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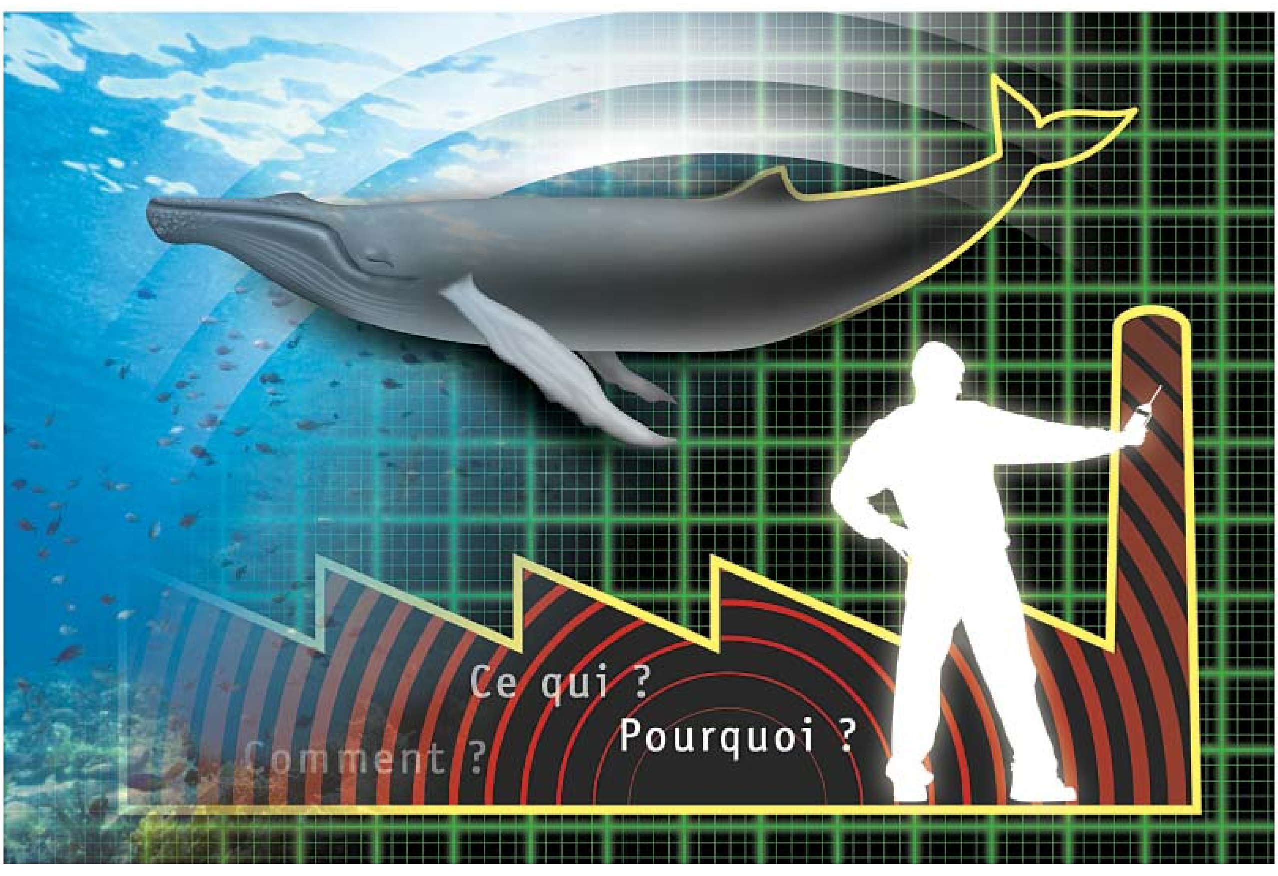

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CANADIAN ACOUSTICS publishes refereed articles and news items on all aspects of acoustics and vibration. Articles reporting new research or applications, as well as review or tutorial papers and shorter technical notes are welcomed, in English or in French. Submissions should be sent directly to the Editor-in-Chief. Complete instructions to authors concerning the required camera-ready copy are presented at the end of this issue.

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EDITORIAL / EDITORIAL

Le temps passe à la vitesse du son! Il y a déjà un an, je vous adressais mon éditorial. Vous aviez peut-être oublié que le numéro du mois de juin est consacré en bonne partie à des publications de nos collègues qui utilisent la langue de Molière pour faire connaître leurs travaux. À titre de rédactrice-adjointe francophone, j'ai le privilège de vous présenter ce numéro.

Dans cette édition de juin, vous pourrez lire un article de collègues québécois qui se sont penchés sur l'évaluation de la procédure établie en 1993, en Montérégie, pour encadrer les activités de dépistage de la surdité professionnelle. Il est apparu important pour ces professionnels de la santé de s'assurer que les activités de relance des dossiers susceptibles de bénéficier des services de réadaptation ou de répondre aux critères d'indemnisation aient porté fruits. La problématique du dépistage de la surdité professionnelle suscite de vifs débats dans les pays industrialisés. Les démarches entreprises au Québec méritent d'être mises en évidence afin de montrer l'importance d'agir adéquatement dans ce dossier qui touche un grand nombre de travailleurs exposés au bruit.

Un autre article francophone nous vient de l'Algérie. Celui-ci fait suite à un article paru récemment sur la simulation des caractéristiques acoustiques du conduit vocal. Je profite de l'occasion pour inviter nos collègues de langue française du monde entier à nous soumettre leur publication. Nous sommes choyés au Canada de pouvoir compter sur la revue « Acoustique Canadienne » qui nous permet de publier nos travaux récents en français. Plusieurs pays n'ont pas cette chance.

Trois autres articles de nos collègues anglophones viennent enrichir ce numéro de juin. Un premier article porte sur l'acoustique sous-marine, plus précisément sur la détection du chant des baleines à l'aide de spectrogrammes. Le deuxième article nous plonge dans le monde des vibrations du corps humain à l'intérieur des véhicules militaires. Enfin, un dernier article traite de l'échantillonnage de l'exposition au bruit de groupes de travailleurs. Il y en a donc pour satisfaire tous les goûts!

Nous reproduisons aussi un document intitulé « Acous-

Time is flying at the speed of light! Already a year has passed since my last editorial. You might have forgotten that the June issue of the journal is dedicated in part to publications from colleagues who share with us, in Molière's language, their work. As assistant editor, it is my privilege to present this special number.

In this June issue, you can read an article from our Quebec colleagues who examined a protocol established in 1993 to guide screening activities for occupational noise-induced hearing loss. It seemed important to these health professionals to verify that follow-up examinations were successful in identifying those individuals susceptible of beneficiating from rehabilitation services or of meeting workers' compensation criteria. The issue of screening for occupational hearing loss has generated heated debates in industrialized countries. The approaches set forth in Quebec warrant attention as they demonstrate the need to act adequately in such cases where a great number of noise-exposed workers are concerned.

Another francophone article originates from Algeria and follows an article published recently on the simulation of the acoustic characteristics of the vocal tract. I gladly seize this opportunity to invite our French-speaking colleagues from all over the world to submit their publications. In Canada, we are fortunate to have the "Canadian Acoustics" journal to publish in French the fruits of our research endeavours. Many countries don't share such opportunities.

Three other articles from Anglophone colleagues enrich this June issue. One deals with underwater acoustics and more specifically addresses the performance of spectrograms in detecting whale calls. The second transports us to the military world by exploring whole-body vibrations in military vehicles. Finally, the third article focuses on noise exposure group surveys. This issue therefore covers many themes and is sure to satisfy everyone's likings.

A document entitled "Acoustics in Canada" recently published in "Echoes", the journal of the Acoustical Society of America, can also be found in this issue and provides a tics in Canada » récemment publié dans le journal « Echoes » de l'Acoustical Society of America. Ce papier dresse un portrait très encourageant des activités en cours au Canada, dans tous les domaines de l'acoustique. Vous êtes fortement invités à le lire, afin de vous mettre à jour sur ce que font nos collègues d'un océan à l'autre.

Enfin, n'oubliez pas que la prochaine Semaine de l'Acoustique se tiendra à London, Ontario, du 12 au 14 octobre 2005. Vous êtes invités à soumettre vos résumés de publication avant le 24 juin 2005. Vous n'avez qu'à consulter le présent numéro où vous trouverez tous les détails sur ce congrès qui se promet d'être énergisant. Vous aurez peut-être manqué le congrès conjoint de l'Acoustical Society of America et de l'ACA qui se tenait à Vancouver du 16 au 20 mai 2005, mais vous aurez la chance de vous reprendre à London, si vous voulez profiter de l'occasion pour échanger avec vos collègues sur les sujets passionnants de l'acoustique.

À l'an prochain pour mon éditorial à saveur francophone!

Votre rédactrice-adjointe,
Chantal Laroche

very encouraging overview of the many activities currently under way in Canada throughout the various fields of acoustics. I strongly encourage you to read this document to keep up to date with the activities carried out by our Canadian colleagues from coast to coast.

Finally, don't forget the next Acoustic Week (October 12-14, 2005) in London, Ontario. You are invited to submit your publication abstracts before June 24th 2005, and to consult the current issue of the journal for more information on what promises to be a lively convention. If you missed the joint convention of the Acoustical Society of America and the ACA held in Vancouver from May 16th to the 20th, seize this opportunity to make up for an exchange with colleagues on an array of captivating topics in acoustics by attending the Acoustic Week in London.

Till next year for my editorial with a French twist!

Your assistant editor,
Chantal Laroche

LES EXAMENS AUDITIFS EN MILIEU DE TRAVAIL EN MONTERGIE: ÉVALUATION DES OBJECTIFS VISES

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RÉSUMÉ

Suite à la réorganisation de la santé au travail en Montérégie, de nouvelles lignes directrices ont été proposées pour les activités de dépistage de la surdité professionnelle et adoptées en 1993 par le Regroupement des médecins en santé au travail. Après plusieurs années d'implantation, il leur est apparu nécessaire d'évaluer la procédure établie en insistant plus particulièrement sur les examens de relance d'un sous-groupe de travailleurs répondant aux critères définis dans ces lignes directrices. Le premier volet couvert par cette évaluation est l'atteinte des objectifs visés par la relance, soit l'identification des travailleurs susceptibles de bénéficier de services de réadaptation ou du droit à l'indemnisation. Le deuxième volet concerne l'évolution de l'audition des travailleurs exclus de la relance, c'est-à-dire dans quelle mesure la stratégie actuelle permet-elle de rejoindre l'ensemble des travailleurs susceptibles de manifester des besoins en matière de réadaptation ou de bénéficier du droit à l'indemnisation. Finalement, le nouveau guide définissant les activités de dépistage de la surdité professionnelle est présenté. Ce guide a été adopté en février 2004 par le Regroupement des médecins en santé au travail de la Montérégie basé sur les résultats de cette évaluation.

ABSTRACT

Following a restructuring of the occupational health sector in the Montérégie region, new guidelines were proposed for screening measures of occupational hearing loss and were adopted in 1993 by the Regroupement des médecins en santé au travail. After many years of implementation, it was judged necessary to evaluate the established protocol by focusing more specifically on follow-up examinations of a sub-group of workers meeting the criteria defined within these guidelines. The first issue addressed by this evaluation refers to the accomplishment of goals set forth regarding follow-up examinations, which consist of identifying workers susceptible of benefiting from rehabilitation services or workers' compensation. The second point of interest relates to the progression of hearing loss in workers excluded from follow-up examinations. In other words, the evaluation seeks to determine if current practices can reach the entire population of workers susceptible of demonstrating rehabilitation needs or benefiting from workers' compensation. Finally, the new guide defining the screening measures of occupational hearing loss is presented. Founded on the results of this evaluation, the guide was adopted in February 2004 by the Regroupement des médecins en santé au travail de la Montérégie.

1. INTRODUCTION

En 1992, la réorganisation de la santé au travail en Montérégie a conduit au regroupement des ressources au sein de sept (7) centre locaux de services communautaires (CLSC). Ces organismes publics ont le mandat d'élaborer et de mettre en œuvre un programme de santé spécifique adapté aux entreprises ciblées dans la loi sur la santé et la sécurité du travail [1]. Dans cette foulée, il est vite apparu nécessaire, pour les médecins responsables au sein du nouveau Regroupement des médecins en santé au travail, de réviser et d'harmoniser les pratiques en matière de dépistage de la surdité professionnelle. Les lignes directrices proposées pour les activités de dépistage de la surdité professionnelle ont été précisées dans un document adopté en juin 1993 par le Regroupement des médecins en santé au travail de la Montérégie [2]. Le document adopté reflétait le bilan des connaissances en matière de surveillance de l'audition des travailleurs, au regard de l'objectif de prévention de l'apparition ou de l'aggravation d'une perte auditive causée par le bruit en milieu de travail.

En 1995, ces lignes directrices ont été entérinées, avec quelques modifications, par les membres d'un Comité aviseur à la Direction générale de la santé publique du ministère de la santé et des services sociaux du Québec sur les examens auditifs en milieu de travail [3].

Description de la stratégie de dépistage adoptée en 1993 et de la révision souhaitée.

Compte tenu des effets pervers que peut comporter une surveillance considérée comme une série d'examens répétés dans le temps auprès de tous les travailleurs exposés au bruit (ex. ciblage du travailleur plutôt que du bruit, sentiment de fausse sécurité chez le travailleur, qualités métriques limitées de l'examen audiométrique, protocole d'analyse standardisé mal adapté à l'identification d'une détérioration réelle de l'audition), le Regroupement des médecins a rejeté cette option [2].

Bien que les connaissances scientifiques ne permettaient pas, en 1993, de conclure à l'utilité des examens auditifs comme outil de sensibilisation menant à la modification du milieu ou des comportements des travailleurs, l'expérience sur le terrain des intervenants témoignait de la capacité d'une campagne de dépistage à motiver l'entreprise dans le but d'adopter et d'implanter des mesures de réduction du bruit.

C'est ainsi que les activités de dépistage retenues prévoient deux types d'examens ayant des objectifs distincts, soit l'examen initial et l'examen de relance.

L'examen initial poursuit des objectifs à la fois individuels et collectifs. Sur le plan collectif, il peut servir à mieux connaître l'état de l'audition des travailleurs à risque et contribuer aussi à la reconnaissance de la situation à risque préalable à l'adoption de mesures préventives efficaces. Sur le plan individuel, il permet d'une part, d'identifier les travailleurs atteints de surdité professionnelle de divers stades, de les informer et de les sensibiliser à l'état de leur audition en relation avec le milieu de travail et d'autre part, d'identifier et d'orienter ceux qui pourraient bénéficier de services de réadaptation ou du droit à l'indemnisation.

