedure

Since one of the objectives of this study was to eventually analyze noise level differences before and after the nurses' training, the noise measurement procedure had to be very strict and representative of the noise encountered on a typical day in the NICU. In order to do so, different methods were consulted such as the standards related to noise measurements (e.g. CSA Standards Z107.56, 1994), and the methods proposed for the work environment (Laroche, 1989) and other environments such as nursery schools (Truchon-Gagnon & Hétu, 1988). The methods for noise level measurements intended for nursery schools were favored in this case, since they can account for a multitude of noise sources, and the very variable noise characteristics encountered in NICUs (Truchon-Gagnon & Hétu, 1988). In fact, these methods combine two complementary approaches. The first is a quantitative approach which aims to evaluate noise levels, by means of a sound level meter, at different times of the day and for different noise sources. The second is a qualitative approach which aims to obtain the maximum amount of information regarding noise sources and their origins, by means of an observation chart (Bélair, Lafleur, et Leroux, 1986).

Quantitative and qualitative noise samples were taken during eight periods of approximately six hours each, including three day shifts (7am to 3pm), three evenings shifts (3pm to 11pm) and two nights shifts (11pm to 7am). The use of computerized measurement equipment (01 dB software on Toshiba T5200) was chosen in order to collect as much data as possible at one site. Moreover, the computerized measurement system permitted the recording of digitized sound samples directly onto a hard-drive. These audionumeric recordings consisted of a few seconds each and were obtained approximately every five minutes. These recordings allowed a comparison with the measured sound levels and facilitated the recognition of noise sources identified by means of an observation chart. This procedure also served as a validation tool for the research assistant's visual and auditory observations.

The noise-level measurements did not, at any time, interfere with the work of the nursing staff. The microphone was positioned 1 meter from the neonate's head. The microphone positions were chosen to allow for a more accurate characterization of the noise levels throughout space. The exact microphone placement will be repeated in each room after the training session, in order to correctly recreate the testing scenario. The data collection of the noise-level measurements after the nurses' training, will be the object of another project.

A major concern during the data-collection procedure was to ensure that no bias existed while the measurements were being taken. The nursing staff, clinicians and parents were all informed that noise measurements were being taken during the eight week period and that the audio-recorded data collected would remain confidential. Also, in order to ensure the representativeness of the noise environment, the nursing staff was consulted daily at the end of each measurement period. Had the nurses stated that the measurements were not representative, we would have eliminated the data during those shifts.

4.3 Specific procedures for noise level measurements

The noise level measurements were performed according to the method prescribed in CSA Standards Z107.56 (1994). In all instances, the computerized sound level meter (01 dB software) was calibrated *in situ* by the use of an acoustic calibrator (1 kHz, 94 dB), prior to and following each measurement session. If, at the end of the measurement, the calibration had shifted more than 0.5 dB, the data would have been discarded. Also, the microphone was positioned 1 meter from the neonate's head. For each of the microphone placements, the following data were collected: (a) description of the activities in the room's surroundings (by means of an observation chart), (b) duration, date and time of measurement, (c) $L_{Aeq,1sec}$. (A-weighted equivalent continuous sound pressure level for each 1 second period), (d) percentage of the average time devoted to each activity, and (e) microphone placement.

4.4 Description of the neonatal intensive care unit at CHEO

The NICU at CHEO consists of three rooms and a reception area. Figure 1 shows a diagram of room #3. The noise measurements were performed in rooms #2 and #3 since room #1 was rarely used. Each room can be occupied by up to eight infants, whether in cribs, bassinets, incubators or beds with overhead heaters. In rooms #2 and #3, both side walls had windows from mid-wall to ceiling. The walls in both rooms were covered with gyps, the floors were covered with ceramic tiles and ceilings were surfaced with acoustic tiles. A rectangular melamine covered work station containing two computers and a sink was located in the centers of each of the rooms. A second sink was located at the entrance door, along the front wall. A telephone and an intercom system speaker were placed beside the door. The metal-covered ventilation system was located on the back wall on the right hand side. Typically, three to four infants were placed along the two side walls, to a maximum of eight to a room.

5. DATA ANALYSIS

5.1 Analysis of sound level measurements

The data were analyzed according to the qualitative and quantitative approaches. The observations obtained by means of the chart were paired with the sound levels measured by the computerized measurement system. The noise levels were then averaged for each typical situation in the NICU, as well as for each half hour, one hour, day, evening and night periods. The data are presented in tables to facilitate their comparison, as well as their comparison to the post-training measurements. The data presented in the Table 1 are divided on the basis of the time of day of the work shift. As a result, there are three sets of data (day, evening and night) displaying the sound level measurements obtained on those various day, evening and night shifts. Also, the ceiling (L_5) and floor (L_{95}) noise levels are displayed in Table 1. The L_5 or ceiling noise levels indicate that only 5% of all noise levels would be superior to this given value. On the other hand, the L_{95} or floor noise levels indicate that 95% of all noise levels would be superior to this given value.

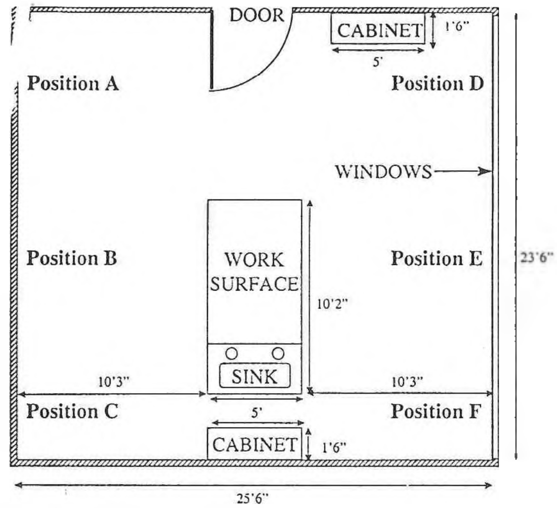

Figure 1. Diagram of room #3

5.2 Determination of the occurrence of presentation of various noise sources

The total number of occurrences for each of the identified noise sources was listed for each of the measurement periods. This total was then divided by the duration of the measurement period, in hours, which produced a number of presentations per hour. As for the samples of the infants' speech and cries, the duration and occurrence of these presentations were combined and are therefore presented as a percentage of time.

6. RESULTS AND DISCUSSION

6.1 Sound level measurements

An example of the variation of sound levels obtained in the course of the first day shift are presented in Figure 2. Although it may be interesting to study the variation in sound levels from one day to another for the same time period, it may also be useful to measure the sound level variations within a 24 hour period. Table 1 gives minimum and maximum overall L5 and L95 values for each time period.

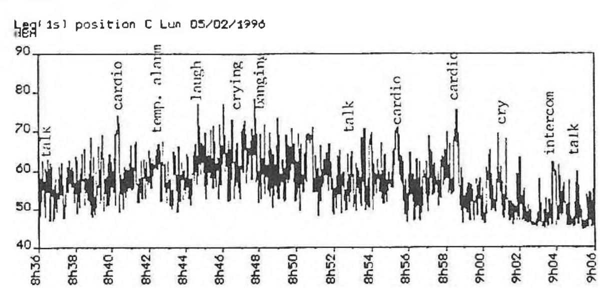

Figure 2. Example of the sound pressure level's evolution (dBA) as a function of time. Different sound sources are identified on the figure.

	Day shifts		
	Overall	L_{95}	L_5
Sound levels	59-62 dBA	48-51 dBA	65-67 dBA
AVERAGE	61 dBA	50 dBA	66 dBA
	Evening shifts		
	Overall	L_{95}	L_5
Sound levels	61-65 dBA	45-61 dBA	65-68 dBA
AVERAGE	63 dBA	57 dBA	67 dBA
	Night shifts		
	Overall	L_{95}	L_5
Sound levels	48-55 dBA	39-47 dBA	54-61 dBA
AVERAGE	53 dBA	45 dBA	59 dBA
	24 hour period		
OVERALL AVERAGE	61 dBA	53 dBA	65 dBA

Table 1. Minimum and maximum overall sound levels, floor sound levels (L5) and ceiling sound levels (L95) for each shift period and a 24 hour period.

6.2 Relationship between sound levels and the period of the day

The average overall sound level for a 24 hour period obtained in this study was 61 dBA. During the day shifts, the overall sound levels increased due to medical and radiology rounds. Radiology work was generally completed in the early afternoon, between 12:00pm to 2:00pm, which may have caused floor noise and therefore, overall sound levels, to increase. Moreover, the presence of infant cries, conversations, and the set-off of alarms contributed to these elevated sound levels, which appear to be more prevalent in the morning, from 8:30am to 9:30am.

Fluctuating sound levels during the evening were usually due to excessive conversation (e.g. nursing staff shift change, medical intervention) or to infant cries, which often led to more frequent set-off of alarms. Also, the noise levels were highly affected by the equipment in the NICU. As for the night period, infant cries and warning alarms caused the many sound level variations.

6.3 Overall, floor noise and maximum sound level

As indicated in Table 1, the average sound level was highest during the evening shifts (63 dBA) and lowest during the night shifts (53 dBA). The average sound level measured in the 24 hour period was 61 dBA. This particular sound level is higher than the recommended sound levels in a private residence, which are 35 dBA during the night and 45 dBA in the daytime, and in hospitals, which are 30 dBA for the background noise and 40 dBA for the maximum noise level (Berglund & Lindvall, 1995).

The floor noise levels were highest in the evening (57 dBA) and lowest during the night shifts (45 dBA). Again, these noise level exceeded the recommended levels established by the WHO (Berglund & Lindvall, 1995). Furthermore, the average floor noise level for the 24 hour period is 53 dBA, which once again exceeds the recommended noise levels established by the WHO (Berglund & Lindvall, 1995).

There was no marked difference in maximum sound level measurements (L_5) between the day and evening shifts. However, the maximum sound levels (L_5) obtained during the night shift were lower than those obtained during the day and evening shifts. Finally, as demonstrated in Table 1, the noise level measurements obtained during the evening shifts were higher than those obtained during the day and night shifts.

6.4 Presentation of sound levels and occurrence of various common noise sources

Tables 2 and 3 focus on sound level and the occurrence of individual noise sources, in order to determine their level of contribution to the overall sound levels. As indicated in Table 2, the highest average sound level among the warning alarms was the IV pump alarm (68 dBA). In regards to human vocalizations, laughter had the highest average sound level (73 dBA). Finally, the act of "putting down the crib's wall" (75 dBA) produced the highest average sound level overall, as well as the highest level within the object noise sources.

As indicated in Table 3, the cardio monitor alarm was the most frequent among the warning alarms (5 times per hour). Among human vocalizations, conversation occurred most often (38 % of the time). As for object noise sources, sink and towel ripping noises were the most frequent (4.7 times per hour, each).

7. GENERAL DISCUSSION

Given the fact that the primary objective of this study was to develop a valid and reliable method of noise measurement within the NICU as well as the eventual evaluation of the impact of a specified training program, it was imperative throughout this study to ensure the method's replicability. As described in the methodology, the various methods and protocols utilized throughout the data collection for this study were chosen carefully and executed rigorously, to ensure their reproducibility in a post-training study. Recommendations are formulated based on these data.