La population ciblée par cet examen doit donc présenter un certain risque d'atteinte à l'audition afin de pouvoir servir adéquatement les objectifs visés tout en permettant une intervention à un moment où il est possible d'améliorer le pronostic de la maladie en termes de prévention d'une aggravation et d'une atténuation des situations de handicap, c'est-à-dire les situations où la perte auditive constitue une limitation à leur fonctionnement familial, social ou professionnel. À cette fin, les travailleurs dont le niveau d'exposition est au moins équivalent à 85 dBA (LAeq, 2000H $\geq$ 85) et ayant été exposé au bruit durant au moins 5 ans dans leur carrière constituent la population à risque. Ils sont alors soumis à l'examen initial dans le cadre du programme de santé spécifique à l'établissement. Nous nous assurons ainsi qu'autour de 10 % des travailleurs présenteront une atteinte auditive causée par le bruit et que le bilan qui en résultera ait plus de chance d'amener l'employeur à reconnaître la nocivité du bruit dans son entreprise [8].

Les lignes directrices de 1993 prévoient aussi que certaines conditions aggravantes peuvent conduire à l'assouplissement du critère de la population ciblée par l'examen initial, en termes de l'ancienneté ou du niveau d'exposition minimal requis (ex. si exposition à des bruits impulsionnels, à des niveaux sonores >100 dBA).

Selon les résultats de l'examen initial, un certain nombre de ces travailleurs est ciblé pour l'examen de relance. L'objectif visé par ce deuxième examen est uniquement d'ordre individuel et tient compte du caractère irréversible de l'atteinte et des situations de handicap associées. C'est ainsi que l'examen de relance vise l'identification, l'information et l'orientation des travailleurs susceptibles de bénéficier de services de réadaptation ou du droit à l'indemnisation. Une périodicité minimale de 5 ans entre les deux examens a été retenue principalement pour tenir compte de l'évolution de l'atteinte ou des situations de handicap nécessaire pour rencontrer l'objectif visé par la relance.

À partir des résultats de l'examen initial, un critère empirique fondé sur une moyenne de seuils aux mêmes fréquences que celles utilisées pour le calcul du critère d'indemnisation en vigueur au Québec, a servi à définir la population ciblée pour cet examen. Puisque l'examen audiométrique a un pouvoir limité pour identifier les travailleurs ayant des situations de handicap [2], une entrevue avec les travailleurs ciblés par la relance devait compléter cet examen. On parle ici d'une « évaluation des situations de handicap » réalisée par l'intervenante en soins infirmiers, habituellement au moment de la remise du résultat d'examen.

C'est ainsi que, parmi les travailleurs visés par l'examen initial et qui n'ont pas fait l'objet d'une référence (réadaptation ou indemnisation), les travailleurs ciblés par la relance sont ceux dont l'atteinte auditive correspond, pour au moins une oreille, à l'un des critères suivants:

- une moyenne des seuils auditifs à .5-1-2-4 kHz $\geq$ 25 dBHL;
- une moyenne des seuils auditifs à .5-1-2-4 kHz entre 20-24 dBHL si l'âge à l'examen initial est de 45 ans ou plus.

Dans les faits, cela correspond à environ 15 % de la population des travailleurs ciblés par l'examen initial. Pour être admissibles à cet examen, ces travailleurs devront également avoir été soumis durant cette période à des niveaux d'exposition $\geq$ 85 dBA.

Puisque l'implantation de ces nouvelles lignes directrices était prévue au moment de la mise à jour des programmes de santé spécifiques à l'établissement, il a fallu attendre environ trois à quatre années avant qu'un nombre significatif d'examens de relance soient réalisés en Montérégie. C'est ce qui explique probablement pourquoi les doléances touchant majoritairement l'examen de relance ont été exprimées davantage vers la fin des années '90 par les intervenants impliqués dans le dépistage. Elles concernaient particulièrement les travailleurs exclus de la relance.

En effet, les travailleurs non admissibles à l'examen de relance, sur la base des résultats à leur examen initial, n'ont plus accès à aucune forme systématique de suivi en termes d'examen de dépistage. Les intervenants se sont questionnés sur l'évolution de l'audition de ces travailleurs exclus de la relance. Par exemple, ils s'interrogeaient sur la possibilité que certains de ces travailleurs deviennent indemnisables après une période de temps plus ou moins prolongée. Un comité interdisciplinaire chargé de la révision des lignes directrices de 1993 a alors été mis sur pied en 2000. Il était formé de médecins, infirmières et audiologiste de la Direction de santé publique et des équipes locales de santé au travail.

À l'automne 2001, Manon Blackburn, alors résidente IV en santé communautaire, a rédigé une proposition de devis d'évaluation de l'examen de relance dans le cadre de son stage en santé au travail. Au cours de l'hiver 2002, elle présenta son document de réflexion au comité interdisciplinaire [4].

Deux objectifs généraux y sont proposés pour répondre aux besoins du comité concernant la population cible à l'examen de relance:

Volet 1 :

Évaluer l'atteinte des objectifs visés par la relance tels que décrits dans les lignes directrices de 1993. L'examen de relance permet-il d'identifier des travailleurs susceptibles de bénéficier de services de réadaptation ou du droit à l'indemnisation?

Volet 2 :

Documenter l'évolution de l'audition des travailleurs exclus, non admissibles à la relance, parce que l'état de leur audition à l'examen initial ne répond pas aux critères prévus pour l'examen de relance. Dans quelle mesure, avec le temps, ces travailleurs ne pourraient-ils pas bénéficier de services de réadaptation, du droit à l'indemnisation, ou du moins, rencontrer les critères d'admissibilité à la relance? En somme, il s'agit de déterminer si la stratégie définie dans les lignes directrices de 1993 permet de rejoindre l'ensemble de la population qui pourrait bénéficier de services en matière de réadaptation ou du droit à l'indemnisation.

2. MÉTHODOLOGIE

Pour des raisons d'espace, seuls quelques-uns des indicateurs utilisés sont présentés. Pour plus de détails, le lecteur est invité à lire le rapport complet de l'évaluation [5].

2.1 Volet 1

L'approche privilégiée pour procéder à l'évaluation de ce premier volet est de type normative [6]. Les deux aspects suivants de l'évaluation sont présentés ici:

a) Évaluation des effets

Cela consiste à évaluer l'écart entre les résultats obtenus et les objectifs prévus, notamment à l'aide des deux indicateurs présentés dans le Tableau 1.

b) Évaluation de la qualité

Cela consiste à évaluer la qualité de l'intervention. Celle-ci étant constituée de plusieurs composantes, la plus pertinente, ici, concerne la globalité des soins.

Dans le contexte du dépistage de la surdité professionnelle, cela réfère à l'évaluation globale de la santé auditive du travailleur, c'est-à-dire en tenant compte des diverses dimensions fonctionnelles telles que la présence d'incapacités et de handicaps ainsi que son intérêt pour des

Tableau 1 : Caractéristiques des indicateurs associés aux effets de l'intervention

Indicateur	Norme et Type de calcul	Source de données
Proportion de travailleurs possiblement indemnisables (moyenne des seuils ≥ 30 dBHL) lors de l'examen de relance. a) travailleurs admissibles à la relance. b) travailleurs non admissibles à la relance.	Norme : Déterminée *a posteriori.* Pour a) et b) : Nombre de travailleurs possiblement indemnisables à l'examen de relance ——— Nombre total de travailleurs examinés lors de la relance	Dossiers au CLSC (examens de relance).
Proportion des travailleurs possiblement non indemnisables (moyenne des seuils <30 dBHL à l'examen de relance) qui rapportent vivre des situations de handicap. a) travailleurs admissibles à la relance. b) travailleurs non admissibles à la relance.	Norme : Déterminée *a posteriori.* Pour a) et b) : Nombre de travailleurs non indemnisables avec situations de handicap. ——— Nombre total de travailleurs non indemnisables.	Dossiers au CLSC (examens de relance).

Tableau 2 : Caractéristique de l'indicateur associé à la qualité de l'intervention (globalité des soins)

Indicateur	Norme et Type de calcul	Source de données
Proportion des travailleurs possiblement non indemnisables (moyenne des seuils < 30 dBHL à l'examen de relance) qui ont fait l'objet d'une évaluation des situations de handicap par l'infirmière du CLSC.	Norme : 90 % chez les admissibles à l'examen de relance	Dossiers au CLSC (examens de relance).

services de réadaptation, sans égard au caractère indemnisable de son atteinte auditive. Cette évaluation, sous forme de questions ciblées sur les difficultés les plus communes et « handicapantes » vécues par les travailleurs et son entourage, est réalisée par l'intervenante en soins infirmiers de l'équipe santé au travail du CLSC. L'infirmière fournira alors au travailleur l'information utile pour répondre à ses besoins ou le référera à un audiologiste et à un médecin. L'indicateur retenu pour évaluer la globalité des soins est présenté au Tableau 2.

Le devis utilisé correspond à une étude descriptive transversale sur l'ensemble des travailleurs admissibles et non admissibles qui ont fait l'objet d'une relance entre le 1er octobre 1999 et le 31 octobre 2000.

Un questionnaire a été développé pour procéder à la collecte des données nécessaires à la classification des travailleurs en vertu de leur admissibilité à l'examen de relance et aux calculs des indicateurs retenus pour l'évaluation. Ces données ont été tirées des rapports d'examens auditifs de dépistage, de l'évaluation des situations de handicap réalisée par l'infirmière et des rapports d'évaluation audiologique ou médicale. Un logiciel, développé et diffusé par une compagnie québécoise, visant expressément la création et l'utilisation de questionnaires a été utilisé pour appuyer cet outil.

Une infirmière, spécifiquement formée pour le projet, a fait la collecte de données au moyen de l'outil informatique sur un poste fixe dans chaque CLSC. La banque de données a été ensuite envoyée par courrier électronique à la Direction de santé publique. Pour des raisons de confidentialité, l'outil informatique et la base de données ont été effacés dès que la collecte fut complétée dans un CLSC. La collecte s'est déroulée sur une période de six semaines à partir de la fin avril 2002. Les données saisies ont été analysées via le logiciel SPSS 8.0 [7]. Des analyses de type chi-carré ont été effectuées pour permettre la comparaison au plan statistique des résultats obtenus pour les travailleurs admissibles et non admissibles.

2.2 Volet 2

L'objectif de ce volet consiste à vérifier si la stratégie définie dans les lignes directrices de 1993 pour définir la population admissible à l'examen de relance permet de rejoindre l'ensemble de la population qui manifeste ou risque de manifester des besoins en matière de réadaptation ou de bénéficier du droit à l'indemnisation. En effet, dans quelle mesure les travailleurs exclus de la relance ne pourraient-ils pas rencontrer les critères d'admissibilité à l'indemnisation, vivre des situations de handicap pour lesquels des suivis de réadaptation pourraient être requis ou encore se conformer aux critères d'admissibilité à la relance et y être soumis cinq ans plus tard?

Deux types de méthodes distinctes ont été utilisés pour mener à bien ce volet d'évaluation. Seule la principale est présentée ici.

Une étude descriptive transversale a été réalisée auprès des travailleurs non admissibles à la relance, c'est-à-dire ceux qui auraient dû être exclus compte tenu des critères en vigueur, mais qui ont quand même subi un examen de relance entre le 1e octobre 1999 et le 31 octobre 2000.

On cherche à vérifier la proportion des travailleurs non admissibles ayant une atteinte possiblement indemnisable ou répondant au(x) critère(s) de relance lors du second examen. Pour des raisons d'accessibilité aux sources de données, nous n'avons pu évaluer dans quelle mesure ces travailleurs vivaient des situations de handicap nécessitant des services de réadaptation. En effet, on ne s'attend pas à ce que les travailleurs non admissibles fassent systématiquement l'objet d'une évaluation des situations de handicap par l'infirmière. Elle jugera plutôt de la pertinence de cette évaluation en fonction de l'ampleur de la perte auditive à l'examen de relance ou du type de symptômes et d'incapacités rapportés lors du questionnaire « Histoire Auditive » réalisé préalablement à l'examen audiométrique.

Les données nécessaires à l'évaluation du volet 2 ont été colligées à l'aide des mêmes instruments, sources et méthodes que ceux décrits pour le volet 1.

2.3 Limites de la méthodologie

Considérant que les données étudiées ne portent que sur une année (octobre 1999 à octobre 2000), on ne peut pas présumer que la pratique régionale en matière de dépistage de la surdité soit demeurée la même depuis la fin de la période ciblée par cette évaluation, ni que cette dernière reflète celle d'avant la période à l'étude.

On convient que les travailleurs admissibles ont fait l'objet d'une attention particulière parce que sélectionnés sur la base de critères de relance.

Toutefois, en ce qui concerne les travailleurs non admissibles, soulignons que l'échantillon étudié ici ne correspond pas à l'ensemble des non admissibles à la relance sur la base de l'examen initial mais bien à une sous-population sélectionnée selon des critères propres à chaque équipe (médecin-infirmière) de santé au travail, notamment l'importance de la perte auditive, l'âge, le délai encouru depuis l'examen initial ou une demande du milieu. Les travailleurs sélectionnés pour la relance malgré leur statut de non admissibles ne sont donc pas nécessairement représentatifs de l'ensemble des travailleurs non admissibles. En fait, il est même probable que bon nombre de travailleurs non admissibles relancés, perçus comme plus vulnérables par les intervenants, soient potentiellement plus susceptibles de développer une atteinte auditive que l'ensemble des travailleurs non admissibles. Un biais de sélection pourrait donc être présent. L'analyse des résultats de cette étude devra en tenir compte.

Enfin, des erreurs dans la collecte de données demeurent toujours possibles même si plusieurs précautions ont été prises pour tenter de les réduire (ex : instrument de collecte standardisé, une seule personne effectuant la collecte des données, supervision de celle-ci la première journée).

3. PRÉSENTATION ET ANALYSE DES RÉSULTATS

3.1 Volet 1 : Évaluation de l'atteinte des objectifs visés par la relance

Pendant la période à l'étude, 524 travailleurs ont fait l'objet d'une relance : 135 travailleurs étaient admissibles et 389 travailleurs étaient non admissibles. Parmi ces derniers, 79 ne pouvaient pas présenter une détérioration auditive significative de l'audition, principalement en raison d'un délai trop court entre l'examen initial et la relance. Ils ont été exclus des analyses. Celles-ci ont donc porté sur quatre cent quarante-cinq (445) travailleurs soit 310 travailleurs non admissibles et les 135 travailleurs admissibles.

Évaluation des effets

a) Identifier les travailleurs pouvant bénéficier du droit à l'indemnisation

L'indicateur concerne la proportion des travailleurs, admissibles et non admissibles, possiblement indemnisables lors de l'examen de relance.

Naturellement, si les critères d'admissibilité sont bien conçus on s'attend à ce qu'une proportion importante de travailleurs admissibles à la relance deviennent possiblement indemnisables durant le délai minimal de 5 ans requis pour l'examen de relance et que peu de travailleurs non admissibles le deviennent.

En examinant de plus près les données des 135 travailleurs admissibles, on a constaté que 28 travailleurs présentaient déjà à ce moment une atteinte « possiblement indemnisable » à l'examen initial et qu'ils n'avaient pas encore consulté. Comme nous voulons ici comparer deux populations au niveau de la progression d'une atteinte auditive infrabarème à l'examen initial vers une atteinte possiblement indemnisable à l'examen de relance, nous devions conserver uniquement les 107 travailleurs admissibles qui présentaient au départ une atteinte infrabarème. Ne pas avoir procédé ainsi aurait fait en sorte de gonfler artificiellement l'écart entre les deux groupes au niveau du pourcentage global de travailleurs possiblement indemnisables, comme le démontrent les données affichées entre parenthèses dans le tableau 3.

Au moment de l'examen de relance, une proportion significativement plus importante de travailleurs admissibles répondent au critère d'indemnisation, soit 44,9 % vs 5,2 % chez les non admissibles, (χ^2 : p < 0,01). Cette tendance se maintient peu importe le type d'atteinte (APB ou ANB), mais elle est plus marquée pour les APB (43,8 % vs 4,5 %, près de 10 fois plus). Comme ils sont sélectionnés sur la base de leur perte auditive et en partie en fonction de leur âge, on ne s'étonnera pas que les travailleurs admissibles sont, comparativement aux travailleurs non admissibles, significativement plus âgés, ont cumulé une ancienneté d'exposition au bruit en carrière professionnelle plus importante autant à l'examen initial qu'à l'examen de relance et présentent une perte auditive moyenne plus marquée (données non présentées). Cela peut expliquer qu'il y a une proportion significativement plus importante de travailleurs possiblement indemnisables chez les admissibles et ce malgré un délai encouru entre les deux examens moins important et une exposition moins fréquente à des niveaux supérieurs (> 100 dBA) que les non admissibles (données non présentées).

Tableau 3 : Nombre et proportion des travailleurs admissibles et non admissibles possiblement indemnisablesou non à l'examen de relance

	Total	Possiblement indemnisable		Non indemnisable	
	Nb.	Nb.	%	Nb.	%
Admissibles					
APB[1]	64 (67)	28 (31)	43,8 (46,2)	36 (36)	56,2 (53,8)
ANB	43 (68)	20 (37)	46,5 (54,4)	23 (31)	53,5 (45,6)
TOTAL	**107 (135)**	**48 (68)**	**44,9 (50,3)**	**59 (67)**	**55,1 (49,7)**
Non admissibles					
APB	222	10	4,5	212	95,5
ANB	88	6	6,8	82	93,2
TOTAL	**310**	**16**	**5,2**	**294**	**94,8**

1 - APB : Atteintes auditives probablement causées par le bruit incluant, s'il y a lieu, les auditions normales pour l'âge en vertu du système d'analyse standardisé en vigueur [8].

ANB : Atteintes auditives non seulement causées par le bruit [8].

Les données entre parenthèses correspondent au nombre total de dossiers incluant ceux possiblement indemnisables à l'examen initial.

Le fait que presque un travailleur admissible sur deux devient possiblement indemnisable au moment de la relance démontre une certaine robustesse des lignes directrices de 1993. Afin de vérifier s'il s'agit de travailleurs véritablement indemnisables d'un point de vue clinique, il est intéressant de mentionner que le suivi est connu pour 41 des 48 travailleurs dont l'atteinte est suprabarème. 30 d'entre eux (73 %) sont actuellement indemnisés par la Commission de la santé et de la sécurité au travail (CSST). Cette proportion pourrait grimper jusqu'à 85 % si les cinq travailleurs en attente d'une décision de la CSST étaient indemnisés.

Il est intéressant aussi de présenter des données concernant la performance de nos critères de relance en terme de sensibilité, spécificité et de la validité prédictive positive et négative.

Mentionnons qu'il ne s'agit pas ici de la performance du critère au regard d'un diagnostic médical/audiologique d'atteinte indemnisable ou non mais bien au regard de la classification au dépistage via le système d'analyse standardisé. Nous disposons des données sur le diagnostic clinique pour une majorité de travailleurs admissibles et non admissibles possiblement indemnisables, mais ce n'est pas le cas pour les « non indemnisables » qui pour la plupart, comme nous le présenterons dans les prochaines sections, n'ont pas fait l'objet d'une référence. D'autre part, rappelons que le groupe des non admissibles n'est pas représentatif de l'ensemble des travailleurs non admissibles.

Malgré cette réserve, en référant au tableau 3, la sensibilité serait de 75,0 % (48/64) et la spécificité de 83,3 % (294/353). La validité prédictive positive est de 44,9 % (48/107) et négative de 94,8 % (294/310) compte tenu d'une prévalence de 15,3 % (64/417).

On peut affirmer que nos critères sont plutôt libéraux quant à l'objectif d'identifier des travailleurs possiblement indemnisables. En effet, moins de 1 travailleur admissible sur 2 vus en relance est possiblement indemnisable mais ces mêmes critères font en sorte que les examens de relance ne sont pas effectués inutilement puisque presque 95 % des non admissibles ne deviennent pas possiblement indemnisables.

On ne peut toutefois pas passer sous silence le fait que plus de 5 % des 310 travailleurs non admissibles à la relance sont aussi possiblement indemnisables. Comme notre évaluation n'est pas faite sur toute la cohorte des travailleurs qui ont été soumis à l'examen initial mais sur un échantillon de non admissibles, il est justifié d'examiner les données de ces 16 travailleurs de plus près.

Parmi ceux-ci, dix avaient au départ une atteinte probablement causée par le bruit alors que l'atteinte des six autres n'était pas seulement causée par le bruit. Le résultat de la consultation audiologique et médicale a confirmé le caractère indemnisable de l'atteinte de 8 travailleurs sur les 13 pour lesquels on dispose d'une telle information.

Cela signifie donc que si les équipes avaient appliqué intégralement le protocole de 1993, environ 3 % des travailleurs considérés non admissibles auraient été éventuellement privés de leur droit à l'indemnisation puisqu'ils n'auraient pas été revus à la relance. Considérant l'hypothèse que les travailleurs non admissibles vus à la relance présentent des caractéristiques probablement plus proches des admissibles que l'ensemble des non admissibles, il y a lieu de croire que la proportion de travailleurs non admissibles privés de leur droit d'indemnisation par l'application du protocole de 1993 serait, de fait, en deçà de ce 3 %.

b) *Identifier les travailleurs pouvant bénéficier de services de réadaptation*

L'indicateur concerne ici la proportion des travailleurs admissibles et non admissibles possiblement non indemnisables à l'examen de relance et qui rapportent vivre des situations de handicap. Par travailleur possiblement non indemnisable, on entend ici ceux infra barèmes aux deux oreilles.

Certains pourraient s'étonner qu'on restreigne l'évaluation des situations de handicap à la seule population des travailleurs possiblement non indemnisables. Cette décision s'explique par le fait que les travailleurs possiblement indemnisables sont en principe référés d'emblée en clinique d'audiologie. Nous considérons que cette évaluation est alors réalisée par l'audiologiste.

Pour aborder la question, on se doit d'abord de vérifier quels travailleurs ont fait l'objet d'une évaluation des situations de handicap par l'infirmière du CLSC (aspect qualité de l'intervention / globalité des soins). En effet, c'est lorsque l'infirmière l'interroge à ce sujet, le plus souvent lors de la remise des résultats au dépistage, que le travailleur précise ses incapacités et handicaps. À ce moment, elle peut lui fournir l'information utile pour répondre à ses besoins ou le diriger pour une intervention plus spécialisée en clinique.

L'indicateur correspond ici à la proportion des travailleurs admissibles et non admissibles, possiblement non indemnisables (infrabarèmes), qui ont fait l'objet d'une évaluation des situations de handicap par l'infirmière du CLSC.

Dans le tableau 4, le nombre total de travailleurs admissibles possiblement non indemnisables passe de 59 (voir tableau 3) à 67. En effet, parmi les 28 travailleurs admissibles retranchés des calculs au tableau 3 parce qu'ils étaient possiblement indemnisables à l'examen initial, 8 d'entre eux auparavant classés comme ayant une ANB se sont avérés possiblement non indemnisables à l'examen de relance (passent de 23 à 31). L'analyse plus approfondie des résultats aux examens auditifs de ces travailleurs nous permet de croire qu'il s'agit d'une pathologie transitoire qui se serait résorbée entre les deux examens.

Bien qu'on ne puisse certifier que tous les travailleurs considérés dans la colonne « Pas d'évaluation des situations de handicap » n'ont pas fait l'objet d'une telle entrevue, il n'en demeure pas moins qu'une information est disponible seulement pour un faible pourcentage d'entre eux. En effet, on s'attendait, du moins chez les travailleurs admissibles plus atteints que les non admissibles, de retrouver l'information pour la presque totalité des travailleurs sauf peut-être pour ceux absents lors de la remise des résultats, puisque l'évaluation des situations de handicap fait partie du protocole. D'ailleurs, nous nous étions fixé une norme de 90 % (voir Tableau 2).

La proportion de travailleurs ayant fait l'objet

Tableau 4 : Nombre et proportion des travailleurs admissibles et non admissibles possiblement non indemnisables, selon l'évaluation des situations de handicap par l'infirmière du CLSC

		Évaluation des situations de handicap		Pas d'évaluation des situations de handicap[1]	
		Nb.	%	Nb.	%
Admissibles					
APB	36	15	41,7	21	58,3
ANB	31	10	32,3	21	67,7
TOTAL	**67**	**25**	**37,3**	**42**	**62,7**
Non Admissibles					
APB	212	46	21,7	166	78,3
ANB	82	15	18,3	67	81,7
TOTAL	**294**	**61**	**20,7**	**233**	**79,3**

[1] Cette variable inclut les réponses : « non » ou « non précisées » dans le dossier du travailleur. Dans ce dernier cas, aucune information qui permettait de confirmer une telle évaluation n'est présente dans le dossier du travailleur.

d'une évaluation des situations de handicap est toutefois significativement plus élevée parmi les admissibles (37,3 %) que chez les non admissibles (20,7 %), (χ^2 : p < 0,01). On doit toutefois noter l'effectif réduit d'admissibles (N = 67). Il est étonnant d'observer que chez les admissibles, soit le groupe de ceux les plus atteints et réellement visés par la relance, on dispose d'une information sur l'évaluation des situations de handicap pour moins de quatre travailleurs sur dix.

Chez les non admissibles, la faible proportion de ceux ayant fait l'objet d'une évaluation des situations de handicap est moins surprenante si l'on considère que 69 des 294 travailleurs possiblement non indemnisables, soit 23,5 %, ont une moyenne de seuils calculée sur les fréquences d'intérêt .5-1-2-4 kHz ≤ 10 dBHL aux deux oreilles autant à l'examen initial qu'à l'examen de relance. Le nombre de travailleurs pour lesquels une évaluation des situations de handicap s'avère pertinente diminue d'autant, mis à part ceux qui pourraient rapporter des acouphènes incommodants.

On comprendra qu'avec un si faible échantillon de travailleurs qui a fait l'objet d'une évaluation des situations de handicap, on ne peut prétendre pouvoir évaluer adéquatement cet objectif de relance visant l'identification des travailleurs pouvant bénéficier de services de réadaptation.

On se doit de préciser que les données sur les 86 travailleurs ayant fait l'objet d'une évaluation des situations de handicap nous ont permis de constater qu'à l'aide des informations et du soutien qu'elle donne aux travailleurs, l'intervenante en soins infirmiers semble répondre à des besoins spécifiques concernant les situations de handicap, notamment en ce qui a trait à la démystification des acouphènes et à l'information sur des stratégies d'écoute et de communication facilitantes. Au besoin, elle réfère aussi les travailleurs à des ressources plus spécialisées, tel l'audiologiste.

3.2 Volet 2 : Évolution de l'audition des travailleurs exclus de la relance

Les analyses réalisées dans le cadre du premier volet nous ont permis de constater qu'un certain nombre de travailleurs non admissibles à une relance systématique peuvent devenir possiblement indemnisables dans le temps (ici 16/310, voir 3.1).

Le volet 2 vise à déterminer dans quelle mesure les 294 travailleurs non admissibles et possiblement non indemnisables se conforment, à l'issue de ce second examen, aux critères d'admissibilité à la relance. Si l'on se réfère aux lignes directrices actuelles, la nouvelle relance devrait s'effectuer au minimum 5 ans plus tard.

Parmi ces 294 travailleurs, il y en a 212 dont l'atteinte est possiblement causée par le bruit (APB) et 82 dont l'atteinte est non seulement causée par le bruit (ANB).

Tout en procédant, pour chaque travailleur, à une analyse de l'atteinte ou non du (des) critère(s) de relance et du délai associé entre les deux examens, nous avons procédé à une analyse « audiologique » des seuils auditifs afin d'identifier, le cas échéant, une détérioration significative entre les deux examens.

Nous avons surtout porté notre attention sur les 212 travailleurs avec une APB puisque la détérioration éventuelle de seuils peut être associée à l'âge ou au bruit et non pas à une pathologie autre comme dans le cas des 82 travailleurs avec une ANB pour lesquels on ne dispose pas d'une investigation clinique confirmant l'origine de l'atteinte.

Nous avons analysé plus en détail les travailleurs qui se conforment au(x) critère(s) de relance dans un délai d'environ cinq ans tel que recommandé dans le protocole actuel.

Parmi les 212 travailleurs avec une APB, on a constaté que seuls 149 présentaient une moyenne de seuils (.5-1-2-4 kHz) ≥ 10 dBHL à au moins une oreille à l'examen de relance. Soixante-trois (63) travailleurs présentaient donc une moyenne ‹10 dBHL aux deux oreilles. Afin d'être le plus sensible et conservateur possible, le dénominateur a été fixé à 149 plutôt qu'à 212.