General noise source	Specific noise source	Average sound level *
- warning alarms	- IV pump alarm - cardio monitor alarm - feeder pump alarm - overhead heater alarm - oxygen saturation monitor alarm	68 dBA (60-71) 66 dBA (56-69) 65 dBA (59-70) 64 dBA (62-67) 63 dBA (56-66)
-human vocalizations	- laughing - baby cries - coughing - conversation	73 dBA (56-80) 69 dBA (58-74) 69 dBA (62-73) 64 dBA (52-69)
- object noises	- putting down crib railing - cupboard door bang - object dropped - poll or crib rolled - radio - binder - towel ripped - radiology - supply cart rolled - telephone ring - floor washing, chair rolled - oscillator, intercom, sink - sterile pack snapped open - paper shuffled - musical mobile - ventilator	75 dBA (71-77) 71 dBA (58-76) 70 dBA (53-73) 69 dBA (52-75) 69 dBA (68-70) 68 dBA (54-71) 67 dBA (56-72) 67 dBA (64-69) 66 dBA (54-70) 65 dB 64 dBA (52-68) 63 dBA (53-67) 60 dBA (54-62) 58 dBA (51-61) 54 dBA (53-54) 48 dBA

*(minimum and maximum values - dBA)

Table 2. Various sound sources, in descending order of sound levels

General noise source	Specific noise source	Occurrence
- warning alarms	- cardio monitor alarm - syringe pump alarm - overhead heater alarm - oxygen monitor alarm - IV pump alarm	5 min. per hour 2 min. per hour 1.5 min. per hour 1 min. per hour 0.6 min. per hour
- human vocalizations	- conversation - crying - coughing - laughing	38% of the time* 15 % of the time* 0.5 times per hour 0.2 times per hour
- object noises	- sink - towel ripped - cupboard banged - binder - intercom - object dropped	4.7 times per hour 4.8 times per hour 1.4 times per hour 0.6 times per hour 0.7 times per hour 0.5 times per hour

*frequency of occurrence for conversation and crying is presented as a percentage value because these are continuous, rather than instantaneous

Table 3. Various sound sources in descending order of presentation occurrence

7.1 Comparison of sound levels with other studies

The average sound levels were higher by as much as 10 dB in comparison with those obtained in previous studies. These differences could be explained in part by the fact that the methods and protocols in other studies were not identical to those adopted throughout this study. However, these differences are more likely due to the fact that the noise sources at CHEO emit higher sound levels. As previously mentioned, the average overall sound level obtained in this study for a 24 hour period was 61 dBA. Nagorski Saunders (1995) obtained an overall sound level of 58 dBA. Anagnostakis et al. (1980) measured an overall sound level of 51 dBA, which is much lower than that obtained in this study. Furthermore, based on physics principles, this 10 dBA difference represents ten times more acoustic energy in the NICU at CHEO.

7.2 Occurrences and sound levels of the noise sources

Based on the observations and measurements obtained in this study, conversation, infant cries and the set-off of alarms represent the primary noise sources in the NICU at CHEO. The average sound level of conversation obtained in this study was 64 dBA, a level comparable to that reported by Thomas (1989) of 58-64 dB. Furthermore, over the course of this study conversation occurred more often than all other noise sources identified in the NICU. It was present 38% of the time, whereas infant cries were only present 15% of the time. However, these cries were measured at relatively higher sound levels than conversation (69 dBA vs. 64 dBA), making them an important contributor to the overall sound level in the NICU. As a result, conversation and infant cries, which can be continuous noise, contributed greatly to the overall noise level. The floor noise level could have been influenced by the presence of these noise sources. Furthermore, the floor noise level depended on the equipment functioning in the room.

Some warning alarms (10 per hour), "banging" noises (cupboard doors, binder, carts, etc.), a person coughing and other noise sources (telephone ringing, sink, ripping of a paper towel) were identified as being intermittent-short duration noises, emitting sound levels of over 60 dBA. In fact, as measured in this study, the average sound levels of the IV pump alarm and of the sink were 68 dBA and 62 dBA, respectively. Similarly, Thomas (1989) reported an average sound level of 56 dB for the IV pump alarm and 66 dB for the sink. Although many of these noises are of short duration, it is important to note that they may still cause distress for the infants, as impact noises are more disturbing than continuous noises. More specifically, sound level measurements for impact noises produced by both the O2 saturation monitor alarm and the Drager SC-8000 incubator temperature alarm were 62 dBA and 73 dBA respectively, exceeding the 60 dB noise level sufficient to increase anxiety, as reported by Standing and Stace (1980).

Finally, the World Health Organization (1980) specifies that noise levels higher than 30 dBA Leq may cause frequent arousals during sleep in hospitals. The floor noise levels in the NICU at CHEO largely exceed this 30 dBA value.

7.3 Physiological measures to consider in pre- and post-noise reduction

Very few studies used physiological measures to demonstrate the outcome of noise reduction on neonates in NICUs (Als et al., 1994; Kurdahi Zahr & Balian, 1995). In Kurdahi Zahr & Balian's study, three physiological measures: infant's heart rate, respiratory rate (RR) and oxygen saturation (SaO2) were used. Many variables were studied in Als et al. (1994) experiment but they were based on medical outcome variables like average daily weight gain and number of days on oxygen. It would be interesting to consider these types of physiological and medical variables in a pre- and post- training study, because it would give stronger support to noise reduction than simply considering infants' states (like quality of sleep), as it as been done in other studies (Strauch et al., 1993).

8. RECOMMENDATIONS

The following paragraphs present recommendations regarding warning alarms, human vocalizations and object-related noises.

8.1 Warning alarms

Several different alarms were identified in the NICU. These alarms generally produced abrupt, intermittent, and relatively high-pitched signals louder than 60 dBA. This level is able to startle a child and neighboring infants, as well as to cause annoyance to the nursing staff. Furthermore, as observed in the NICU, each child was usually monitored by at least one of these alarms. As the state of health of the newborn decreased, the number and frequency of alarms increased. In order to reduce their duration and occurrence, the NICU staff would need to respond more rapidly to the alarms and their causes. In addition, the alarms must be perceived by the NICU staff through the continuous ambient noise, which includes conversation and equipment. As a result, the reduction of background noise is also a priority. Once the background noise is lowered, reducing the sound levels of the various alarms would be essential, and would require the efforts of manufacturers.

These recommendations are similar to those proposed in other studies examining noise and the audibility and identification of various alarms in hospitals. In fact, Cropp, Woods, Raney & Bredle (1994), as well as Montahan, Hétu & Tansley (1993), concluded that the number and frequency of alarms that were set-off in the various intensive care units were too abundant for the staff to correctly discern them from one another. As a result, both these studies encouraged the reduction of noise in these ICUs by limiting the number of alarms, by finding alternatives to auditory alarm signals, by designing better units and by reducing the background noise levels. Another study by Nagorski Saunders (1995) concluded that shielding the top and sides of the incubators with quilted coverings was an effective method of *in-situ* noise reduction.

8.2 Human vocalizations

Another recommendation would be to organize an awareness campaign focused on the negative effects of noise on patients and staff which would emphasize noise reduction. As demonstrated in the study by Benini, Magnavita, Lago, Arslan & Pisan (1996), it is important to train NICU caregivers about the effects of noise, especially human vocalizations, and about the significance of noise reduction on newborns. In order to do so, a committee could be formed with the reduction of conversations near the resting infants as its first goal. Ideally, posters would be displayed reminding staff and visitors that silence is an essential condition for sleep. Moreover, end of work shift nursing reports should not, as much as possible, be held in proximity to the infants. Also, the number of physicians and students near the newborns during medical rounds should be reduced or these rounds should not be held near resting infants. Finally, if possible, the parents could bring their child into a separate visitor's room, in order to give him or her reprieve from environmental noises, such as other infant cries, conversation and alarms.

8.3 Object-related noises

Numerous recommendations are presented in regards to object-related noise productions. Table 4 presents examples of recommendations.

Noise sources	Noise reduction recommendations
- stainless steel trays, pans and sinks	- cover with absorbent material, such as liquid rubber
- carts, chairs, and cribs	- fit with larger wheels, cover with absorbent material, regular maintenance (lubrication of mobile parts)
- cupboard doors	- absorbent pads
- ceramic-tile floors	- cover with absorbent material
- binders (loud clicking sounds)	- replace with those equipped with sliding-closing apparatus
- towel dispenser	- replace with those that do not require "ripping"
-sterile packs	- open with scissors (instead of tearing)
- housekeeping and other outside noise	- keep NICU door closed as much as possible
- noise within the NICU (bathing the infants, procedures performed on the infants, washing hands, medical rounds, etc.)	- utilize the center room as an "activity station"
- reverberation within the NICU	-curtain the windows and acoustic paneling on ceiling

Table 4. Recommendations for object-related noises

9. CONCLUSIONS

The measurement method has been validated throughout this study. Ultimately, the various measurements will be repeated in a post-training session, in order to evaluate whether or not, based on this study's recommendations and the training program, the noise levels in the NICU have significantly decreased.

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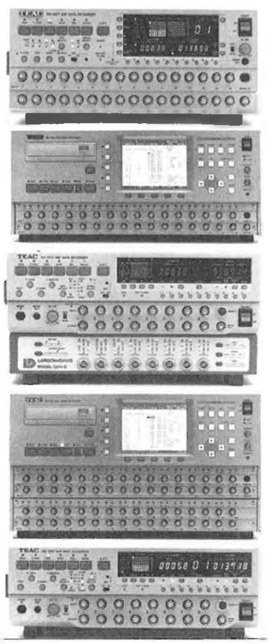

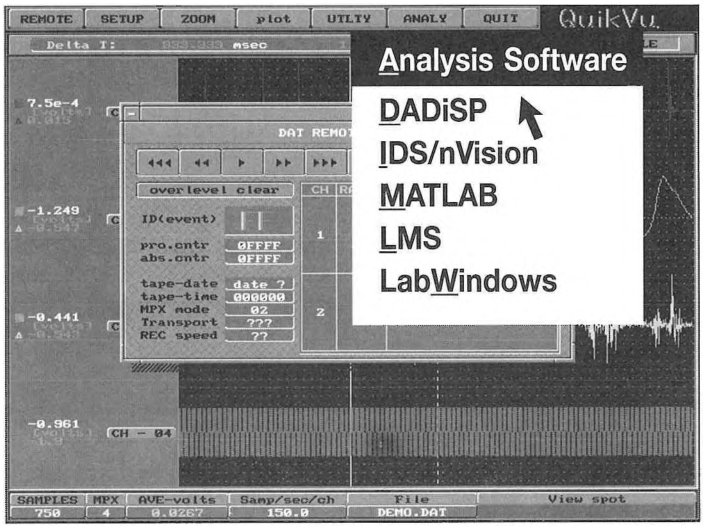

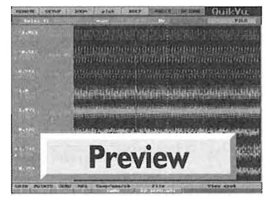

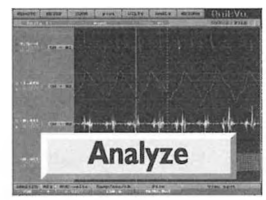

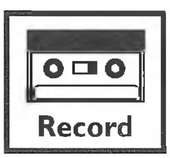

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REVIEW OF ONTARIO'S LAND-USE APPROVALS PROCESS
One Acoustical Consultant's Opinion

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ABSTRACT

Residential developments adjacent to industrial developments are generally considered incompatible land-uses. However, in the Greater Toronto Area (GTA), in order to satisfy the demand for more houses, it has become increasingly more common to attempt to locate residential development adjacent to existing and/or proposed industrial developments. The focus of this paper is to provide some insights into the current approvals process, the difficulties being experienced with the current system and the potential solutions.

SOMMAIRE

Le développement de zones résidentielles à proximité de zones industrielles sont généralement considérés comme des terres à usages incompatibles. Cependant, comme la Région du Grand Toronto fait face à une demande de logements de plus en plus croissante, il est devenu courant de tenter de développer des projets de construction d'habitations à coté des zones industrielles pré-établies ou en voie de développement. L'intérêt de cet article est de fournir quelques perspicacités dans le processus courant d'approbation des projets, et dans les difficultés expérimentés avec le système actuel ainsi que la proposition de solutions potentielles.

INTRODUCTION

Noise and vibration are issues that are not always taken seriously by municipalities, developers, builders or industrial operators. Many times these issues are addressed in a project because it is the only way an approval will be obtained. There is no real desire to make the living environment, both indoors and outdoors acoustically acceptable nor acoustically desirable. It is simply a matter of doing the minimum in order to satisfy a condition of approval. There are exceptions to the above comments; however, the exceptions are not common.

This approach may have been acceptable in the past but there are signs that the rules are changing. In Ontario, the Ministry of the Environment (MOE) was the agency responsible for the review and final approval on most noise related issues. In the recent past the MOE has been downloading much of its approval tasks to the local area municipalities. While it was originally thought that this would result in less red tape and faster approvals, the opposite has been the case. Most municipalities are not equipped with the technical expertise to review acoustical matters and consequently rely on peer reviews of noise issues prior to providing an approval of the noise report. This can and does frequently result in disagreements amongst consultants because there is not a definitive authority providing the approval. The interpretation of the guidelines is left to the municipality and/or the consultants, resulting in many differences in the application of the guidelines.