Les résultats démontrent que 25 des 149 travailleurs, (16,7 %) deviennent « relançables » dans un délai voisin de 5 ans. Pour la majorité de ces travailleurs, il s'agit:

- du simple effet de l'âge, le travailleur ayant atteint l'âge de 45 ans alors qu'à l'examen initial la moyenne de seuils était entre 20-24 dBHL;
- de travailleurs dont l'atteinte était déjà « limite » avec le critère de relance de 20 dBHL à l'examen initial;
- de travailleurs âgés de plus de 50 ans à l'examen de relance et dont le niveau d'exposition est entre 90 – 99 dBA.

Pour les 82 travailleurs avec une ANB, on note la même tendance même s'il y a davantage de travailleurs dont c'est l'âge (facteur 45 ans) qui les rendent admissibles à la relance.

3.3 Synthèse

À partir des résultats obtenus, malgré les limites méthodologiques rapportées à la section 2, on peut formuler les constats suivants concernant l'examen de relance:

- La proportion élevée de travailleurs non admissibles parmi les travailleurs relancés confirme que l'adhésion des équipes en santé au travail aux lignes directrices de 1993 était mitigée, notamment en regard de l'exclusion de certains travailleurs.
- Concernant l'objectif d'identification des travailleurs possiblement indemnisables, les critères de relance, tels que définis dans les lignes directrices actuelles, permettent d'identifier un nombre important de travailleurs à l'intérieur du délai minimal de cinq ans requis après l'examen initial. En effet, presque un travailleur admissible sur deux devient possiblement indemnisable. La « sensibilité » des critères de relance se situe à 75,0 % et la « spécificité » à 83,3 %. La « validité prédictive positive » est de 44,9 % et la « validité prédictive négative » est de 94,8 %.

- L'absence d'information sur l'évaluation des situations de handicap chez une majorité de travailleurs semble indiquer que les équipes de santé au travail ne se sont pas conformées à l'objectif poursuivi par l'examen de relance au regard de l'identification des travailleurs pouvant bénéficier de services de réadaptation.
- Lorsqu'une évaluation des situations de handicap est réalisée, l'intervenante en soins infirmiers, par l'information et le soutien qu'elle donne aux travailleurs, semble répondre à leurs besoins spécifiques et, s'il y a lieu, les réfère à des ressources cliniques spécialisées.
- L'application « stricte » du protocole actuel fait en sorte que d'autres travailleurs, devenus possiblement indemnisables (5 %) ou admissibles à la relance n'auraient pas été identifiés, car considérés non admissibles à une relance systématique en vertu des lignes directrices.
- Par ailleurs, il n'en demeure pas moins qu'un nombre important d'examens ont été nécessaires chez des travailleurs non admissibles pour permettre d'en identifier une dizaine confirmés indemnisables. Il faut sûrement se questionner quant à une meilleure utilisation des ressources.

Pour le comité interdisciplinaire chargé de la révision des lignes directrices de 1993, il s'agissait de faire les ajustements nécessaires afin que les travailleurs non admissibles les plus susceptibles de devenir possiblement indemnisables ou admissibles à la relance dans un plus court délai (5-10 ans) soient visés par un examen de relance.

4. RECOMMANDATIONS ET SUIVI

Lors de l'élaboration des lignes directrices en 1993, on ne voulait pas fractionner indûment les populations cibles et la périodicité. Force nous a été de constater que, pour diminuer le nombre de travailleurs non admissibles faisant « inutilement » l'objet d'une relance après cinq ans, on se devait d'établir des critères plus précis et systématiques.

Si l'on considère l'information synthèse rapportée ci-haut, une relance systématique après 10 ans auprès d'un autre sous-groupe de travailleurs était maintenant justifiée.

Après discussions, la proposition suivante touchant l'examen de relance a été acceptée en novembre 2003 par le Regroupement des médecins en santé au travail de la Montérégie. Pour plus de détails, le lecteur se référera au nouveau « Guide définissant les activités de dépistage de la surdité professionnelle », adopté le 7 février 2004 [9].

Activités de dépistage : examen de relance

Tous les travailleurs ayant eu un examen initial font l'objet de la relance, la périodicité varie toutefois selon l'ampleur de l'atteinte identifiée lors de cet examen.

Les critères d'atteinte à l'examen initial correspondent à la moyenne des seuils auditifs à 500 Hz – 1 000 Hz – 2 000 Hz – 4 000 Hz calculée à l'OG et à l'OD. Si l'une ou l'autre ou les deux oreilles rencontrent un critère de moyenne de seuils donné, la périodicité correspondant à ce critère s'applique.

Critères d'atteinte à l'examen initial et périodicité correspondante:

En ce qui concerne le critère conduisant à un délai minimal de 10 ans pour la relance :

1. Moyenne ≥ 25 dBHL
   OU
   Moyenne entre 20 – 24dBHL et âgé de 45 ans et plus
   ↓
   <u>DÉLAI MINIMAL pour effectuer la relance</u> : 5 ans
2. Parmi les travailleurs qui ne répondent pas au 1er critère, ceux dont la moyenne ≥ 15 dBHL
   ↓
   <u>DÉLAI MINIMAL pour effectuer la relance</u> : 10 ans
3. Tous les autres travailleurs (moyenne < 15 dBHL aux 2 oreilles)
   ↓
   <u>DÉLAI MINIMAL pour effectuer la relance</u> : 20 ans ou à la retraite

Précisons que 100 % des dossiers non admissibles indemnisés et plus de 90 % de ceux devenus admissibles à la relance dans un délai d'environ 5 ans, soit 23 dossiers sur les 25 identifiés à 3.2, seraient interceptés par ce critère.
Sur la base des données issues des 310 travailleurs non admissibles, l'application de ce nouveau critère de délai se traduirait par un examen de relance pour environ 80 travailleurs. On peut considérer ce nombre très acceptable par rapport au nombre total de dossiers non admissibles réalisés durant la période du 1er octobre 1999 au 31 octobre 2000. On comprend que le niveau d'exposition des travailleurs visés doit être ≥ 85dBA durant le délai prévu pour la relance.

Concernant l'objectif d'identification des travailleurs vivant des situations de handicap et pouvant bénéficier de services de réadaptation, nous convenons, que pour y répondre, des démarches plus formelles doivent être entreprises avec les intervenantes en soins infirmiers. En ce sens, la table régionale en soins infirmiers de la Montérégie est le lieu privilégié pour entamer ces discussions au regard des questions suivantes : Pourquoi y a-t-il si peu d'informations dans les dossiers de travailleurs entre le 1er octobre 1999 et le 31 octobre 2000? Compte tenu des services cliniques disponibles et accessibles en Montérégie ainsi que des services de réadaptation offerts par la CSST, quels objectifs vise-t-on par cette évaluation? Auprès de qui la fait-on? Quand et où la faire? Comment? Invite-t-on la conjointe? Où s'arrête notre rôle d'information, de sensibilisation et de soutien/suivi du travailleur et où commence celui de la clinique ou du centre de réadaptation? Un sous-comité de travail a été mis sur pied au printemps

2004 et a pour mandat l'élaboration des procédures/outils requis. Les coordonnateurs des équipes locales de CLSC ont accepté un tel mode de fonctionnement et ont aussi invité l'auteure principale à diffuser les résultats de ces travaux lors d'une journée de rassemblement annuelle où toutes les infirmières seront présentes.

La mise en application du nouveau protocole est effective depuis janvier 2004 et s'applique aux mises à jour des programmes de santé.

Finalement, parallèlement à ces travaux, des discussions sont en cours avec les responsables du Centre montérégien de réadaptation afin qu'il adapte son offre de services aux besoins des travailleurs atteints de surdité professionnelle.

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Etude par Simulation des Caractéristiques Acoustiques du Conduit Vocal avec Pertes

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RÉSUMÉ

Après avoir étudié théoriquement la propagation du son dans un conduit vocal avec pertes, on décrit le simulateur mis au point. La méthode retenue permet d'obtenir la fonction de transfert, la valeur des fréquences des formants et les bandes passantes du conduit vocal. Le simulateur permet de déterminer la contribution des différentes sources de pertes au niveau des fréquences et des bandes passantes des formants.

ABSTRACT

Wave propagation in a lossy vocal-tract with yielding walls is studied. Simulation method of this vocal-tract is described. The method adopted allowed us to calculate the transfer function, the formant frequencies and the formant bandwidths of the vocal-tract. The results obtained permit the determination of the differential contribution of the different loss sources for formant frequencies and formant bandwidths.

1. Introduction

L'étude de la parole à l'aide d'analogues temporels du conduit vocal permet de mieux connaître les processus acoustiques se produisant dans le conduit vocal. Une connaissance des relations existant entre les différents types de pertes et leurs effets sur les caractéristiques acoustiques du conduit vocal est essentielle tant pour la réalisation des modèles articulatoires que pour l'analyse de la parole.

Le but de ce papier est de présenter un simulateur analogue du conduit vocal, basé sur la théorie de propagation d'une onde acoustique dans un tube non uniforme. En reprenant certains travaux et en les complétant, nous avons essayé de déterminer avec précision les caractéristiques acoustiques des voyelles du français par simulation numérique.

Par la suite, nous ferons tout d'abord une étude théorique du modèle puis nous présenterons les différents types de pertes. Enfin, nous discuterons les résultats obtenus avec notre simulateur.

2. Rappels theoriques et modele utilise

2.1 Cas général

Le modèle mathématique présenté a pour but de reproduire d'une manière simple le fonctionnement du conduit vocal. Ce dernier est assimilé à un tube de section variable et à parois non rigides. Le modèle discrétise le conduit vocal en un assemblage de tubes élémentaires cylindriques. On se ramène ainsi à l'étude de la propagation à travers une série de tubes cylindriques mis bout à bout d'une onde plane, en tenant compte des différentes conditions aux limites (viscosité, chaleur, vibrations des parois et rayonnement aux lèvres).

Considérons un élément de masse $dm = \rho d\tau$ où ρ est la densité volumique de l'air et $d\tau$ l'élément de volume. Si en ce point règne la pression $P(x,t)$, l'élément considéré sera soumis à la force :

$$F = -\frac{\partial P}{\partial x} d\tau \tag{1}$$

en utilisant la deuxième loi de Newton, on peut écrire :

$$F = dm\gamma = \frac{d}{dt}(\rho V d\tau) = \rho\, d\tau \frac{dV}{dt} \tag{2}$$

où V est la vitesse corpusculaire, l'élément de masse étant considéré constant, on a :

$$\frac{d}{dt}\rho d\tau = 0 \tag{3}$$

nous avons aussi :

$$\frac{d}{dt}V = \frac{\partial V}{\partial t} + \frac{\partial x}{\partial t}\frac{\partial V}{\partial x} \tag{4}$$

Dans cette expression, la variation de x n'est pas quelconque, elle est donnée par la vitesse de la particule $dx = V.dt$, on aura donc:

$$\frac{d}{dt}V = \frac{\partial V}{\partial t} + V\frac{\partial V}{\partial x} \quad (5)$$

On obtient en égalant les deux types de force :

$$-\frac{\partial P}{\partial x} = \rho\frac{\partial V}{\partial t} + \rho V\frac{\partial V}{\partial x} \quad (6)$$

Considérons la masse *m* du volume d'air τ inclus entre deux sections planes *A(x)* et *A(x+dx)* du conduit vocal, *A(x)* est l'aire de la section à l'abscisse *x* et au temps *t*. Cette masse est égale à :

$$\mathrm{d}m = \iint_{A(x)} \rho.dA.dx \quad (7)$$

et la variation du flux à travers les deux sections est égale à :

$$-\frac{\partial}{\partial x}\left[\iint_{A(x)} \rho V dA\right]dx \quad (8)$$

écrivons que la masse se conserve au cours du temps :

$$\frac{\partial}{\partial x}\left[\iint_{A(x)} \rho V dA\right]dx = \frac{d}{dt}\iint_{A(x)} \rho dA dx \quad (9)$$

Les relations (6) et (9) sont des expressions non linéaires de *P, V* et ρ . A l'état d'équilibre, on a les valeurs P_0 , V_0 et ρ_0. La propagation du son apporte des perturbations *p, v* et ρ' , on peut écrire :

$$P = P_0 + p\ ; \quad V = V_0 + v\ ; \quad \rho = \rho_0 + \rho'. \quad (10)$$

L'air étant considéré comme un gaz parfait, la propagation du son est adiabatique (Morse, 1968) ; on peut en dériver une expression entre ρ et *p*, à savoir :

$$\rho = \rho_0\left(1 + \frac{1}{\rho_0 c^2}p\right) \quad (11)$$

où *c* est la vitesse du son.

En reportant les expressions de *P*, *V* et ρ dans les équations (6) et (9) et en négligeant les termes de perturbation du second ordre, on obtient :

$$-\frac{\partial p}{\partial x} = \rho_0\frac{\partial v}{\partial t} + \rho_0 V_0\frac{\partial v}{\partial x} \quad (12.a)$$

$$-\frac{\partial}{\partial x}\iint_{A(x)}\left(v + \frac{1}{\rho_0 c^2}pV_0\right)dA = \frac{\partial}{\partial}\iint_{A(x)}\left(1 + \frac{1}{\rho_0 c^2}p\right)dA \quad (12.b)$$

En première approximation, étant donné que le gaz est parfait, on peut poser :

$$u = \iint_{A(x)} v dA = vA \quad (13)$$

$$pA = \iint_{A(x)} p dA \quad (14)$$

$v = \dfrac{u}{A}$; où *u* est la vitesse volumique.

On obtient:

$$\frac{\partial p}{\partial x} = \rho_0\frac{\partial}{\partial t}\frac{u}{A} + \rho_0 V_0\frac{\partial}{\partial x}\frac{u}{A} \quad (15.a)$$

-

$$\frac{\partial u}{\partial x} - \frac{1}{\rho_0 c^2}V_0\frac{\partial(pA)}{\partial x} = \frac{\partial A}{\partial} + \frac{1}{\rho_0 c^2}\frac{\partial(pA)}{\partial} \quad (15.b)$$

1. Nous supposons des parois rigides

$$\frac{\partial A}{\partial t} = 0 \quad (16)$$

$$\partial\left(\frac{u}{A}\right) = \frac{1}{A}\partial u \quad (17)$$

2. Généralement, la vitesse corpusculaire V_0 est faible devant la vitesse du son *c* :

$$V_0\frac{\partial}{\partial x}\left(\frac{u}{A}\right) = 0 \quad (18)$$

$$V_0\frac{\partial}{\partial}(pA) = 0 \quad (19)$$

Les équations (15) s'écrivent donc (Stevens, Kasowski & Fant, 1957):

$$-\frac{\partial p}{\partial x} = \rho_0\frac{\partial}{\partial t}\left(\frac{u}{A}\right) \quad (20.a)$$

$$-\frac{\partial u}{\partial A} = \frac{\partial A}{\partial t} + \frac{1}{\rho_0 c^2}\frac{\partial pA}{\partial t} \quad (20.b)$$

Les équations régissant la propagation d'une onde acoustique dans un tube rigide, appelées ''équations de Webster'', s'écrivent finalement:

$$-\frac{\partial p}{\partial x} = \frac{\rho_0}{A}\frac{\partial u}{\partial t} \quad (21.a)$$

$$-\frac{\partial u}{\partial x} = \frac{A}{\rho_0 c^2}\frac{\partial p}{\partial t} \quad (21.b)$$

Les équations (21) représentent un système aux dérivées partielles décrivant la propagation unidimensionnelle d'une onde acoustique, dans un tube uniforme, à parois rigides.