In order to gain a full appreciation of the complications and pitfalls with the current system, some background is required. Addressing noise and applying/interpreting the MOE guidelines is complex and at times confusing; however, there are possible solutions to improve the current system and ensure residential developments and industries can co-exist.

APPROVAL PROCESS

Until recently most municipalities were required to obtain MOE approval on noise related issues. For example, a new residential development proposed adjacent to any source of noise (including transportation and stationary sources) was required, as a condition of draft plan approval, to submit an Environmental Noise Report. In some cases, a Preliminary

Noise Report may have been required to establish feasibility of meeting sound level limits by implementing noise mitigation measures into the development. Approval from both the area municipality and the MOE was required to clear the conditions of draft plan approval. The MOE was solely responsible for the review of stationary sources of noise such as dust collectors, truck terminals, and asphalt plants, etc.; while the area municipality was generally responsible for the review of transportation sources. Because the MOE was closely involved in the review of noise reports, most municipalities did not require staff who were highly skilled in the area of acoustics or familiar with the MOE Guidelines.

Once the downloading process began, the MOE was no longer required to clear the conditions of draft plan approval, though they were still available for comment. The MOE still retained jurisdiction over stationary sources of noise.

Stationary sources of noise are quickly rising to the forefront in many proposed residential developments because insufficient importance is being placed on to the acoustical impact of these sources on the future residents or the impact of the residents on the commercial/industrial facilities.

STATIONARY SOURCES

The sources of noise associated with industry are referred to as stationary sources. Stationary sources as defined by the MOE are sources of noise that may move, but are generally confined to the premises where the activity takes place. Trucks once they have left the public roads are required to be included as a stationary source of noise, though the trucks themselves do not require a Certificate of Approval.

The evaluation of a stationary source of noise comes about as a result of one of three conditions:

- A new residential development must prepare a Noise Report to clear conditions of draft plan approval, addressing all sources of noise, including stationary sources. The MOE Land-Use Guideline, LU-131 applies in these cases;
- A new stationary source of noise, itself, must prepare a noise/vibration report to ensure that it does not adversely impact any existing, proposed or zoned residential lands. The applicable guideline in this instance is NPC-205. In addition, a Certificate of Approval may also be required; or
- A complaint investigation results in the assessment-investigation of a stationary source.

CERTIFICATE OF APPROVAL PROCESS

In Ontario many operations/facilities are required to have a Certificate of Approval (C of A) in order to operate. A C of A is required not only for noise and vibration but also for air quality issues. The MOE has several documents itemizing the specific sources that require a C of A, as well as details regarding the documentation needed when applying for a C of A. Other than specific noise by-laws which are enforced by each municipality, a C of A is the only noise item governed by legislation and not by guidelines alone. The Environmental Protection Act (EPA) regards noise and vibration as contaminants and requires that a C of A be issued by the MOE for specific sources. Because of this inclusion in the EPA, stationary sources of noise have an importance not associated with transportation sources. This causes much confusion.

THE CURRENT SYSTEM

While the MOE has retained the responsibility for issuing Certificates of Approval, there is not a formal process for notifying new stationary sources of noise that they may require a C of A. The onus for obtaining a C of A is with the stationary source. Large companies with significant resources and significant sources of noise are aware of the process and generally will obtain a C of A. Smaller operations and most municipalities are not aware of these requirements and more importantly, are not aware of the implications of allowing residential developments to be located adjacent to commercial/industrial facilities. Most municipalities require that new residential developments submit a noise/vibration report to ensure compliance with the MOE/municipal noise guidelines. The same requirement does not apply to new commercial/industrial facilities. This is a serious oversight because once the residential development and industrial development are built the onus for compliance with the EPA falls on the shoulders of the industry. If complaints arise, the onus for compliance is with the industry and not with the residents, regardless of who was there first. If the industry is found to be out of compliance they may be required to mitigate at their own cost, which may be considerable; fines may be imposed on the industry; they may be required to shut down a portion of the operation or shut down for part of the day/night until they can comply with the EPA; in the worst case scenario they may be permanently shut down or be forced to relocate if compliance is too onerous or too expensive.

A further complication is that the guidelines which apply to a stationary source of noise when an application for a C of A is made or a complaint is being investigated differ from the guidelines that apply when the residential proponent is investigating a stationary source. That is, NPC-205 is more stringent than LU-131. The implication of this difference is that even if the residential proponent mitigates the stationary source to comply with LU-131, the stationary source of noise would be out of compliance if a complaint arose and if NPC-205 were applied. The reason is that NPC-205 applies anywhere on the residential property, whereas LU-131 applies only to the façade of the building and to the outdoor amenity area (usually the rear yard).

In the recent past there have been numerous applications to rezone industrial land to residential use. This is not necessarily a problem if appropriate mitigation measures are implemented. The most significant omission in the design of mitigative measures is separation distance. There are two reasons why separation distance is resisted as a desirable mitigative measure. First, the "buffer" land is costly and second, a suitable development use for the buffer lands may be difficult to find. Many applications seek to provide mitigation through the use of sound barriers, upgraded architectural elements and/or central air conditioning.

While these are all useful components of a comprehensive solution there are several deficiencies with this approach alone. These include:

- MOE guidelines do not advocate the use of upgraded architectural elements and air conditioning as mitigation methods. The reason is that for many stationary sources these techniques do not provide sufficient reduction in the sound level, particularly if there are tonal components to the sound. The MOE guidelines do not set indoor sound level limits but rather, limits at the outside façade of the building and on the residential property.

- The use of innovative house designs such as blank walls, insensitive uses such as bathrooms on the façade nearest the source and sealed windows all appear to be viable solutions to the problem but can pose difficulties. The occupant can change the interior space of a house and windows can be replaced. The innovative house design may not be easy to sell, prompting the builder to modify the design so it does sell. These modifications in effect negate any protection the industry might have had.

- Mitigation at the receptor cannot contemplate expansion of the industrial facility. While it is possible to allow for some future growth, even the industry itself may not be aware of where the future will take them. Allowing controls mainly at the receptor may severely restrict the potential growth of the industry.

- The industrial property may be zoned for "noisier" uses than are currently operating on the site. The MOE guidelines require that all permitted uses be evaluated in the preparation of noise reports. However, even if it is possible to evaluate the potential impact of the permitted uses, it is not possible to implement the mitigative solutions because the operation does not yet exist.

- In many cases the sources of noise are elevated to the extent that excessively high sound barriers may be required to achieve the guidelines. In some cases it is not possible to achieve the guidelines with the use of sound barriers. Even if sound barriers are technically feasible there are several issues that arise. Who will maintain the structure? Is it aesthetically pleasing?

- If mitigation is implemented at source, many of the existing sources can be attenuated to achieve the MOE guidelines. This however also has serious implications. How significant should the modifications to the operation be? Who pays for the "upgraded" mitigation? Who pays for the ongoing maintenance of the mitigation? Who pays for the additional mitigation if complaints arise? Who enforces any agreements between the developer and the industry? Does the presence of residential development restrict the use of the property or the saleability of the property? How are these "intangible" issues addressed in any agreement?

Not all land uses are compatible nor can they be made compatible simply by introducing a few physical barriers. The solution to this problem lies in increased awareness and better planning.

Most Official Plans and Secondary Plans contemplate the interface between various uses and allow for transition zones between very incompatible uses. Why then, do municipalities allow themselves to be pressured into changing their Official Plans, particularly after much time and study is spent developing the Official Plans? Why do most municipalities require noise reports for new residential developments but not for new industrial developments?

Much is made of the issue that the MOE guidelines are just guidelines and therefore there is room for flexibility and interpretation. While this is true for many sources it does not hold true for industry. The primary reason is that industries are regulated under the EPA and the EPA is not a guideline, it is law. Unfortunately the EPA does not set the sound level limits with which the industry must comply, but rather refers to the Ministry of the Environment as the authority responsible for the issuance of C of A's. Therefore by default the MOE Guidelines are the documents which apply.

The final element in this complex equation is the resident. In evaluating the acoustical impacts of noise sources much importance is placed on the numerical analysis and whether or not the "sound level limits" can be achieved. There is merit and necessity in this approach; however, it cannot be the only component addressed. Ultimately the resident has the right to enjoy his/her property. While this is addressed in the EPA, the mechanisms in place to ensure this right are riddled with holes. The province does not have a mechanism to ensure that industries requiring a C of A do in fact have one. The guidelines do not address maximum sound levels but rather averages over specified periods of time. The municipalities do not generally request noise/vibration reports for proposed industrial facilities. While Guideline D-6, "Compatibility between Industrial Facilities and Sensitive Land Uses", does recommend separation distances as well as mitigation between unlike uses, there is no mechanism to ensure this occurs.

One simply has to look at the number of Ontario Municipal Board (OMB) Hearings dealing with the issues discussed above to realize that there is definitely room for improvement in the way this complex issue is currently being addressed.

SOLUTIONS

In order to reduce the incidence of conflict a co-operative effort including the following is required:

- the MOE in conjunction with the municipalities must devise an approach to make stationary noise sources aware of the C of A process. This could be done as a requirement prior to the issuance of building permits; and
- acoustical consultants should have more regard for the MOE guidelines, not just the noise guidelines but also Guideline D-1, "Land Use Compatibility" and Guideline D-6, particularly in light of the implications to the homeowners and industries under the EPA.
- Municipalities need to be cognizant of the potential conflict;
- Municipalities need to ensure that their Official Plans and Secondary Plans reflect the potential incompatibility and allow for the appropriate buffer and transitional zones;
- Municipalities need to adhere to their Official Plans and Secondary Plans;
- Municipalities must ensure that new industries, prior to the issuance of building permits address the potential noise/vibration concerns;

Ultimately, the issues and solutions all boil down to money. In many cases the cost of land drives the final mitigative solution. However, the cost of the OMB hearing, lawyers, consultants, on-going complaint investigation, shut down of business, cost of litigation, the loss of enjoyment of property and continuation of land use compatibility must be factored into the formulation of a comprehensive solution.

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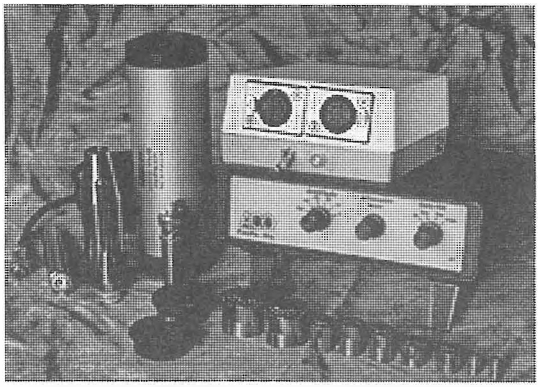

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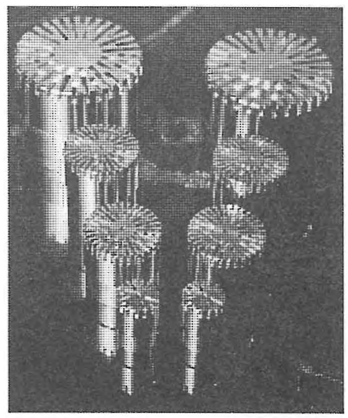

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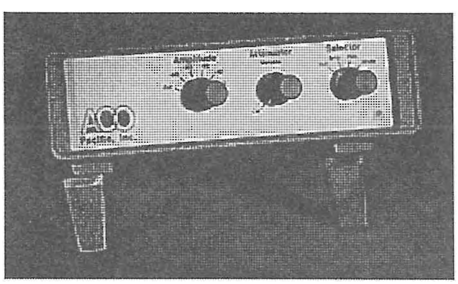

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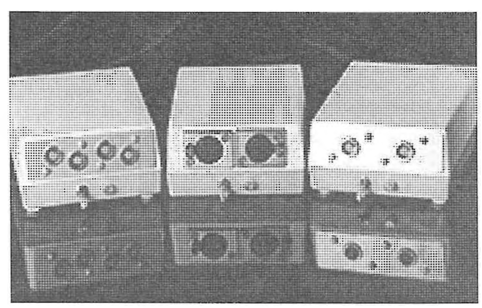

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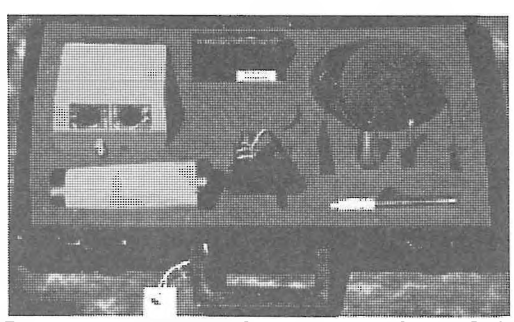

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SUBJECTIVE EVALUATION OF DIFFERENT ERROR CORRECTION SCHEMES FOR APPLICATION WITH A 900 MHZ FREQUENCY HOPPER COMMUNICATION SYSTEM

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SUMMARY

This paper presents an analysis of subjective tests conducted with a 900 MHz frequency hopper. The primary purpose of such a study is to evaluate the listeners' response to radio channel interference causing loss of speech data. The pre-testing phase determined the users' preference for a 32 kbits/s Adaptive Delta Pulse Code Modulation (ADPCM) system. The three main tests performed determined the parameters of the error correction schemes most preferred by the listeners. The purpose of the tests performed was three-fold: to determine the type of correction scheme preferred by the listeners, to subjectively evaluate the performance of the preferred correction scheme, and to determine the response of the listeners to different interference scenarios. Results from the subjective testing performed are presented and analyzed in this report.

SOMMAIRE

Ce papier présente les resultats d'une étude sur la qualité de reception d'un radio 'frequency hopper' en présence de signaux parasites. Différentes methodes de corrections sur la perte de donnés fut analysées. La qualité accoustic fut mésuré subjectivement en déterminant la réaction des écouteurs en simulant la perte et correction de données en presence de signaux parasites variées.

1. INTRODUCTION

Wireless communication systems are required to communicate information quickly, efficiently and securely over selected frequency ranges. Each channel has a limited bandwidth or frequency range in which it must operate and the frequency spectrum is becoming increasingly more congested.

Spread spectrum is a modulation scheme that uses the spectrum efficiently. It can carry many uses with a reasonable level of security and operates with a minimum amount of interference [9]. In a spread spectrum system, the signals are spread over a wide range of frequencies by using a variety of broadband or frequency hopping techniques.

"Frequency hopping" is one of the spread spectrum techniques which uses special coding techniques, or pseudo-random sequences, sent between the transmitter and receiver, to determine the frequency that carries the digital information, or the carrier frequency [3] (see Figure 1).

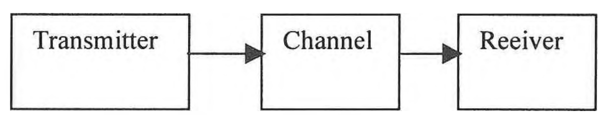

Figure 1 Block diagram of a communication system

In a frequency hopping system, the users are bounced from one available frequency to another during communication. This technique gives the most effective use of the available bandwidth as well as increased signal power without compromising capacity. However, interference is still present and subjectively noticeable in some circumstances with the use of frequency hoppers. The effect of having many users utilizing the same frequency bandwidth promotes a special problem since it becomes possible for one user to jam the signal of another. Jamming occurs when two transmissions interfere with each other on the same receiver unit (see Figure 2). This creates noise or other user perceived anomalies that considerably degrade the audio quality. Jamming can occur when the transmitted signal is interrupted, from a wall in an office building, for example, causing the receiver to pick up spurious data. In the particular case of frequency hoppers, jamming can also be caused by the carrier frequencies of two users hopping to the same frequency at the same instantaneous time. Errors, caused by jamming, can be introduced into the signal from anomalies inherent in the transmit and receive modes of a wireless communication unit transporting digital information. During the process of converting analog speech into digital data to be transmitted, redundancies or errors could become part of the speech waveform as well as errors that can be introduced through corruption in the radio transmission medium (free air). These errors are quantified through the bit error rate (BER). An error can occur in transmission from the receiver to transmitter, from transmitter to receiver or from transmitter to transmitter

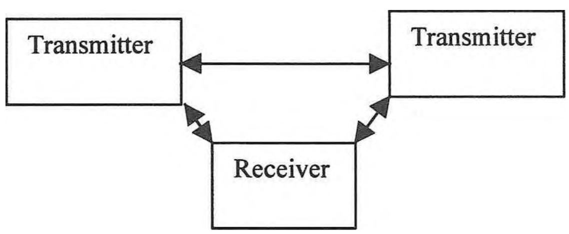

Figure 2 Jamming can occur between receiver and transmitter as well as between transmitters.

as shown in Figure 2 above, which is a real world problem. The bit error rate (BER) is the probability of an error occurring in a bit, or a change in the transmitted information. This is defined and set by the software we had written to incorporate errors in the given speech samples used for testing.

In this paper, subjective testing was performed on two types of interference associated with such a frequency hopping system where a number of units share the same frequency bandwidth. Software was created which simulated the methods of correcting the 'errors' or lost data due to the effects stated above. Several techniques were used to correct corrupted data. These ranged from very simple techniques to very advanced and complicated error correction techniques. In this article we analyzed two of the simplest techniques. The first correction method studied, called 'repeating', used the previously sent block of data picked up by the receiver and then repeated it. A second correction method, called 'muting', simply muted any erroneous data that was picked up by the receiver. The results of subjective testing and the test methodology for the two correction methods are presented in this paper.

2. EXPERIMENT

Digital speech transmission systems could generate degradations that involve difficulty in the listening path. These degradations could be perceived to the end user as clicks, pops, distortion, fuzziness, etc. in the receive listening audio path. To account for the listening transmission path, eight second-long high quality recordings of both male and female voices, speaking Harvard sentences, were used to effectively create the receive transmission audio. Sentences, about eight seconds long, were deemd to be appropriate for this type of subjective testing. The sentences were recorded in a soundproof room [8]. The speech recordings, originally existing on DAT tapes, were then converted to a format understood by the computer sound card. This way, every subjective listener test person would listen to the same audio file each time creating a consistent test base. All of the files required for a particular test were then loaded onto the laptop computer and modified by custom software to incorporate various degrees and types of errors. The recordings were then played from the laptop through the computer's high quality sound card to an audio handset. All subjective testing took place in a low ambient noise sound room. For additional consistency the same handset was used for each of the cases. The results from this series of tests helped the designer's choose the best error correction scheme that was available to them. To assist the designers in making the correct decision from the results, the Mean Opinion Score or MOS method [3] was used to assess the subjective listener's opinions on the various audio samples.

The Mean Opinion Score (MOS) method is a standard method used extensively for subjective listening tests. "The MOS is an opinion scores that represents a listener's assessment of the quality of a speech sample expressed over an appropriately chosen scale. CCITT recommends the use of a five-point scale {excellent, good, fair, poor, bad} which is typically numerically mapped to the decimal {5,4,3,2,1} scale" [3].

Each of the listeners judged the material on its overall quality. Test 1 and Test 2 involved comparison tests or Degradation Category Rating (DCR) MOS tests. A reference audio sample, with uncorrected errors, was played to the listener followed by the same sample using a specific error-correcting scheme (either muting or repeating) for the DCR tests. Listeners rated their perceived increase or decrease in quality level against the reference sample. Test 3 used an Absolute Category Rating (ACR) method where only one sample was heard at a time. After hearing each sample, the listener was required to record their opinion. The ACR MOS test method is appropriate for situations where a few sentences would be heard in a group and where several methods of degradation would be used in a row.

The speech samples used in the listening tests contain audible errors created by software that simulated conditions of jamming and with various levels of BER. Because channel bandwidth is at a premium, there is a definite need for speech coding at low bit rates, while maintaining acceptable fidelity or quality of reproduction. A major motivation for bit rate reduction for voice coding is to allow enough available bandwidth for the data to share the same channel. There are fundamental limits on bit rate suggested by speech perception and information theory. The standard reference for high quality transmission is a 64 kbits/s PCM communication system (which typically corresponds to 8-bit samples at an 8 kHz sampling rate). A 64 kbits/s system typically produces 4.5 or more on a MOS scale when no errors are introduced. Using this as a reference system, a frequency hopper spread spectrum radio was investigated that supported 32 kbits/s ADPCM with possible error correction. A 32 kbits/s ADPCM system would have 4-bit samples at an 8 kHz sampling rate. The fewer bits used to relay the data, the fewer would be the mistakes in terms of the BER and in jamming. It was found through previous listening tests that a 32 kbits/s ADPCM communication system offered the best audio quality for the least number of bits.

Test 1 determined the type of correction scheme and the threshold of correction for errors preferred by listeners for corrected jammed signals. The threshold would determine the level of correction for errors used by the software. The threshold and error correction scheme (muting the error or repeating the previous block of information) preferred by listeners was established after averaging all of the scores on the MOS tests. Test 2 threshold levels were based on the results from Test 1. For Test 2, since jamming was of more concern for audio quality, the threshold parameters of Test 1 for jamming were incorporated into several selected BER's. Test 3 is based on the chosen threshold and error correction schemes determined from Tests 1 and 2. Test 3 determined when the audio quality would degrade for jamming as the numbers of users increased. It compared two different scenarios that might occur in a jamming situation. The listeners evaluated the audio quality when the jams occurred as users interfered with each other at the same time or when the interference occurred at different times. The recommended practice for subjective testing was to use at least 24 people to listen to each test [3]. For all tests presented in this paper, at least 24 people participated and reported their evaluation utilizing DCR or ACR MOS tests.

3. RESULTS AND DISCUSSIONS

3.1 Test 1

Preliminary testing determined that the subjective testing should focus more on jamming tests rather than BER tests. In this project, jamming contributed to the quality of the audio signal to a greater degree than does BER, meaning, if a signal was jammed, it ws much more noticeable to a listener than the BER factor. Therefore, Test 1 was performed to find out whether jamming using a correction scheme called muting or using the repeating method of a previous block was preferable. The listeners would find which threshold level was most acceptable using the DCR MOS subjective test method.

Each trial for this test involved comparing two speech samples derived from the same original speech sample. The original speech sample was corrupted with errors and became sample A. A second speech sample, sample B, took the A speech sample and corrected these errors with one of the error correction methods, muting or repeating, at a chosen threshold value (from 1 to 7). Each trial compared a speech sample with errors, called sample A, followed by a speech sample with the errors corrected, called sample B. Each subject gave a rating for each comparison, based on the rating schedule shown below in Figure 3 for a DCR MOS test. In this first round of tests, the data acquired from one subject was thrown out. The listener gave every speech sample the same rating. Since the degree in difference of audio quality was quite high between each sample it was thought that this particular listener had given us erroneous data. (**Note:** This was the only data for the complete set of testing, that was thrown out.)

The same Or poorer Quality	Slightly better quality	Moderately better quality	Much better quality	Very much better quality
1	2	3	4	5

Figure 3 DCR MOS Test rating schedule.

Figure 4 (shown on the next page) shows a graph describing the data for Test 1. It shows how for an increasing number of errors detected before being corrected (the threshold) the quality of the audio samples quickly degrades to less than 4.5 MOS test rating. The numbers along the bottom describe the threshold levels while the numbers along the left-hand side describe the MOS rating. The data or lines on the graph represent the score of each error correction scheme (repeating or muting) versus the threshold level.

From the results of Test 1 it was concluded that threshold level 2 plus or minus one threshold and the muting error correction scheme for jamming were the most optimal as they gave the highest MOS ratings from the 30 listeners involved in the testing.

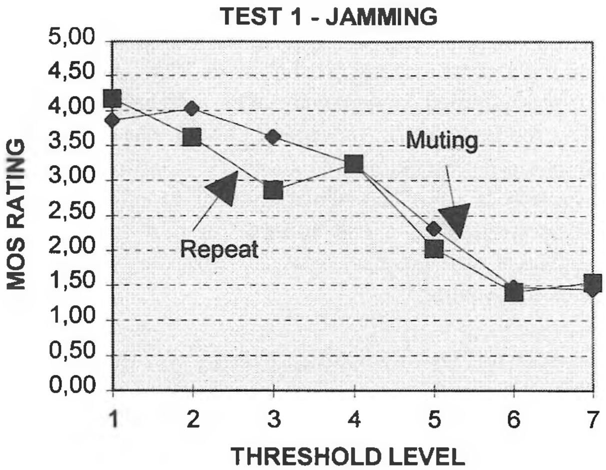

Figure 4 Test 1. Jamming from Threshold's 1 to 7.