Pour notre cas, nous allons résoudre ces équations dans le cas d'un conduit vocal statique (synthèse des voyelles).

2.2 Le modèle de Kelly & Lochbaum

Notre simulateur est une application directe du modèle de Kelly & Lochbaum avec pertes (Kelly, 1962).
Si l'aire *A(x,t)* est constante, le système d'équations (21) admet des solutions de la forme:

$$U_k(x,t) = U_k^{+}(t-\frac{x}{c}) - U_k^{-}(t+\frac{x}{c}) \qquad (22)$$

$$P_k(x,t) = \frac{\rho c}{A_k}(U_k^{+}(t-\frac{x}{c}) + U_k^{-}(t+\frac{x}{c})) \qquad (23)$$

avec U_k^+ onde se propageant dans le sens positif et U_k^- onde se propageant dans le sens négatif.

Nous étudions maintenant la jonction entre deux tubes élémentaires, ceci en tenant compte de la continuité pression et débit de part et d'autre de la jonction:

$$P_k(l_k,t) = P_{k+1}(0,t) \qquad (24)$$

$$U_k(l_k,t) = U_{k+1}(0,t) \qquad (25)$$

Ce système peut être schématisé par la figure 1 :

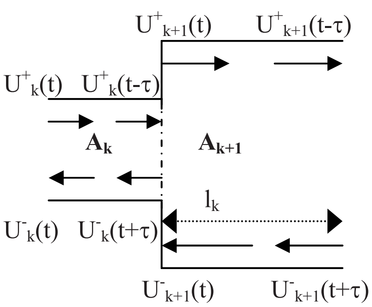

Figure 1. Jonction entre le tube *k* et le tube *k+1*.

Nous en déduisons le système suivant:

$$[U_k^+(t-\tau_k) + U_k^-(t+\tau_k)] = \frac{A_k}{A_{k+1}} U_{k+1}^+(t) + U_{k+1}^-(t)$$

$$U_k^+(t-\tau_k) - U_k^-(t+\tau_k) = U_{k+1}^+(t) - U_{k+1}^-(t)$$

Ce système, une fois résolu s'écrit:

$$U_{k+1}^+(t) = (1+r_k)U_k^+(t-\tau_{kk}) + r_k U_{k+1}^-(t) \qquad (26)$$

$$U_k^-(t+\tau_k) = -r_k U_k^+(t-\tau_k) + (1-r_k)U_{k+1}^-(t)$$

avec

$$r_k = \frac{A_{k+1} - A_k}{A_{k+1} + A_k} \qquad -1 \le r_k \le 1$$

r_k est le coefficient de réflexion de la *k* ième jonction

Si nous raisonnons en terme de pressions, le système d'équations (21) admet aussi comme solutions:

$$P_k(x,t) = P_k^+(t-\frac{x}{c}) + P_k^-(t+\frac{x}{c}) \qquad (27.a)$$

$$U_k(x,t) = \frac{A_k}{\rho c}(P_k^+(t-\frac{x}{c}) - P_k^-(t+\frac{x}{c})) \qquad (27.b)$$

De la même manière, la résolution de ce système d'équations donne une solution en ondes de pressions de la forme :

$$P_{k+1}^+(t) = (1-r_k)P_k^+(t-\tau_k) + r_k P_{k+1}^-(t) \qquad (28.a)$$

$$P_k^-(t+\tau_k) = -r_k P_k^+(t-\tau_k) + (1+r_k)P_{k+1}^-(t) \qquad (28.b)$$

3. Conditions aux limites et diverses pertes dans le conduit vocal

Dans la réalité, la propagation des ondes dans le conduit vocal se fait avec des pertes, une partie est due au déplacement de la masse d'air à l'intérieur du conduit vocal, l'autre partie provient du rayonnement de l'onde acoustique aux lèvres.

3.1. Pertes dues au déplacement de l'air à l'intérieur du conduit vocal

a- Vibration des parois

Les parois n'étant pas rigides, celles-ci se déforment sous l'influence de l'onde sonore: l'expression de l'aire de la section devient dépendante du temps, *A(x,t),* sous l'influence de la pression *p(x,t)* régnant à cet endroit (Figure 2):

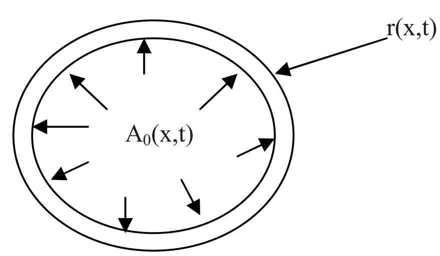

Figure 2. Vibration des parois.

Si l'on note $A_0(x,t)$ et $S_0(x,t)$ les valeurs respectives de la fonction d'aire et de la circonférence d'une section donnée, *A(x,t)* sera liée à cette valeur par l'expression suivante :

$$A(x,t) = A_0(x,t) + r(x,t).S_0(x,t) \qquad (29)$$

r(x,t) est le déplacement de cette section. Chaque élément de parois peut être considéré comme un système mécanique composé d'une masse (M_p) reliée à un ressort avec amortissement (b_p), qui oscille localement sans liaison, ni couplage avec les éléments voisins. Comme il s'avère que les fréquences d'oscillation propres de ce système sont faibles (Fant, 1972), on peut, dans la plupart des cas, négliger le ressort. Dans ces conditions, r(x,t) obéit à la relation suivante :

$$p - b_p \frac{\partial r}{\partial t} = M_p \frac{\partial^2 r}{\partial t^2} \qquad (30)$$

Le report de cette nouvelle valeur de *A(x,t)* dans les équations (21) après avoir négligé les termes du second ordre, conduit à:

$$-\frac{\partial p}{\partial x} = \frac{\rho_0}{A_0}\frac{\partial u}{\partial t} \qquad (31.a)$$

$$-\frac{\partial u}{\partial x} = \frac{A_0}{\rho_0 c^2}\frac{\partial p}{\partial t} + S_0 \frac{\partial y}{\partial t} \qquad (31.b)$$

Ce système s'écrit alors:

$$-\frac{\partial p}{\partial x} = Zu \qquad (32.a)$$

$$-\frac{\partial u}{\partial x} = Yp + Y_p p \qquad (32.b)$$

Dans lesquelles *Z*, *Y* et Y_p deviennent fonction de la section considérée:

$$Z(\omega, x) = j\omega \frac{\rho_0}{A_0(x)} \qquad (33)$$

$$Y(\omega, x) = j\omega \frac{A_0(x)}{\rho c^2} \qquad (34)$$

$$Y_p(\omega, x) = \frac{1}{j\omega M_p(x) + b_p(x) + \dfrac{k_p(x)}{j\omega}} \qquad (35)$$

Enfin, l'impédance des parois peut être représentée par la connexion série d'une résistance et d'une inductance:

$$Z_p = \frac{R_p + j\omega L_p}{S.l} \qquad (36)$$

où
S est la circonférence de la section considérée et *l* sa longueur. Avec $R_p = b_p = 1600\ g.cm^{-2}s^{-1}$
et $L_p = M_p = 1.4\ g.cm^{-2}$ (par unité de surface)
(Mrayati, 1976).

Pour notre cas, cette impédance a été simulée par un tube élémentaire en dérivation à chaque jonction, terminé par une résistance $Z_t = R_p$ (Figure 3) (Degryse, 1981).

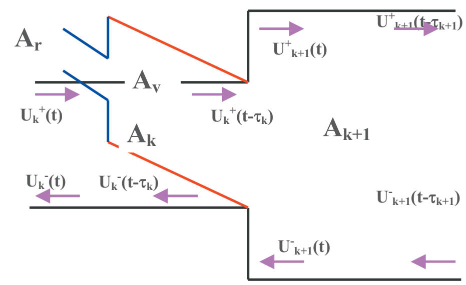

Figure 3. Tube élémentaire en dérivation d'une jonction.

A_v représente l'aire du tube équivalent à l'inductance
A_r représente l'aire du tube équivalent à la résistance

Avec $A_v = \dfrac{\rho_0 l^2 S}{L_p}$ et $A_r = \dfrac{\rho_0 c S l}{R_p}$

Par conséquent, le coefficient de réflexion à la jonction entre A_v et A_r s'exprime par :

$$R_v = \frac{A_v - A_r}{A_v + A_r} = \frac{R_p - L_p \frac{c}{l}}{R_p + L_p \frac{c}{l}}$$

Dans ce cas, les équations de propagation en pressions, s'écrivent :

$$P^+_{k+1}(t) = \frac{2A_k}{A_{k+1} + A_k + A_v} P^+_k(t - \tau_k) + \frac{A_{k+1} - (A_k + A_v)}{A_{k+1} + A_k + A_v} P^-_{k+1}(t) + \frac{2A_v}{A_{k+1} + A_k + A_v} P_v(t)$$

$$P^-_k(t - \tau_k) = \frac{A_k - (A_{k+1} + A_v)}{A_{k+1} + A_k + A_v} P^+_k(t - \tau_k) + \frac{2A_{k+1}}{A_{k+1} + A_k + A_v} P^-_{k+1}(t) + \frac{2A_v}{A_{k+1} + A_k + A_v} P_v(t)$$

$$P_v(t) = (P^+_k(t) + P^-_k(t))R_v$$

b- Pertes par viscosité/chaleur

Généralement, on introduit ces pertes dans le modèle sous forme d'une atténuation par cellules. Dans notre cas, les pertes par viscosité-chaleur sont introduites en branchant une résistance *R* à la jonction entre les deux tubes. Cette résistance s'écrit d'après (Fant, 1960) :

$$R = \frac{S}{A^2}\sqrt{(\omega\mu \frac{\rho}{2})} \qquad (37)$$

S étant la circonférence du tube, *A* son aire, ρ la masse volumique de l'air, μ le coefficient de viscosité et ω la pulsation. Un terme de pertes *D* est introduit comme étant le rapport de la résistance R sur la somme des impédances des tubes de la jonction. Ce terme s'écrit :

$$D=\frac{\pi}{c}\sqrt{\frac{f\mu}{\rho A}} \qquad (38)$$

et numériquement si f s'écrit en Hz et A en m^2 :

$$D = 3{,}626.10^{-5}\sqrt{\frac{f}{A}}$$

(39)

Pour introduire ces pertes dans les équations de propagation, on ajoute le terme D aux coefficients de réflexions de chaque équation de propagation, et on divise toute l'expression par $(1+D)$. On aboutit au système d'équations suivant:

$$P_{k+1}^{+}(t)=\frac{1}{1+D}[(1-r_k)P_k^{+}(t-\tau_k)+(r_k+D)P_{k+1}^{-}(t)]$$

$$P_k^{-}(t+\tau_k)=\frac{1}{1+D}[(-r_k+D)P_k^{+}(t-\tau_k)+(1+r_k)P_{k+1}^{-}(t)]$$

3.2. Pertes dues au rayonnement aux lèvres

L'impédance du rayonnement aux lèvres est définie comme étant celle d'un piston dans un baffle infini (Morse, 1968).

$$Z_r=\frac{\omega^2\rho}{2\pi c}+j\omega\left(\frac{8\rho}{3\pi\sqrt{\pi A}}\right) \qquad (40)$$

avec ρ la densité de l'air et A l'aire aux lèvres.

Cette impédance a été adaptée au modèle de Kelly & Lochbaum par Degryse (1981). Elle peut être approchée comme une connexion en parallèle sur le dernier tube du conduit d'une inductance L et d'une résistance R.

Avec : $L=\frac{8\rho}{3\pi\sqrt{\pi A}}$ et $R=\left(\frac{\rho c}{A}\right)\left(\frac{128}{9\pi^2}\right)$

Dans notre modèle, nous avons simulé l'inductance L par une aire A_l , et la résistance R par une aire A_r, comme le montre la figure 4.

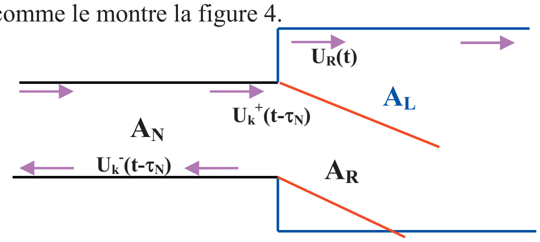

Figure 4. Jonction entre le dernier tube et le tube de rayonnement.

Avec

A_N aire du dernier tube du conduit vocal.

A_L aire équivalente à l'inductance L et qui s'exprime par $L=\frac{3\pi\sqrt{\pi A_N}\,l}{8}$.

A_R aire équivalente à la résistance R et qui s'exprime par $R=\frac{9\pi^2 A_N}{128}$.

Sachant qu'il n'y a pas d'onde se propageant dans le sens négatif dans l'aire A_l , les équations (28) deviennent alors :

$$P_N^{-}(t+\tau_k)=\frac{A_N-(A_L+A_R)}{A_N+A_L+A_R}P_N^{+}(t-\tau_k)-\frac{2A_L}{A_N+A_L+A_R}P_r(t)$$

$$P_r(t)=\frac{2A_N}{A_N+A_L+A_R}P_N^{+}(t-\tau_k)+\frac{(A_n+A_R)-A_L}{A_N+A_L+A_R}P_r(t)$$

avec :

P^{+}_N onde de pression positive du dernier tube ;
P^{-}_N onde de pression négative du dernier tube ;
P_r onde de pression au rayonnement.

4. Validation de SIMCV

4.1 calcul des fréquences des trois premiers formants des voyelles orales du Français

Dans cette partie, nous allons développer une méthode de validation objective de notre simulateur, baptisé SIMCV, en se basant sur la caractérisation acoustique des voyelles orales du français.