3.2 Test 2

Test 1 determined the type of error correction scheme that would be used and the threshold of correction for jamming at 1 jam/second according to the DCR MOS test. Test 2 used this chosen threshold value and error correction scheme with the selected bit error rates. Since jamming and the BER could only be corrected with one chosen threshold, there was a need to see how the parameters chosen from Test 1 for jamming compared to the selected BER's. This compariosn was performed in Test 2.

The BER's were chosen in the follwoing manner. For a BER of 0.1%, a threshold of 1 was found to be worse than the original file, and also worse than a threshold of 3 at the same BER. The repeating method was found to be worse than the muting at a threshold of 1 and 3 at 0.1% BER. Both error correction formats were worse than the original sample. It was difficult to distinguish between the thresholds at BER of 0.1%. The BER's of 0.01% and 0.001% were almost impossible to distinguish between corrected and uncorrected samples at these thresholds. Therefore, nothing was tested below 0.01% BER since anything below 0.01% BER was acceptable. The chosen BER's were 0.5%, 0.1%, 0.05% and 0.01%.

Testing was accomplished by comparing a speech sample that was corrected at each specific to the original uncorrected speech sample. All of the samples were corrected using the muting correction method at Threshold's 1, 2 and 3 chosen from Test 1. Since the threshold DCR MOS test values were so close in Test 1, it was difficult to conclude if threshold of 2 is absolutely superior. Therefore, 3 threshold values were chosen.

For this test, a non-corrected file was compared with a corrected file according to the rating system shown in Figure 5. This is the same DCR MOS rating system used for Test 1.

The test group ended up consisting of 31 people.

Moderately poorer quality	Slightly poorer quality	Same quality	Slightly better quality	Moderately better quality
1	2	3	4	5

Figure 5 DCR MOS Test rating schedule.

The different BER's are shown along the bottom with the MOS Rating along the left-hand side. The different lines within the graph itself represent the three thresholds.

Referring to Figure 6 below, it appeared that a threshold level of 2 seemed to get the best MOS rating for a BER greater than or equal to 0.1%.

From Test 2 it was evident that the optimal BER performance was with a threshold of 2 (see Figure 6) as it scored the highest overall MOS rating vs. BER.

3.3 Test 3

Test 3 was run on a different principle than the previous two tests. There were no comparisons involved for the ratings. An absolute rating schedule, as shown below in Figure 7, was used for each trial based on a single speech sample that was heard one at a time by the listener.

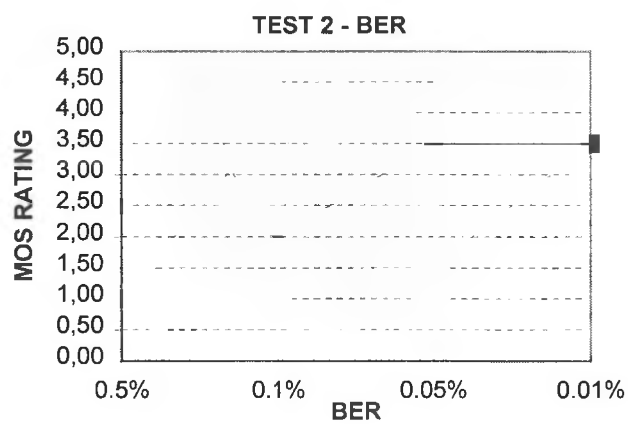

Figure 6 Test 2 for a chosen threshold of 2 with threshold's 1 and 3 using the muting correction scheme and the selected BER's.

Bad Poor Fair Good Excellent
1-----------2----------3---------4-----------5

Figure 7 ACR MOS Test rating schedule.

This test made comparisons of what it would be like to have several users jam at once or jam at a different point in time. For instance, if there were 3 jams occurring in one second (1000 ms) and they were close together, then there would be 30 ms of straight jam (since each jam equals 10 ms) with 970 ms of the regular speech sample not affected. If there were 3 jams that were far apart or dispersed, then you would hear 10 ms of jamming, then 323 ms of regular speech, then 10 ms of jamming, then 323 ms of regular speech, and finally 10 ms more of jamming followed by 323 ms of speech. The jamming was programmed into the speech samples by prewritten software. This same pattern would work for any other number of jams, except for the case of having only one jam where, of course, it cannot be dispersed. Figure 8 shows the system of jamming used for Test 3.

3 Jams/s Close Together
30 ms of Jam per 1000 ms (1 second) of speech
|XXXXXXXXX |XXXXXXXXX |
1 second 1 second

3 Jam/s Dispersed
10 ms of Jam alternating with 323 ms of speech
|XXX XXX XXX |XXX XXX XXX |
1 second 1 second

Figure 8 System 3 Jams/s close together and dispersed.

The results of Test 3 for close together jams (to simulate jamming at the same time) and jams far apart (to simulate dispersed jams) are shown in Figure 9.

From the data in Figure 9, it appears that when the jams are dispersed (highlighted as Far in the figure), most ratings are below fair (MOS < 2.5). The best scenario for dispersed jams is 4 jams since there is a drop off in quality after that. For close together jams, the ratings are fair – up to 9 jams, with an anomaly at 3 jams/s.

4. CONCLUSIONS

A 32 kbits/s ADPCM coding scheme gave the best audio quality for the lowest number of bits. For Test 1, the

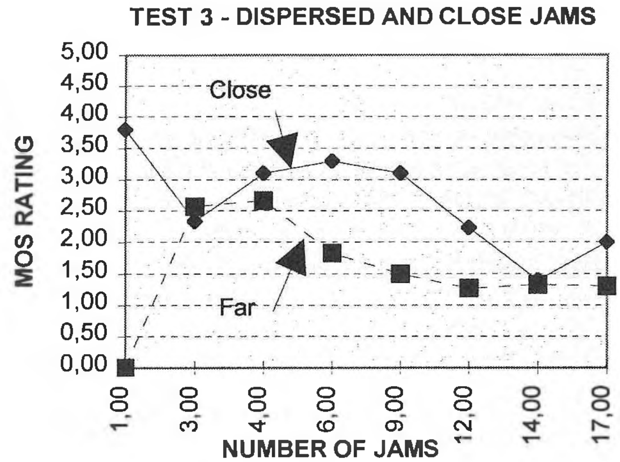

Figure 9 Test 3 for far apart and close Jams from 1 to 17 Jams with a muting error correction scheme at threshold 2.

threshold chosen was number 2. That is, the error correction scheme was invoked only after two consecutive errors were detected. These threshold levels received the highest ratings from the listeners. The correction scheme chosen was muting since the speech samples that were corrected using this scheme received higher ratings than the samples corrected with the repeating "previous block" method. The DCR MOS test rating was used since the basis of the test was to compare a reference sample to a corrected sample.

Test 2 concentrated on finding the BER with the best audio quality for the chosen threshold and error correction scheme from Test 1. To give more variety during testing, the chosen threshold from Test 1 along with the upper and lower threshold were chosen for Test 2. The level chosen from Test 2 that had the best audio quality for BER was threshold 2, which was the same as the threshold chosen for Test 1. Test 2 was conducted for a BER of 0.5%, 0.1%, 0.05% and 0.01%. Any BER meeting or exceeding 0.01% would have an acceptable level of audio quality according to our preliminary tests. Once again, the DCR MOS test for comparison ratings was used.

Test 3 incorporated parameters found from Test 1 and Test 2, which are a threshold of 2 with a muting correction scheme, to do a density evaluation for jamming. From reviewing the data, it was evident that using more than 4 dispersed jams did not have an acceptable audio quality. Between 1and occurring at the same time, or close jams, has a fair quality (except at 3 jams), but there was a drop off on either side of these values. Test 3 used the ACR MOS test method that asks for the overall opinion of each sample on its own.

Based on these findings it appears that using the muting correction method with a threshold of 2 for jamming and a

BER above 0.01% are the parameters with the best subjective audio quality for this project.

As efforts were taken to have consistency within each test it was interesting to find that a vast number of different opinions for audio quality can come from different people. It appeared that each person seemed to interpret the rating system differently. However, since the MOS system is a standardized method for performing subjective tests, it must also be standard that you can expect a certain number of people to fall within the mean and be able to expect certain deviations from the mean.

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6. GLOSSARY

BER

Bit Error Rate. The probability (in decimals) of a bit being subject to error. There is 1 parity bit per sample and 10 parity bits per block. If the BER is 0.0001%, there is the probability of 1 in 1000 bits having an error. So in 1000 samples or in 100 blocks, there is a chance of one parity bit being wrong.

Jamming

Jamming consists of period and duration. The period is the periodic time (in milli-seconds) for jamming to be active. The duration is the time (in milli-seconds) for the length of the jamming. For example, if you want to jam a signal 3 times far apart in one second, you simply enter a 10 ms jam at intervals of 323 ms. If you want the jams to be close together, you would enter 30 ms of jamming with 970 ms remaining since 1 second consists of 1000 ms. Each jam consists of 10 ms of jamming per second. A practical example of jamming is when a frequency hopping radio hops between pseudo-random frequencies at 10 milliseconds and at a certain time interval hops to a frequency that is occupied by another signal. The radio hopper will experience 'jamming' for 10 milliseconds until it hops to a new frequency.

Threshold

The threshold levels in this paper range from 1 to 10. A block will be replaced by all 1's (muting) or the previous block if the number of bit errors in the block (40 bits with 10 parity bits) equals the error threshold. So, if there are 2 errors in a block and you are correcting these errors with a threshold of 2, then this particular block will be replaced according to the error correction scheme you have prescribed.

Block Contains 10 samples, which are 40 bits and 10 parity bits.

Sample Contains 4 bits and 1 parity bit.

Parity Bit Determines whether the sample contains an error or not. The parity bits are introduced after ADPCM encoding as a way to introduce errors into the samples. The bit itself is not corrected.

Muting An error correction scheme where an entire block is muted.

Repeating An error correction scheme where an entire block is replaced by the data from the block immediately before it.

1 block = 10 samples with 10 parity bits.
1 sample = 4 bits with 1 parity bit.
1 block = 40 bits plus 10 parity bits or 50 bits in total.
1 burst = 4 blocks = 40 samples = 200 bits.
1 hop = 2 Tx and 2 Rx bursts = 800 bits = 10 ms
1 burst = 2.5 ms
10 ms = 8 blocks of Tx, 8 blocks of Rx.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT

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

EDGAR AND MILLICENT SHAW POSTDOCTORAL PRIZE IN ACOUSTICS

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

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

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

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

1990	*Bradley Frankland*	*Dalhousie University*	*1994*	*Michael Lantz*	*Queen's University*
1991	*Steven D. Turnbull*	*University of New Brunswick*	*1995*	*Kristina Greenwood*	*University of Western Ontario*
	Fangxin Chen	*University of Alberta*	*1996*	*Mark Pell*	*McGill University*
	Leonard E. Cornelisse	*University of Western Ontario*	*1997*	*Monica Rohlfs*	*University of Alberta*
1993	*Aloknath De*	*McGill University*	*1998*	*Marlene Bagatto*	*University of Western Ontario*

FESSENDEN STUDENT PRIZE IN UNDERWATER ACOUSTICS

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

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

ECKEL STUDENT PRIZE IN NOISE CONTROL

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

1994	*Todd Busch*	*University of British Columbia*	*1996*	*Nelson Heerema*	*University of British Columbia*
1995	*Raymond Panneton*	*Université de Sherbrooke*	*1997*	*Andrew Wareing*	*University of British Columbia*

DIRECTORS' AWARDS

Three awards are made annually to the authors of the best papers published in *Canadian Acoustics*. All papers reporting new results as well as review and tutorial papers are eligible; technical notes are not. The first award, for $500, is made to a graduate student author. The second and third awards, each for $250, are made to professional authors under 30 years of age and 30 years of age or older, respectively. Coordinator: Delila Giusti, Jade Acoustics, Concord, ON L4K 4H1.

STUDENT PRESENTATION AWARDS

Three awards of $500 each are made annually to the undergraduate or graduate students making the best presentations during the technical sessions of Acoustics Week in Canada. Application must be made at the time of submission of the abstract. Coordinator: Ramani Ramakrishnan, Aiolos Engineering, Toronto ON M9W 1K4, Tel: (416) 674-3017.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

ANNONCE DE PRIX

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

Prix Post-Doctoral Edgar et Millicent Shaw en Acoustique

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

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

Prix Étudiant Alexander Graham Bell en Communication Verbale et Acoustique Comportementale

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

1990	*Bradley Frankland*	*Dalhousie University*	*1994*	*Michael Lantz*	*Queen's University*
1991	*Steven D. Turnbull*	*University of New Brunswick*	*1995*	*Kristina Greenwood*	*University of Western Ontario*
	Fangxin Chen	*University of Alberta*	*1996*	*Mark Pell*	*McGill University*
	Leonard E. Cornelisse	*University of Western Ontario*	*1997*	*Monica Rohlfs*	*University of Alberta*
1993	*Aloknath De*	*McGill University*	*1998*	*Marlene Bagatto*	*University of Western Ontario*

Prix Étudiant Fessenden en Acoustique Sous-marine

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

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

Prix Étudiant Eckel en Contrôle du Bruit

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

1994	*Todd Busch*	*University of British Columbia*	*1996*	*Nelson Heerema*	*University of British Columbia*
1995	*Raymond Panneton*	*Université de Sherbrooke*	*1997*	*Andrew Wareing*	*University of British Columbia*

Prix des Directeurs

Trois prix sont décernés, à tous les ans, aux auteurs des trois meilleurs articles publiés dans l'*Acoustique Canadienne*. Tout manuscrit rapportant des résultats originaux ou faisant le point sur l'état des connaissances dans un domaine particulier sont éligibles; les notes techniques ne le sont pas. Le premier prix, de $500, est décerné à un(e) étudiant(e) gradué(e). Le deuxième et le troisième prix, de $250 chacun, sont décernés à des auteurs professionnels âgés de moins de 30 ans et de 30 ans et plus, respectivement. Coordonnateur: Delila Giusti, Jade Acoustics, Concord, ON L4K 4H1.

Prix de Présentation Étudiant

Trois prix, de $500 chacun, sont décernés annuellement aux étudiant(e)s sous-gradué(e)s ou gradué(e)s présentant les meilleures communications lors de la Semaine de l'Acoustique Canadienne. La demande doit se faire lors de la soumission du résumé. Coordonnateur: Ramani Ramakrishnan, Aiolos Engineering, Toronto ON M9W 1K4, Tel: (416) 674-3017.

NEWS / INFORMATIONS

CONFERENCES

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

1999

15-19 March: Joint Meeting of Acoustical Society of America/European Acoustics Association, Berlin, Germany. Contact: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797; Tel: 516-576-2360; Fax: 516-576-2377; Email: asa@aip.org; WWW: asa.aip.org

23-24 April: Interdisciplinary Views of Hearing Accessibility for Older Adults: The Sum of the Parts – 2nd Annual Conference of the Institute of Hearing Accessibility Research (IHEAR), University of British Columbia, Canada. Contact: Lisa Dillon Edgett, Tel: 604-822-9474; Fax: 604-822-6569; Email: seniors @audiospeech.ubc.ca

27-29 April: International Conference on Vibration, Noise and Structural Dynamics, Venice, Italy. Contact: D. Hill, Staffordshire University, P.O. Box 333, Beaconside, Stafford ST18 0DF, UK; Fax: +44 1785 353552.

10-14 May: 4th International Conference on Theoretical and Computational Acoustics, Trieste, Italy. Contact: A. Marchetto, ICTCA,99, Osservatorio Geofisico Sperimentale, P.O. Box 2011-Opicina, 34016 Trieste, Italy; Fax: +39 40 327040; Email: ictca99@ogs.trieste.it

17-20 May: Society of Automotive Engineers (SAE) and Noise and Vibration Conference & Exposition meeting, Traverse City, MI. Contact: M.J. Asensio, SAE/Troy, 3001 W Big Beaver Rd, Troy, MI, USA. Tel: 248-649-4920, ext. 3106.

24-26 May: 2nd International Conference on Emerging Technologies in NDT, Athens, Greece. Contact: A. Anastassopoulos, Envirocoustics S.A., Eleftheriou Venizelou 7 & Delfon, 14452 Athens, Greece; Fax: +30 1 28 46 805; Email: envac@acci.gr

30 May - 3 June: 16th International Evoked Response Audiometry Study Group Symposium, Tromsø, Norway. Contact: E. Laukli, Otorhinolaryngology, University Hospital, P.O. Box 34, 9038 Tromsø, Norway; Fax: +47 77 62 73 69; email: einar.laukli@rito.no

27-30 June: ASME Mechanics and Materials Conference, Blacksburg, VA. Contact: Mrs. Norma Guynn, Dept. of Engineering Science and Mechanics, Virginia Tech, Blacksburg, VA 24061-0219; Fax: 540-231-4574; Email: nguynn@vt.edu; WWW: http://www.esm.vt.edu/mmconf/

28-30 June: 1st International Congress of the East European Acoustical Association, St. Petersburg, Russia. Contact: EEAA, Moskovskoe Shosse 44, St. Petersburg 196158, Russia; Fax: +7 812 127 9323; Email: krylspb @sovam.com

28 June - 1 July: Joint Conference of Ultrasonics International '99 and World Congress on Ultrasonics '99 (UI99/WCU99), Lyngby, Denmark. Contact: L. Bjorno, Department of Industrial Physics, Technical University, Building 425, 2800 Lyngby, Denmark; Fax: +45 45 93 01 90; E-mail: lb@ipt.dtu.dk; WWW: www.msc.cornell.edu/~ui99/

CONFÉRENCES

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

1999

15-19 mars: Rencontre conjointe de l'Acoustical Society of America et de l'Association d'acoustique européenne, Berlin, Allemagne. Info: ASA, 500 Sunnyside Blvd., Woodbury, NY 11797; Tél: 516-576-2360; Fax: 516-576-2377; Email: asa@aip.org; WWW: asa.aip.org

23-24 avril: Regard interdisciplinaire sur l'accessibilité d'audition pour les personnes agées – 2e conférence annuelle de l'institut de recherches sur l'accessibilité d'audition (IHEAR), Université de Colombie-Britannique, Canada. Info: Lisa Dillon Edgett, Tél: 604-822-9474; Fax: 604-822-6569; Email: seniors @audiospeech.ubc.ca

27-29 avril: Conférence internationale sur les vibrations, le bruit, et la dynamique des structures, Venise, Italie. Info: D. Hill, Staffordshire University, P.O. Box 333, Beaconside, Stafford ST18 0DF, UK; Fax: +44 1785 353552.

10-14 mai: 4e conférence internationale sur l'acoustique théorique et informatisée, Trieste, Italie. Info: A. Marchetto, ICTCA,99, Osservatorio Geofisico Sperimentale, P.O. Box 2011-Opicina, 34016 Trieste, Italy; Fax: +39 40 327040; Email: ictca99@ogs.trieste.it

17-20 mai: Conférence et exposition de la Société des Ingénieurs d'autos (SAE) et conférence Bruit et Vibrations, Traverse City, MI. Info: M.J. Asensio, SAE/Troy, 3001 W Big Beaver Rd, Troy, MI, USA. Tél: 248-649-4920, poste 3106.

24-26 mai: 2e conférence internationale sur les nouvelles technologies de NDT, Athènes, Grèce. Info: A. Anastassopoulos, Envirocoustics S.A., Eleftheriou Venizelou 7 & Delfon, 14452 Athens, Greece; Fax: +30 1 28 46 805; Email: envac@acci.gr

30 mai - 3 juin: 16e Symposium du Groupe d'études international sur l'audiométrie de la réponse réflexe, Tromsø, Norvège. Info: E. Laukli, Otorhinolaryngology, University Hospital, P.O. Box 34, 9038 Tromsø, Norway; Fax: +47 77 62 73 69; email: einar.laukli@rito.no

27-30 juin: Conférence ASME sur la mécanique et les matériaux, Blacksburg, VA. Info: Mrs. Norma Guynn, Dept. of Engineering Science and Mechanics, Virginia Tech, Blacksburg, VA 24061-0219; Fax: 540-231-4574; Email: nguynn@vt.edu; WWW: http://www.esm.vt.edu/mmconf/

28-30 juin: 1er Congrès international de l'Association d'acoustique de l'Europe de l'Est, St. Petersburg, Russie. Info: EEAA, Moskovskoe Shosse 44, St. Petersburg 196158, Russia; Fax: +7 812 127 9323; Email: krylspb @sovam.com

28 juin - 1 juillet: Conférence conjointe de "Ultrason International '99" et "Congrès mondial '99 sur les ultrasons" (UI99/WCU99), Lyngby, Danemark. Info: L. Bjorno, Department of Industrial Physics, Technical University, Building 425, 2800 Lyngby, Denmark; Fax: +45 45 93 01 90; E-mail: lb@ipt.dtu.dk; WWW: www.msc.cornell.edu/~ui99/

4-9 July: 10th British Academic Conference in Otolaryngology, London, UK. Contact: BOA-HNS, The Royal College of Surgeons, 35-43 Lincoln's Inn Field, London WC2A 3PN, UK; Fax: +44 171 404 4200.

5-8 July: 6th International Congress on Sound and Vibrations, Copenhagen, Denmark. Contact: F. Jacobsen, Department of Acoustic Technology, Building 352, Technical University of Denmark, 2800 Lyngby, Denmark; Fax: +45 45 880577; Email: fjac@dat.dtu.dk; Web: www.dat.dtu.dk

1-4 September: 15th International Symposium on Nonlinear Acoustics (ISNA-15), Gottingen, Germany. Contact: W. Lauterborn, Drittes Physikalisches Institut, Universitat Gottingen, Burgerstr. 42-44, 37073 Gottingen, Germany; Fax: +49 551 39 7720; Email: lb@physik3.gwdg.de

15-17 September: British Society of Audiology Annual Conference, Buxton, UK. Contact: BSA, 80 Brighton Road, Reading RG6 1PS, UK; Fax: +44 0118 935 1915; Email: bsa@b-s-a.demon.co.uk; Web: www.b-s-a.demon.co.uk

18-19 October: 1999 Acoustics Week in Canada, Victoria, BC, Canada. Contact: Stan Dosso, School of Earth & Ocean Sciences, University of Victoria, Victoria, BC, Canada, V8W 3P6; Fax: (250) 721-6200; Email: sdosso@uvic.ca

20-22 October: Iberian Meeting of the Spanish Acoustical Society and the Portuguese Acoustical Society, Avila, Spain. Contact: Spanish Acoustical Society, c/Serrano 144, 28006 Madrid, Spain; Fax: +34 91 411 7651; email: ssantiago@fresno.csic.es

1-5 November: 138th meeting of the Acoustical Society of America, Columbus, OH. Contact: Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797; Tel.: 516-576-2360; Fax: 516-576-2377; email: asa@aip.org; WWW: asa.aip.org

2000

20-24 March: Meeting of the German Acoustical Society (DAGA), Oldenburg, Germany. Contact: DEGA, FB Physik, Universität Oldenburg, 26111 Oldenburg, Germany; Fax: +49 441 798 3698; Email: dega@aku.physik.uni-oldenburg.de

4-7 July: 7th International Congress on Sound and Vibration, Garmisch-Partenkirchen, Germany. Contact: H. Heller, DLR, Postfach 3267, 38022 Braunschweig, Germany; Fax: +49 531 295 2320; email: hanno.heller@dlr.de; WWW: www.iiav.org/icsv7.html

3-5 October: WESPRAC VII, Kumamoto, Japan. Contact: Computer Science Dept., Kumamoto Univ., 2-39-1 Kurokami, Kumamoto, Japan 860-0862; Fax: +81 96 342 3630; Email: wesprac7@cogni.eecs.kumamoto-u.ac.jp

16-18 October: National Meeting of the Spanish Congress on Acoustics, 31st National Meeting of the Spanish Acoustical Society, and EAA Tutorium, Madrid, Spain. Contact: Spanish Acoustical Society, c/Serrano 144, 28006 Madrid, Spain; Fax: +34 91 411 7651; email: ssantiago@fresno.csic.es

16-20 October: 6th International Conference on Spoken Language Processing, Beijing, China. Contact: ICSLP 2000 Secretariat, Institute of Acoustics, PO Box 2712, 17 Zhong Guan Cun Road, 100 080 Beijing, China; Fax: +86 10 6256 9079; Email: mchu@plum.ioa.ac.cn

4-9 juillet: 10e Conférence académique britannique sur l'otolaryngologie, Londres, Royaume-Uni. Info: BOA-HNS, The Royal College of Surgeons, 35-43 Lincoln's Inn Field, London WC2A 3PN, UK; Fax: +44 171 404 4200.