Dans une première étape, nous déterminons les fonctions de transfert des onze voyelles orales du Français. Dans une seconde étape, nous déterminons la valeur des fréquences des trois premiers formants, et leurs bandes passantes correspondantes. Les tableaux 1 et 2 donnent les configurations vocaliques adoptées pour les voyelles du Français ainsi que les caractéristiques formantiques de chaque voyelle (Majid ,1986).

Les fonctions de transfert obtenues à l'aide de SIMCV sont données à la figure 5.

Sur la Figure 6, nous avons ordonné les voyelles pour obtenir une représentation qui nous permet une comparaison avec le nomogramme de Majid. Nous remarquons que les formants mesurés par notre simulateur sont assez proches de ceux de Majid, et que l'évolution de ces formants sur l'axe des voyelles est quasi-identique.

4.2 calcul des bandes passantes des trois premiers formants des voyelles du Français

Les valeurs des bandes passantes des formants sont étroitement liées avec les pertes dans le conduit vocal. Leur mesure expérimentale sur de la parole réelle est assez délicate et doit être du type statistique, car les valeurs varient beaucoup d'un locuteur à un autre, d'un contexte à un autre. Notre méthode consiste à mesurer directement, sur les fonctions de transfert, les bandes passantes à –3 dB. La figure 7 donne les résultats obtenus pour les voyelles orales simulées par notre logiciel (SIMCV), et ceux donnés par Majid (1986) .

Nous remarquons que l'évolution des bandes passantes est assez proche de la parole naturelle.

5. Effets des pertes

Dans ce paragraphe, nous allons étudier l'effet des différentes pertes sur les caractéristiques acoustiques du conduit vocal. Pour cela, nous calculons avec notre simulateur temporel (SIMCV) dans les mêmes conditions précédentes, la fonction de transfert du conduit vocal pour chaque voyelle orale du Français, en éliminant à chaque fois un type de perte, on calcule, après, pour chaque cas les fréquences des formants, et leurs bandes passantes.

Sur la Figure 8, nous avons représenté la contribution de chacun des éléments de pertes aux fréquences des formants et nous pouvons constater ceci:

1/ La prise en compte de l'effet de vibration des parois introduit un amortissement supplémentaire. Il y a deux conséquences:

l'amortissement en basses fréquences de la fonction de transfert et la modification de la valeur du premier formant essentiellement aux fréquences basses. La Figure 8.a montre clairement la tendance de F vers F' au-delà de 800 Hz.

2/ L'effet des pertes par viscosité/chaleur est négligeable pour les trois formants (figure 8.b).

3/ L'effet des pertes par rayonnement est d'autant plus important que la fréquence est élevée, ceci est bien vérifié sur la Figure 8.c, où on voit clairement que l'écart en fréquence entre chaque formant augmente avec la fréquence.

Sur la Figure 9, nous avons représenté l'effet de chaque type de pertes sur les bandes passantes et trois constatations principales se déduisent :

1/ Aux fréquences basses (zone du premier formant), les pertes prépondérantes sont dues aux vibrations des parois.

2/ Aux fréquences moyennes (zone du second formant), l'effet des pertes est moins sensible.

3/ Aux fréquences hautes (zone du troisième formant), l'effet prépondérant provient du rayonnement aux lèvres.

Enfin, nous remarquons que nos constatations sont en parfait accord avec la littérature (Mrayati, 1976, Majid, 1986).

6. CONCLUSIONS

Les différents résultats et les conclusions qui en découlent seront utiles lors de la conception d'un synthétiseur analogue –dynamique du conduit vocal et lors de sa mise en œuvre. Ils pourront également contribuer aux recherches d'une parole de synthèse de très bonne qualité, se voulant proche de la parole naturelle.

En reconnaissance automatique de la parole, une meilleure connaissance des valeurs des bandes passantes peut être utile pour décider de la validité d'une détection de formant par exemple. On peut introduire ainsi une contrainte puissante.

Pour les voyelles ayant un premier formant assez bas, cette simulation donne des résultats plus précis que les mesures sur des signaux réels, car le nombre d'harmoniques est alors trop faible.

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Voyelle	[u]	[o]	[ ]	[a]	[ ]	[ε]	[e]	[i]	[y]	[Φ]	[œ]
glotte 1	2.2538	1.7532	2.0745	1.8232	1.6665	1.9099	1.9099	2.5099	2.0798	2.1232	1.8232
2	7.8677	8.4082	5.1492	2.2783	2.3143	5.8209	6.6713	9.8356	3.9450	5.9946	3.0606
3	6.1991	8.0651	3.3784	1.5579	4.0388	8.0184	9.8875	12.966	9.6677	8.3483	4.7337
4	3.0925	2.8169	0.9750	2.2634	3.0317	10.459	10.415	12.763	10.500	7.0596	4.9660
5	2.5600	1.3543	1.8206	2.2597	2.5206	8.3417	6.8314	9.6199	9.2847	3.8769	4.0000
6	2.2356	3.1855	3.0155	4.1532	5.3031	5.4808	4.2314	3.4939	4.9385	1.8748	3.8997
7	2.7320	5.7613	5.7185	7.0087	7.8929	3.9753	2.0546	0.9716	1.5845	1.4414	3.9705
8	6.5382	8.6890	9.4010	7.9538	9.3563	3.3000	2.7577	0.5433	0.6941	2.2079	4.5512
9	13.000	13.1288	10.300	6.8966	8.8997	4.1524	5.2507	1.0114	1.4002	3.0050	5.4356
10	3.2311	7.7889	6.9713	5.0456	8.0521	6.8696		3.8305	1.5736	4.1504	5.6700
11 lèvres	0.5845 cm2	3.2000 cm2	cm2	cm2	cm2	cm2	cm2	cm2	1.5396 cm2	5.5200 cm2	5.6700 cm2

Tableau 1. Configurations vocaliques adoptées pour les voyelles orales du Français (Majid, 1986).

Voyelles	[u]	[o]	[ ]	[a]	[ɑ]	[ε]	[e]	[i]	[y]	[Φ]	[œ]
F1	295	419	519	650	658	538	371	293	285	401	531
F2	734	867	1090	1356	1244	1802	2145	2247	1777	1691	1485
F3	2401	2363	2310	2413	2371	2435	2554	2586	2313	2358	2353
B1	67	48	51	45	51	45	54	61	63	44	41
B2	37	35	36	38	38	71	64	43	41	51	51
B3	35	46	36	64	56	82	119	127	38	41	42

Tableau 2. Fréquences et bandes passantes des trois premiers formants (Hz) des onze voyelles du Français (Majid, 1986).

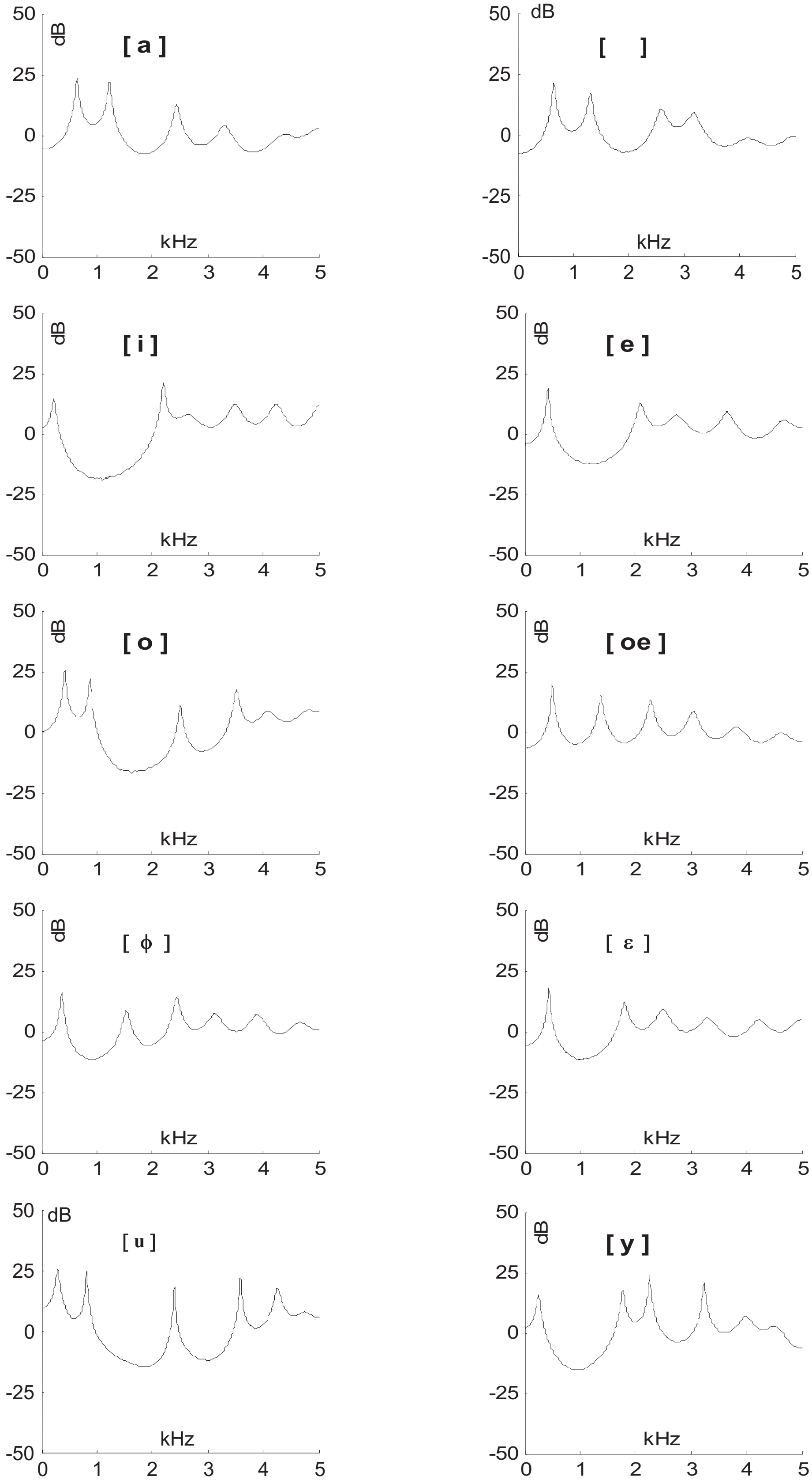

Figure 5. Fonctions de transfert obtenues.

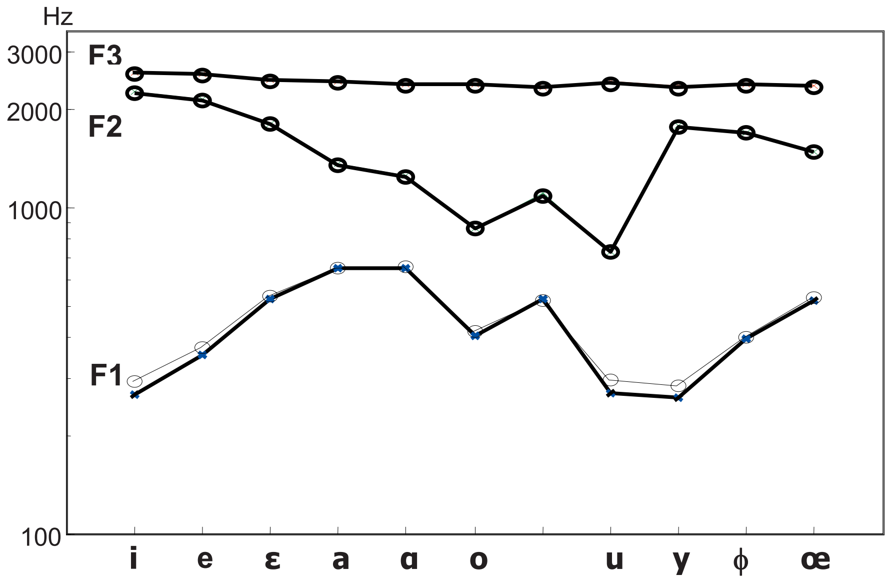

Figure 6. Nomogramme des voyelles orales du Français selon les valeurs des trois premiers formants (échelle logarithmique). x :Valeurs calculées par SIMCV. o : Valeurs calculées Majid (1986).

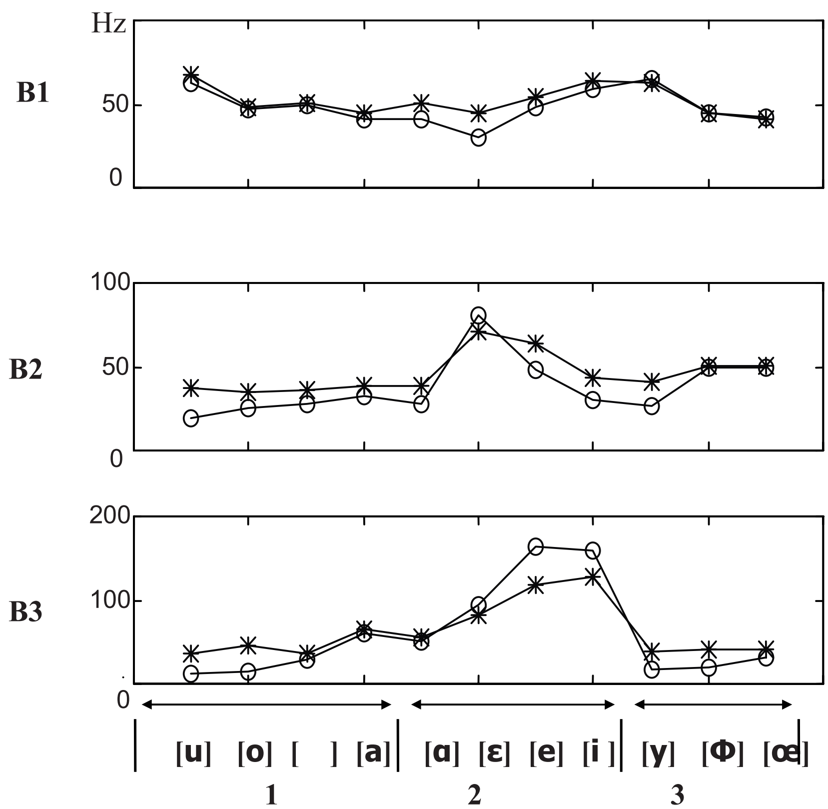

Figure 7. Bandes passantes des trois premiers formants. Comparaison avec valeurs calculées par Majid. (o) : Majid ; (*) : SIMCV. – 1. voyelles arrière ; 2. voyelles avant non arrondies ; 3. voyelles avant arrondies.