5-8 juillet: 6e congrès international sur le son et les vibrations, Copenhague, Danemark. Info: F. Jacobsen, Department of Acoustic Technology, Building 352, Technical University of Denmark, 2800 Lyngby, Denmark; Fax: +45 45 880577; Email: fjac@dat.dtu.dk; Web: www.dat.dtu.dk

1-4 septembre: 15e Symposium international sur l'acoustique non-linéaire (ISNA-15), Gottingen, Allemagne. Info: W. Lauterborn, Drittes Physikalisches Institut, Universitat Gottingen, Burgerstr. 42-44, 37073 Gottingen, Germany; Fax: +49 551 39 7720; Email: lb@physik3.gwdg.de

15-17 septembre: Conférence annuelle de la Société britannique d'audiologie, Buxton, Royaume-Uni. Info: BSA, Reading, UK; Fax: +44 0118 935 1915; Email: bsa@b-s-a.demon.co.uk; Web: www.b-s-a.demon.co.uk

18-19 octobre: Semaine canadienne d'acoustique 1999, Victoria, BC, Canada. Info: Stan Dosso, School of Ocean Sciences, University of Victoria, Victoria, BC, Canada, V8W 3P6; Fax: (250) 721-6200; Email: sdosso@uvic.ca

20-22 octobre: Rencontre ibérique de la Société d'acoustique espagnole et de la Société d'acoustique portuguaise, Avila, Espagne. Info: Spanish Acoustical Society, c/Serrano 144, 28006 Madrid, Spain; Fax: +34 91 411 7651; email: ssantiago@fresno.csic.es

1-5 novembre: 138e rencontre de l'Acoustical Society of America, Columbus, OH. Info: Acoustical Society of America, 500 Sunnyside Blvd., Woodbury, NY 11797; Tél.: 516-576-2360; Fax: 516-576-2377; email: asa@aip.org; WWW: asa.aip.org

2000

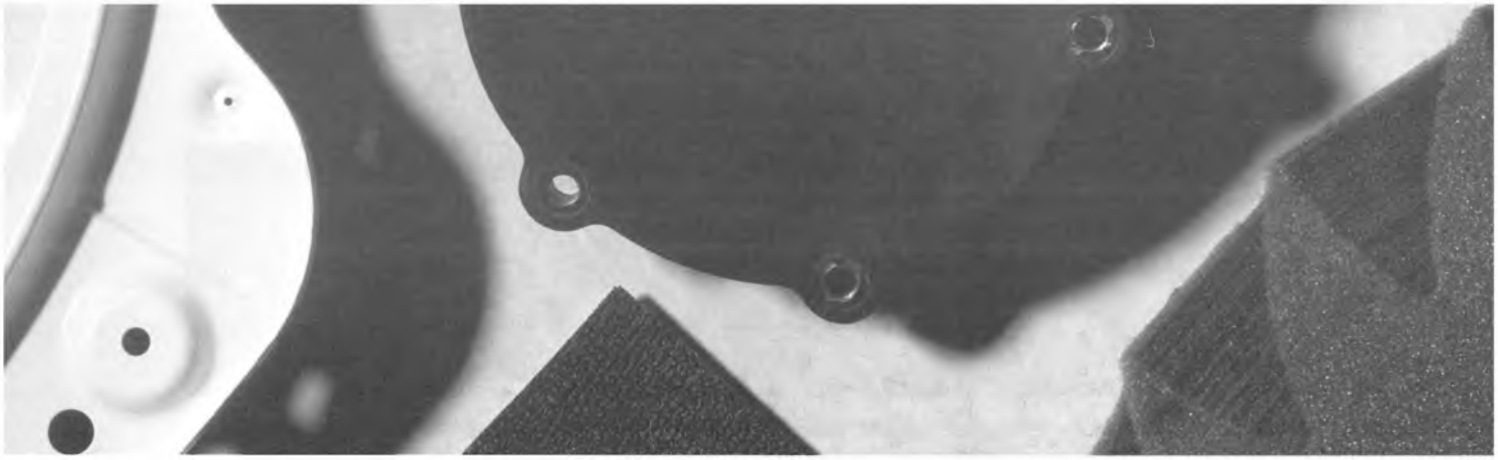
20-24 mars: Rencontre de la Société allemande d'acoustique (DAGA), Oldenburg, Allemagne. Info: DEGA, FB Physik, Universität Oldenburg, 26111 Oldenburg, Germany; Fax: +49 441 798 3698; Email: dega@aku.physik.uni-oldenburg.de

4-7 juillet: 7e Congrès international sur le son et les vibrations, Garmisch-Partenkirchen, Allemagne. Info: H. Heller, DLR, Postfach 3267, 38022 Braunschweig, Germany; Fax: +49 531 295 2320; email: hanno.heller@dlr.de; WWW: www.iiav.org/icsv7.html

3-5 octobre: WESPRAC VII, Kumamoto, Japon. Info: Computer Science Dept., Kumamoto Univ., 2-39-1 Kurokami, Kumamoto, Japan 860-0862; Fax: +81 96 342 3630; Email: wesprac7@cogni.eecs.kumamoto-u.ac.jp

16-18 octobre: Rencontre nationale du Congrès espagnol sur l'acoustique, 31e Rencontre nationale de la Société d'acoustique espagnole, et le EAA Tutorium, Madrid, Espagne. Info: Spanish Acoustical Society, c/Serrano 144, 28006 Madrid, Spain; Fax: +34 91 411 7651; email: ssantiago@fresno.csic.es

16-20 octobre: 6e conférence internationale sur le traitement de la langue parlée, Beijing, Chine. Info: ICSLP 2000 Secretariat, Institute of Acoustics, PO Box 2712, 17 Zhong Guan Cun Road, 100 080 Beijing, China; Fax: +86 10 6256 9079; Email: mchu@plum.ioa.ac.cn



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CALL FOR PAPERS

Acoustics Week in Canada 1999

Laurel Point Inn, Victoria, BC
October 18-19, 1999

Acoustics Week in Canada 1999 will consist of two days of technical and special sessions comprising topics from throughout the field of acoustics and vibration. Papers focusing on the following or additional topics in any area of acoustics are solicited:

Legislation / Environmental Noise	Architectural Acoustics	Musical Acoustics
Speech Perception and Production	Psycho-acoustics	Physiological Acoustics
Underwater Acoustics and Sound Propagation	Vibration Control	Noise Control
Occupational Hearing Loss and Hearing Protection	Canadian Standards	Sound Quality

Abstracts of a maximum 250 words must be submitted by May 31, 1999. The abstract should be prepared and sent in accordance with the instructions appearing in this issue of *Canadian Acoustics.* Submission by e-mail is strongly encouraged; files can be prepared in any word processing software. For those without access to e-mail, digital files on diskette or paper copy should be mailed to the address given in the instructions. Notification of acceptance of abstracts will be sent to authors by June 15, 1999 along with a registration form. Summary papers are due August 7, 1999. This deadline will be strictly enforced to meet the publication schedule of the proceedings issue of *Canadian Acoustics.*

Proposals for **Special Sessions** on a particular topic in acoustics are welcome. Contact Dr. Stan Dosso at the address below prior to May 31, 1999 if you are interested in having a special session at this year's meeting.

Student participation in Acoustics Week in Canada is strongly encouraged. Awards are available to students whose presentations at the conference are judged to be particularly noteworthy. To qualify, students must apply by enclosing an *Annual Student Presentation Award* form with their abstract. Students presenting papers may also apply for a travel subsidy to attend the meeting if they live at least 150 km from Victoria, BC. To apply for this subsidy, students must submit an *Application For Student Travel Subsidy*, included in this issue.

Accommodation and meeting space for delegates of Acoustics Week in Canada 1999 will be at the Laurel Point Inn, located right on the harbour in scenic downtown Victoria, BC. The special room rate for delegates starts at $65.00 per night. To reserve your accommodation, contact the Laurel Point Inn at 1-800-663-7667, stating that you will be attending Acoustics Week in Canada 1999.

Space will be available for **Exhibits** by companies and organizations in the field of acoustics. **Sponsorship** of nutrition breaks and/or lunches is also welcome. If you are interested in either of these opportunities, please contact Doug Whicker, (604) 988-2508, dwhicker@bkla.com.

Important Dates

May 31, 1999	Deadline for submission of abstracts
June 15, 1999	Notification of acceptance of abstracts
August 7, 1999	Deadline for receipt of summary paper and early registration
October 18-19, 1999	Acoustics Week in Canada 1999

For more information contact:

Acoustics Week in Canada 1999
c/o Dr. Stan Dosso
Centre for Earth and Ocean Research, University of Victoria
P.O. Box 3055, Victoria, BC V8W 3P6
Telephone: (250) 472-4341 Fax: (250) 472-4100
sdosso@uvic.ca

APPEL DE COMMUNICATIONS

Semaine canadienne d'acoustique 1999

Laurel Point Inn, Victoria, CB
18-19 octobre, 1999

La semaine canadienne d'acoustique 1999 consistera en deux jours de sessions techniques et spéciales comprenant des sujets du domaine de l'acoustique et des vibrations. Des communications traitant des sujets suivants ou de sujets additionnels dans le domaine de l'acoustique sont sollicitées:

Réglements et bruit environnemental	Acoustique architecturale	Acoustique musicale
Perception et production du language	Psycho-acoustique	Physio-acoustique
Acoustique sous-marine et propagation du son	Contrôle de vibration	Contrôle de bruit
Audiologie	Normalisation canadienne	Qualité du son

Les résumés de 250 mots maximum doivent être soumis avant le 31 mai 1999. Les résumés devront être préparés suivant les instructions incluses dans ce numéro *d'Acoustique Canadienne.* Les soumissions par courrier électronique sont fortement encouragées; les documents peuvent être édités avec n'importe quel traitement de texte. Pour ceux qui n'ont pas accès au courrier électronique, les documents digitaux sur disquette ou papier devront être envoyés à l'adresse indiquée dans les instructions. Une notification d'acceptation des résumés sera envoyée aux auteurs avant le 15 juin 1999 avec un formulaire d'inscription. Un sommaire de la présentation devra etre envoyé avant le 7 août 1999. Cette échéance sera strictement respectée afin de pouvoir publier le programme dans les actes *d'Acoustique Canadienne.*

Les propositions pour les sessions spéciales sur un sujet particulier en acoustique sont les bienvenues. Contactez Dr Stan Dosso à l'adresse ci-dessous avant le 31 mai 1999 si vous désirez avoir une session spéciale durant la conférence de cette année.

La participation d'étudiants à cette Semaine Canadienne d'Acoustique est fortement encouragée. Des prix seront attribués aux meilleures présentations. Les étudiants doivent indiquer leur intention de participer en complétant le formulaire "Prix annuels relatifs aux communications étudiantes" et en le joignant à leur résumé. Les étudiants présentant une communication peuvent aussi faire une demande de subvention pour leur frais de déplacement si ils résident à plus de 150 km de Victoria, CB. Pour demander cette subvention, les étudiants doivent soumettre le formulaire de demande de remboursement pour frais de déplacement inclus dans ce numéro.