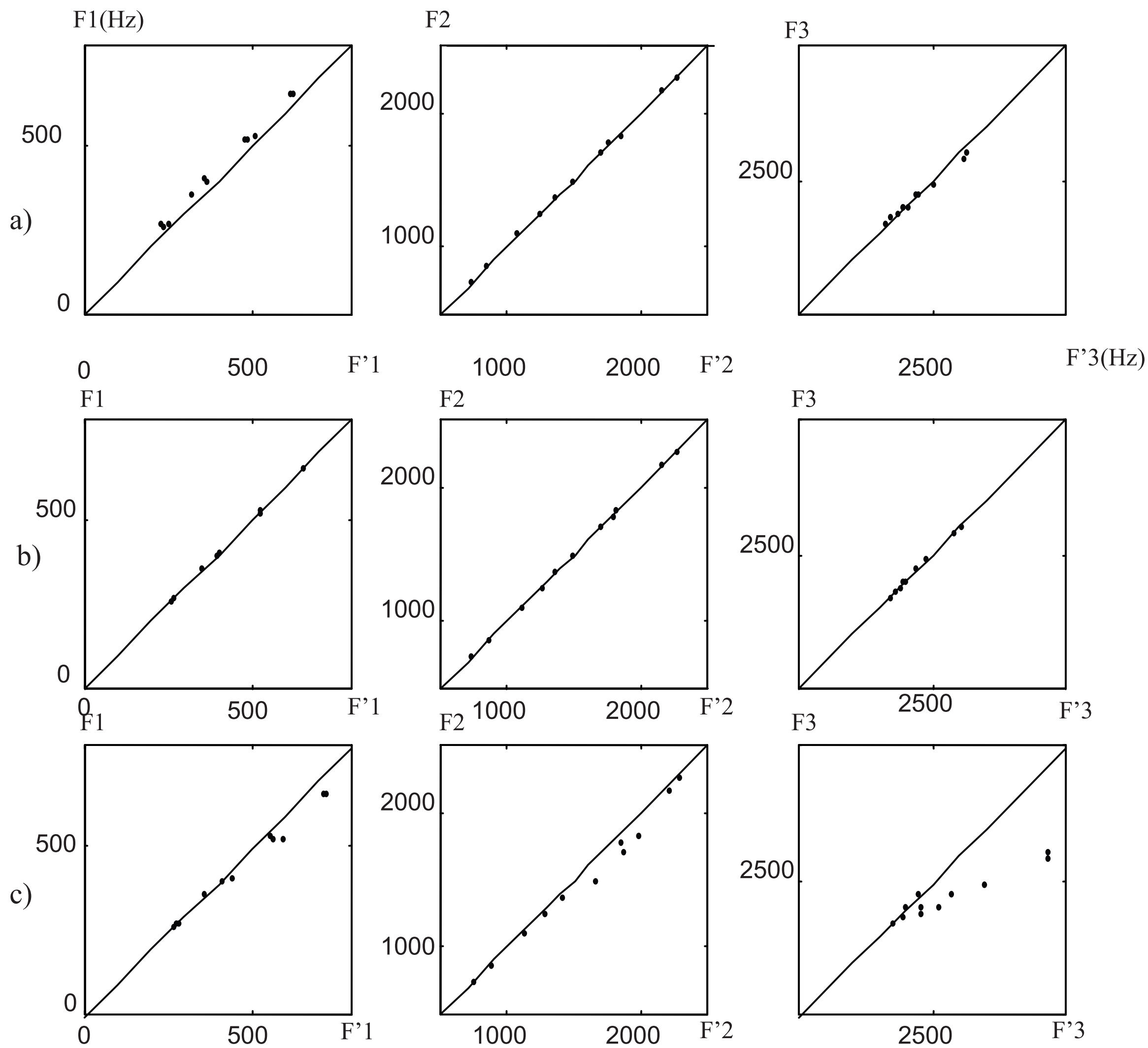

Figure 8. Effets de chacun des éléments de pertes sur les fréquences des formants. a) Effet des pertes par vibrations des parois; b) Effet des pertes par viscosité/chaleur ; c) Effet des pertes par rayonnement aux lèvres.

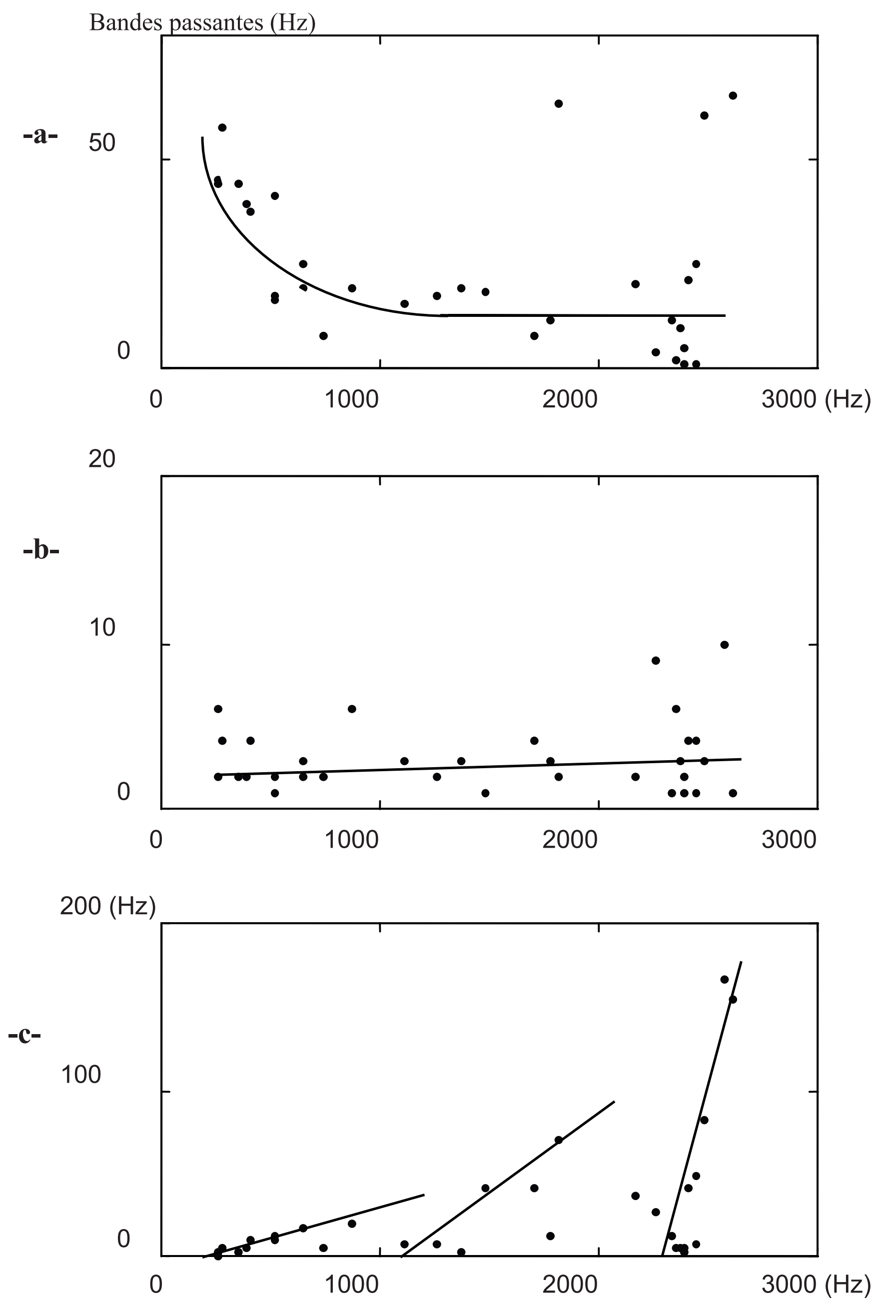

Figure 9. Contribution de chacun des éléments de pertes aux bandes passantes. a) Effets des pertes par vibrations des parois; b) Effets des pertes par viscosité/chaleur; c) Effets des pertes par rayonnement aux lèvres.

Performance Of Spectrogram Cross-Correlation In Detecting Right Whale Calls In Long-Term Recordings From The Bering Sea

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ABSTRACT

We investigated the performance of spectrogram cross-correlation for automatically detecting North Pacific right whale (Eubalaena japonica) calls in long-term acoustic recordings from the southeastern Bering Sea. Data were sampled by autonomous, bottom-mounted hydrophones deployed in the southeastern Bering Sea from October 2000 through August 2002. A human analyst detected right whale calls within the first month (October 2000) of recorded data by visually examining spectrograms and by listening to recorded data; these manual detections were then compared to results of automated detection trials. Automated detection by spectrogram cross-correlation was implemented using a synthetic kernel based on the most common right whale call type. To optimize automated detection parameters, the analyst performed multiple trials on minutes-long and hour-long recordings and manually adjusted detection parameters between trials. A single set of optimized detection parameters was used to process a week-long recording from October 2000. The automated detector trials resulted in increasing proportions of false and missed detections with increasing data set duration, due to the higher proportion of acoustic noise and lower overall call rates in longer recordings. However, the automated detector missed only one calling "bout" (2 or more calls within a 10-minute span) of the 18 bouts present in the week-long recording. Despite the high number of false detections and missed individual calls, spectrogram cross-correlation was useful to guide a human analyst to sections of data with potential right whale calling bouts. Upon reviewing automatic detection events, the analyst could quickly dismiss false detections and search recordings before and after correct detections to find missed calls, thus improving the efficiency of searching for a small number of calls in long-term (months- to years-long) recordings.

1. INTRODUCTION

Long-term, passive acoustic recorders are useful tools for monitoring some marine mammal populations, with potential applications ranging from providing information on behavioral ecology and abundance, to near-real-time localization and tracking of calling animals (*e.g.* Thompson and Friedl 1982, Clark *et al.* 1996, Stafford *et al.* 2001, Gillespie and Leaper 2001, Moscrop *et al.* 2004, Mellinger *et al.* 2004a, b). We used autonomous, bottom-mounted Acoustic Recording Packages (ARPs) (Wiggins 2003) to provide long-term recordings of critically endangered North Pacific right whales (*Eubalaena japonica*) (Brownell *et al*. 2001) and other baleen whale species in the southeast Bering Sea. Here, small numbers (tens) of right whales have been regularly observed since 1996 in the middle-shelf region (between the 50 m and 100 m isobaths) in summer months (Goddard and Rugh 1998, LeDuc *et al.* 2001, LeDuc 2004). We deployed and recovered five ARPs from four sites in the right whale sighting region in 2000-2002 (Figure 1). The ARPs recorded sound continuously in a frequency range (5 to 250 Hz) encompassing that of most North Pacific right whale calls (McDonald and Moore 2002), and provided 36 instrument-months totaling over 100 gigabytes of data.

Because of a paucity of data on eastern North Pacific right whales, each recorded right whale call could contribute to a better understanding of this population. However, manually detecting each right whale call in this large data set would potentially require hundreds of hours of human effort to scan spectrograms visually and to listen to recordings. In contrast, a computer using automated detection software could potentially process a year-long data set within hours to days, and human effort could be focused on reviewing automated detection results and searching for additional calls near times of automatic call detections. We found that automated call detection using spectrogram cross-correlation was effective for detecting bouts of right whale calling in long-term acoustic recordings from the Bering Sea. This paper evaluates the performance of spectrogram cross-correlation in detecting right whale calls within a subset of Bering Sea ARP data.

North Pacific right whales were first recorded in the Bering Sea in 1999 by McDonald and Moore (2002). The most common right whale call type (85%, n=511) was an 'up' call, sweeping up in frequency on average from 90 to 150 Hz in 0.7 s (McDonald and Moore 2002). North Pacific right whale calls and the proportion of different call types were similar to call repertoires of other right whale species (*Eubalaena* spp.) (Clark 1982, Matthews *et al.* 2001). Similarly to North Atlantic right whale calls (Matthews *et al.* 2001, Vanderlaan *et al.* 2003), North Pacific right whale calls were clustered in sporadic ‘bouts’ lasting several minutes, with longer silences (tens of minutes to hours) between bouts (McDonald and Moore 2002).

Automated right whale call detection in Bering Sea acoustic data was challenging for a number of reasons. Right whale call durations were brief (≤ 1 s), and calls were variable in duration, start and end frequencies, and frequency sweep rates (Figure 2, McDonald and Moore 2002). Calls may also have become distorted at the receiver due to the dispersion of normal modes over the flat, shallow continental shelf (Wiggins *et al.* 2004). Overall, calls received on ARPs were infrequent and the total number of calls was low. Flow and strum noise on hydrophones was frequently exacerbated by storms and strong tidal currents characteristic of the Bering Sea middle-shelf (Bond and Adams 2002, Coachman 1986). Also adding to the challenge of automated detection, humpback whales (*Megaptera novaeangliae*) produced sounds (Figure 3), including upswept calls, in the same frequency band used by right whales and recorded by the ARPs.

A variety of automated call detection techniques are available, including matched filtering, spectrogram correlation, energy summation, and neural networks (Stafford *et al.* 1998, Mellinger and Clark 2000, Mellinger 2004, Mellinger *et al.* 2004b). The performance of each of these techniques often depends on the characteristics of a particular species’ acoustic repertoire and behavior and the physical environment in which they are recorded. For example, matched filtering works well when calls are highly stereotyped, and energy summation works well for species that call often and in a frequency band isolated from other sounds (*e.g.*, calls from other species, ship engine noise, cable strumming) (Mellinger 2004). Some techniques, such as neural networks, require a large training set of calls. Right whale calls in Bering Sea ARP recordings were not well suited to matched filtering, energy summation, or neural networks.