L'hébergement des participants à la semaine canadienne d'acoustique et les communications se tiendront à l'auberge Laurel Point Inn, située au centre ville (sur le port) de Victoria,CB. Les participants bénéficient de tarifs spéciaux pour les chambres commençant à $65 par nuit. Pour réserver votre chambre, contacter Laurel Point Inn au 1-800-663-7667 en mentionnant votre participation a la Semaine Canadienne d'Acoustique 1999.

Des espaces seront disponibles pour des **Expositions** de sociétés et d'organisations dans le domaine de l'acoustique. Des **Sponsors** pour les pauses alimentaires et/ou déjeuners sont aussi les bienvenus. Si vous êtes intéressés par l'une de ses offres, contacter Doug Whicker, (604) 988-2508, dwhicker@bkla.com.

Dates importantes:

31 may, 1999	Echéance pour la soumission des résumés
15 juin, 1999	Notification d'acceptation des résumés
7 août, 1999	Echéance pour la réception des sommaires et les premières inscriptions
18-19 octobre, 1999	Semaine Canadienne d'Acoustique 1999

Pour plus d'informations contacter: Semaine Canadienne d'Acoustique 1999
c/o Dr. Stan Dosso
Centre for Earth and Ocean Research, University of Victoria
P.O. Box 3055, Victoria, BC V8W 3P6
Téléphone: (250) 472-4341 Fax: (250) 472-4100 sdosso@uvic.ca

Acoustics Week in Canada 1999
INSTRUCTIONS FOR PREPARATION OF ABSTRACTS

1) Abstracts are to be MAXIMUM 250 words.

2) Submissions may be in either English or French.

3) A cover letter is not necessary.

4) Title of abstract, and names and addresses of authors should be set apart from the abstract. Text of the abstract should be one single, indented paragraph.

5) Do not use footnotes. Use square brackets to cite references or acknowledgements.

6) At the bottom of the abstract, provide the following information:
a) if the paper is part of a special session, indicate the session
b) name the area of acoustics most appropriate to the subject matter
c) name, e-mail address, telephone and fax numbers, including area code, of the author to be contacted for information and to receive the acceptance notice. Authors outside of Canada should include country
d) any AV equipment required for presentation. The meeting organizers cannot guarantee the availability of equipment other than overhead projectors, 35 mm slide projectors and cassette tape players.

7) Electronic submission is preferred. Send abstract as either the body of an e-mail message or as an attachment to **sdunlop@uvic.ca**. Any word processing software is acceptable. For those without access to e-mail, digital files on diskette or paper copy should be mailed to:

Acoustics Week in Canada 1999
c/o Centre for Earth and Ocean Research
University of Victoria
P.O. Box 3055, Victoria, BC,
Canada, V8W 3P6

Acoustics Week in Canada 1999
PREPARATION OF SUMMARY PAPERS FOR PUBLICATION IN CONFERENCE PROCEEDINGS ISSUES

Authors are asked to submit both a camera-ready paper copy and digital file of their summary paper by August 7 to the address given in 7) above. Summary papers should be prepared according to the following specifications:

1) Maximum two pages in two-column format (column width of 3.4" and separation of 1/4").

2) Do not include an abstract.

3) All text in Times-Roman font. Title in 12pt bold with single (12pt) spacing, centred on the page. All other text in 9pt with 0.75 (9pt) line spacing.

4) Authors' names and addresses centred on page with names in bold type. Section headings in bold type.

5) Place figures at the top and/or bottom of the pages, if possible.

6) List references in any consistent format at the end.

Semaine Canadienne d'Acoustique 1999
INSTRUCTIONS POUR LA PREPARATION DES RESUMES

1) Les résumés doivent avoir un MAXIMUM de 250 mots.

2) Les soumissions peuvent être en anglais ou en français.

3) Une lettre d'introduction au résumé n'est pas necessaire.

4) Le titre du résumé et les noms et adresses des auteurs devront être séparés du résumé. Le texte du résumé devra être un seul paragraphe.

5) Ne pas utiliser de notes de bas de page. Utiliser des crochets pour les références et les remerciements.

6) En bas du résumé, fournir les informations suivantes:
a) si la communication fait partie d'une session spéciale, indiquer laquelle
b) identifier le domaine de l'acoustique le plus approprié à votre sujet
c) nom, adresse électronique, adresse postale, numéros de téléphone et fax (incluant les codes régionaux) de l'auteur avec qui on doit communiquer pour information qui doit recevoir la notification d'acceptation. Les auteurs extérieurs au Canada devront préciser le pays.
d) les équipements audio-visuel nécessaires pour les présentations. Les organisateurs de la conférence ne peuvent guarantir les équipements autre que les projecteurs à acétates et à diapositives (35 mm).

7) Les soumissions par courrier électronique sont préférées. Envoyer les résumés soit dans le corps du message, soit en attachement à **sdunlop@uvic.ca.** N'importe quel traitement de texte est accepté. Pour ceux qui n'ont pas accès au courrier electronique, les fichiers digitaux sur disquette ou papier peuvent être envoyés a:

Semaine canadienne d'acoustique 1999
c/o Centre for Earth and Ocean Research
University of Victoria
PO BOX 3055, Victoria, BC
Canada, V8W 3P6

Semaine Canadienne d'Acoustique 1999
PREPARATION DES SOMMAIRES POUR LEUR PUBLICATIONS DANS LES ACTES DE LA CONFERENCE

Les auteurs doivent soumettre un article prêt à copier et une copie digitale de leur sommaire avant le 7 août à l'adresse indiquée en 7) ci dessus. Les sommaires doivent être préparés suivant les instructions suivantes:

1) Deux pages maximum avec deux colonnes par page (largeur des colonnes de 3.4" et séparation de 1/4").

2) Ne pas inclure de résumé.

3) Tout le texte en caractère Times-Roman. Titre en 12pt, caractère gras, en simple interligne (12 pt), centré sur la page.

4) Les noms et adresses des auteurs centrés sur la page avec les noms en caractères gras. Les titres de sections en caractères gras.

5) Placer les figures en haut et/ou en bas des pages si possible.

6) Donner la liste des références dans un format logique à la fin.

Acoustics Week in Canada 1999
STUDENT PRESENTATION AWARDS

The Canadian Acoustical Association makes awards to students who present outstanding papers at Acoustics Week in Canada. Students wishing to be considered for these awards must complete the form below and submit it with their abstract. Three awards of $500.00 are available.

To qualify for a Student Presentation Award, the applicant must be:
a) a full-time graduate student at the time of application
b) the first author of the paper (multiple authors are permitted, but only the first author may receive an award)
c) a member of the CAA
d) registered at the meeting

Presentations eligible for these awards will be reviewed independently by a least three judges and will be considered on the following merits:
a) the way the subject is presented
b) the explanation of the relevance of the subject
c) the explanation of the methodology/theory
d) the presentation and analysis of results
e) the consistency of the conclusions with theory and results

Semaine Canadienne d'Acoustique 1999
PRIX RECOMPENSANT LES COMMUNICATIONS D'ETUDIANTS

L'Association Canadienne d'Acoustique décerne des prix aux étudiants qui présenteront d'exceptionnelles communications à la Semaine Canadienne d'acoustique. Les étudiants souhaitant s'inscrire pour ces prix doivent compléter le formulaire ci-dessous et le soumettre avec leur résumé. Trois prix de $500.00 seront attribués. Pour s'inscrire au concours pour les communications d'étudiants, l'étudiant doit être:
a) un étudiant à temps plein de niveau gradué au moment de l'inscription
b) le premier auteur de la communication (plusieurs auteurs sont permis mais le premier auteur seulement peut recevoir un prix).
c) un membre de l'ACA
d) un participant à la conférence

Les présentations éligibles pour ces prix seront jugées indépendamment par au moins trois juges et seront considérées suivant les mérites suivants:
a) la façon dont le sujet est présenté
b) la pertinence du sujet
c) l'explication de la méthodologie/ théorie
d) la présentation et l'analyse des résultats
e) la consistance des conclusions avec la théorie et les résultats

Acoustics Week in Canada 1999
STUDENT TRAVEL SUBSIDY

Travel subsidies are available to students presenting papers if:
a) they live at least 150 km from Victoria, BC
b) supporting receipts are submitted
c) the application form below is submitted with their abstract
d) they publish a summary paper in the proceedings issue of *Canadian Acoustics.*

Semaine Canadienne d'Acoustique 1999
SUBVENTION POUR LES FRAIS DE DEPLACEMENT DES ETUDIANTS

Des subventions pour les frais de déplacement sont disponibles pour les étudiants présentant des communications si ils:
a) résident à plus de 150 km de Victoria, CB
b) fournissent les reçus a l'appui
c) complètent et soumettent le formulaire ci dessous avec leur résumé
d) publient un sommaire de leur communication dans les actes *d'Acoustique Canadienne.*

Name of Student: ______________________________ **Nom de l'étudiant**

Social Insurance Number: ______________________________ **Numéro d'assurance sociale**
(only required if applying for Presentation Award) *(requis seulement si l'étudiant postule pour un prix pour sa communication)*

Title of Paper: ______________________________ **Titre de la communication**

University/College: ______________________________ **Université/Collège**

Name & Title of Supervisor: ______________________________ **Nom et titre du superviseur**

Required for Student Presentation Award: The undersigned affirms that the above named student is a full-time student and the paper to be presented is the student's original work.

____
Signature of Supervisor

Requis pour le prix pour les communications d'étudiants: Le sous-signé affirmé que l'étudiant cité ci-dessus est un étudiant inscrit à temps plein et que la communication présentée est le travail original de l'étudiant.

____
Signature du superviseur

Required for Student Travel Subsidy: The undersigned affirms that the CAA Travel Subsidy, combined with other travel funds that the above named student may receive to attend the meeting, will not exceed his/her travel costs.

____
Signature of Supervisor

Requis pour la subvention des frais de déplacement de l'étudiant: Le sous-signé affirme que la subvention de l'ACA pour les frais de déplacement combinée à d'autres financements pour le déplacement que l'étudiant cité ci-dessus peut recevoir pour assister à la conférence n'excèdera pas ses frais réél de déplacement.

____
Signature du superviseur

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

SUBSCRIPTION INVOICE

Subscription for the current calendar year is due January 31. New subscriptions received before July 1 will be applied to the current year and include that year's back issues of *Canadian Acoustics*, if available. Subscriptions received from July 1 will be applied to the next year.

FACTURE D'ABONNEMENT

L'abonnement pour la présente année est dû le 31 janvier. Les nouveaux abonnements reçus avant le 1 juillet s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de *l'Acoustique Canadienne* de cette année. Les abonnements reçus après le 1 juillet s'appliquent à l'année suivante.

Check ONE Item Only: / Cocher la case appropriée :

CAA Membership	___	$ 50	___	Membre individuel
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Check areas of interest (max 3): / Cocher vos champs d'intérêt (max. 3):

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Engineering Acoustics / Noise Control	2.	_____	2.	Génie acoustique / Contrôle du bruit
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Musical Acoustics / Electroacoustics	4.	_____	4.	Acoustique musicale / Electroacoustique
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Underwater Acoustics	9.	_____	9.	Acoustique sous-marine
Signal Processing / Numerical Methods	10.	_____	10.	Traitement des signaux / Méthodes numériques
Other	11.	_____	11.	Autre

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PLEASE TYPE NAME AND ADDRESS BELOW:

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Faites parvenir ce formulaire à l'adresse suivante en prenant soin d'y joindre un chèque fait au nom de L'ASSOCIATION CANADIENNE D'ACOUSTIQUE:

Make cheques payable to THE CANADIAN ACOUSTICAL ASSOCIATION. Mail this form with payment to:

Trevor Nightingale
Secretary, Canadian Acoustical Association
P. O. Box 74068
Ottawa, Ontario K1M 2H9

The Canadian Acoustical Association
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L'Association Canadienne d'Acoustique tient à témoigner sa reconnaissance à l'égard de ses Abonnés de Soutien en publiant ci-dessous leur nom et leur adresse. En amortissant les coûts de publication et de distribution, les dons annuels (de $150.00 et plus) rendent le journal accessible à tous nos membres. Les Abonnés de Soutien reçoivent le journal gratuitement. Pour devenir un Abonné de Soutien, faites parvenir vos dons (chèque ou mandat-poste fait au nom de l'Association Canadienne d'Acoustique) au secrétaire de l'Association.

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