The challenges of right whale call detection in our data set led us to investigate spectrogram cross-correlation with a synthetic kernel because this method a) does not require a

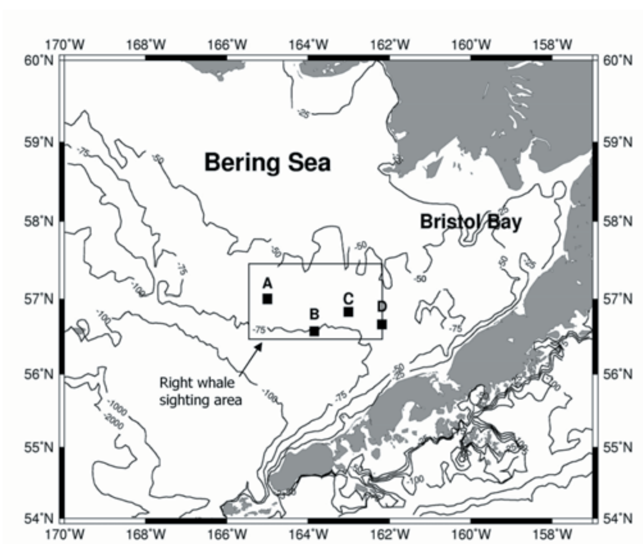


Figure 1. ARP sites A through D, year 2000-2002. Recordings in 2000-01 were from all four sites; recordings the following year (2001-02) were from site C only. Bathymetric contours are displayed at 25-meter increments for depths up to 100 m, and at 1000-m increments for depths of more than 100 m. Right whale visual sighting locations in the Bering Sea since 1996 are bounded by the ‘sighting area’ box.

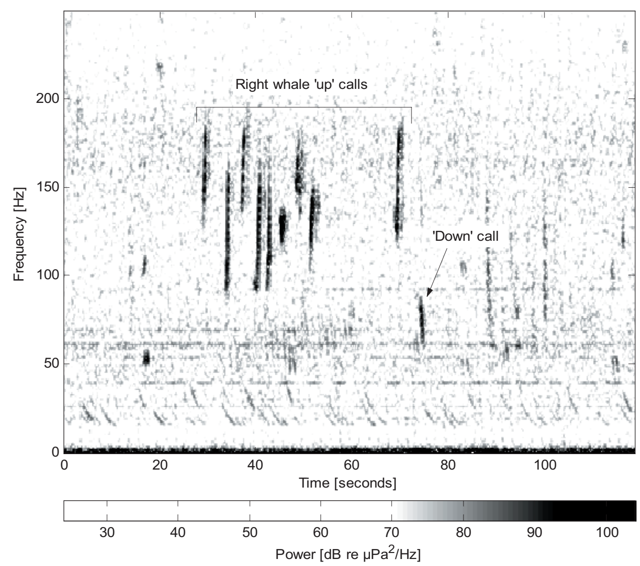


Figure 2. Two-minute excerpt of hour-long recording containing right whale calls, recorded by ARP at site C, 3 October 2000. Spectrogram parameters: 512 point frame and FFT length with same size Hanning window, 75% overlap, for a filter bandwidth of 4.0 Hz. Also visible throughout are fin whale downsweeps from 35-15 Hz.

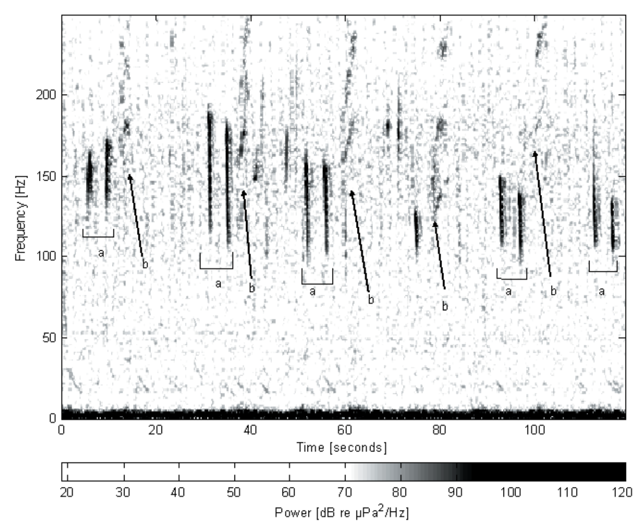


Figure 3. Two-minute excerpt containing humpback whale calls from week-long sound recording, recorded by ARP at site C. Repeated calls are labeled ‘a’ and ‘b’ to show pattern. Spectrogram parameters same as in Figure 2.

large training set of calls, b) may be more suited to detecting brief and infrequent calls in a large and often noisy data set, and c) may be less sensitive to variation and distortion among calls than the other techniques (Mellinger 2004). We configured the automated detector to detect ‘up’ calls, the most common call recorded from North Pacific right whales in the Bering Sea (McDonald and Moore 2002, Munger and Sauter unpub. data, Munger and Rankin unpub. data). In this study, we optimized automated detection parameters using short-duration recordings, and then evaluated the performance of optimized parameters in processing a week-long recording.

2. METHODS

2.1. Data sets

ARPs were configured to record continuously at a sampling frequency of 500 Hz, with a frequency response of -152 dB re 1 V/μPa, flat within 1 dB over the 5-250 Hz frequency band (Wiggins 2003). Acoustic data were digitized to 16-bit samples and stored on computer hard disks to be analyzed after instrument recovery.

Three subsets of acoustic data from the year-2000 ARP recordings were used to test the automated detector: short, intermediate, and long duration recordings. Short and intermediate duration recordings were chosen from previously manually processed data to provide the detector with training sets of calls with which to optimize detection parameters. Short recordings contained right whale ‘up’ calls, humpback whale calls, a combination of both, or no discernible calls; intermediate and long recordings were continuous sections of data containing periods of noise and calls from right and humpback whales.

The first data subset consisted of twelve short (1-to 5-minute) recordings made at different times by four ARPs during October-December 2000. Six of these recordings contained calls in the 80-250 Hz bandwidth, with a total of 26 right whale ‘up’ calls. The other six recordings contained no calls in that frequency range and varied in acoustic noise levels (Figure 4). The average overall right whale call rate in the short data set was 1.96 calls per minute.

The second data subset consisted of four intermediate-length recordings, 65 minutes each (Figure 2), recorded simultaneously on each of the four ARPs on October 3, 2000. Each of these recordings contained right whale and humpback whale calls in the 80-250 Hz band, including 72 right whale ‘up’ calls. The overall average right whale call rate in intermediate-length recordings was 0.28 calls per minute. The intermediate-length recordings did not have any data in common with the short recordings.

The third data subset was a single recording approximately one week in length, taken from the ARP at site C on 2-9 October 2000. This long recording did not share common data with the short recordings, but did encompass the hour recorded by ARP C in the intermediate-length data set. Whale calls were present in at least five days of the week-long data set; these included humpback calls (Figure 3) and 146 right whale ‘up’ calls, the majority of which were recorded during the first three days. The average right whale call rate over the week-long recording was 0.015 calls per minute.

2.2. Manual call detection

After evaluating right whale acoustics literature and discussing right whale call types with colleagues, the human analyst (LMM) visually scanned spectrograms and listened to potential calls throughout the first month of ARP recordings (October 2000). One difficulty in detecting right whale calls was distinguishing between calls of humpback whales and right whales. Humpback whales produced some sounds in the same frequency band as right whales, including short-duration upswept or downswept calls. The most important

(a)

(b)

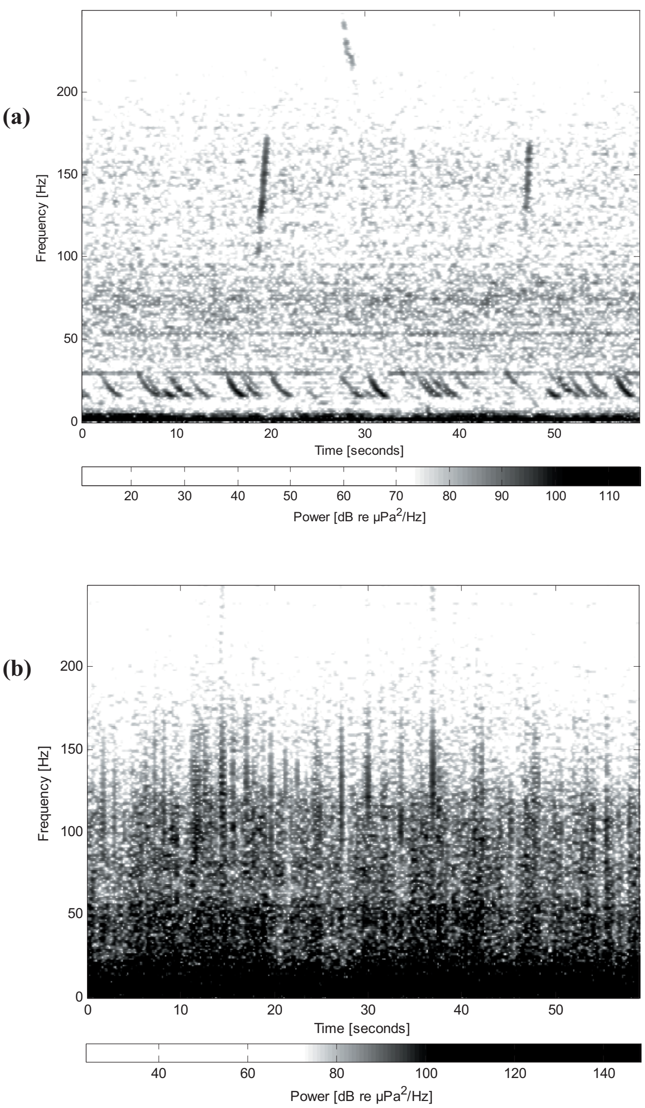


Figure 4. Two examples of sixty-second recordings containing a) right whale ‘up’ calls at approximately 18 s and 47 s, and b) only noise. Spectrograms parameters same as in Figure 2 except 90% overlap.

distinguishing feature in our Bering Sea data set proved to be the temporal pattern of calls. Right whales produced calls (Figure 2) in sporadic bouts, whereas humpback whales produced calls in consistent, repeated patterns (Figure 3). Patterned humpback calling (song) has been reported in late summer/early fall on other northern feeding grounds as well (Mattila *et al.* 1987, McSweeney *et al.* 1989). In addition, ARP recordings of humpback calls and call series often contained harmonics and higher-frequency components, whereas right whale calls were typically tonal upsweeps without harmonics.

The human analyst (LMM) used a software program (*Triton*, Wiggins 2003) written in MATLAB® (The MathWorks, http://www.mathworks.com) to generate and display spectrograms of the ARP data sets. Time series were transformed into the frequency domain using a Fast Fourier Transform (FFT) with a Hanning window (Oppenheim and Schafer 1999). FFT and window length were both 512 points (1.024 s) and overlap was 75-90%. Graphical gain and contrast were adjusted to give the best resolution of the spectrogram. During visual scanning of sequential spectrograms, the time-frequency display window was 0-250 Hz in frequency and usually 60-120 s in duration. When the analyst detected a potential right whale call in the displayed spectrogram, the call portion of the display was expanded in time and spectral parameters were adjusted to 'sharpen' the image--for example, by reducing FFT and window length and increasing the amount of overlap. In addition, potential right whale calls were also played on speakers, to provide the analyst an opportunity to aurally detect and distinguish right whale calls from humpbacks if visual detection was ambiguous.

The analyst noted only right whale 'up' calls for the purposes of this comparative study because the automated detector was configured to detect only 'up' calls. The set of manually-picked right whale 'up' calls provided the basis for comparing automated detection results.

2.3. Automated detection

We used the software program *Ishmael* (Mellinger 2001) for call detection by spectrogram cross-correlation. Spectrograms were generated in *Ishmael* using the same parameters as used in *Triton* to manually detect calls: frame, FFT, and Hanning window length were equal to 512 points (1.024 s), and overlap was 75-94%. ARP spectral data were cross-correlated with a synthetic spectrogram kernel (Mellinger and Clark 2000), which we based on the 'up' calls found in our data sets and consistent with those described in McDonald and Moore (2002). The synthetic call kernel consisted of piecewise, continuous line segment(s) defined by start and end times and their corresponding start and end frequencies (Figure 5). Other detection parameters that were adjusted included the instantaneous bandwidth of the synthetic call kernel (Figure 5), detection threshold, minimum and maximum duration above the detection threshold, and spectrogram equalization time constant (time-averaging to smooth out background noise) (Van Trees 1968; Mellinger 2001, 2004; Mellinger *et al.* 2004a). The minimum time between detections was set to 0 seconds to avoid missing close or overlapping calls.

The spectrogram cross-correlation output is a time series of the unnormalized cross-correlation, which varies with the closeness of the match between the data and the predefined kernel; function peaks above a user-specified threshold are counted as detection events. If the parameters we chose resulted in zero detection events, we discarded that set of parameters and did not include them in this analysis. When detection events occurred, we adjusted one parameter at a time and observed the resulting effect on detector performance. If performance improved and resulted in fewer false detections and/or missed detections, we adjusted the other parameters in an attempt to further minimize missed detections and false detections.

We ran 62 automated detection trials using the short recordings, 22 trials using the intermediate-length recordings, and 1 trial using the week-long recording. Each automated detection event was saved individually as a short (~10 s) sound file. After each detector trial, a human analyst examined each individual detection event to verify whether the detection was correct. Automated detections were classified as correct detections (right whale 'up' calls) or false detections. False detections were further categorized as other biological sounds, including non-upswept calls or calls identified to be from humpback whales, or noise, in which no call was present.

We compared the performance of various detection parameters by plotting receiver operating characteristic (ROC)

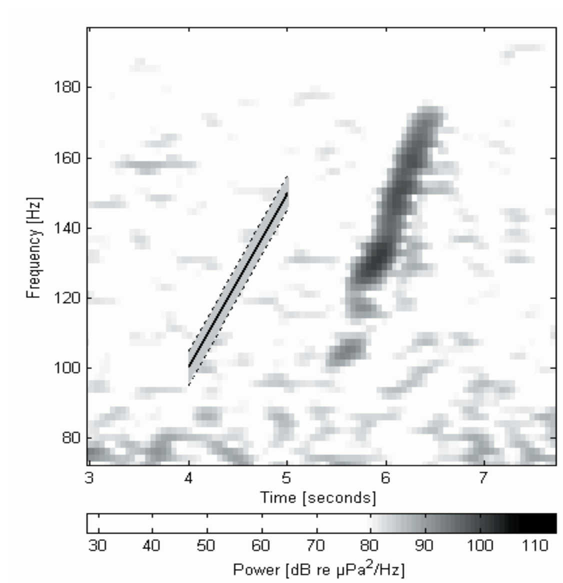


Figure 5. Synthetic call kernel (light gray) from 100 to 150 Hz, lasting 1 s, with 'kernel bandwidth' of 10 Hz bounded by dotted lines. The synthetic kernel precedes a spectrogram of a right whale call, enlarged from Figure 4a at 18 s. Spectrogram parameters: 256-point frame, FFT, and Hanning window length, and 90% overlap, for a filter bandwidth of 7.9 Hz.

curves illustrating the trade-off between false detections and missed calls. False detections were expressed as a percentage of the total number of automated detections. Missed calls were expressed as percentages of the total number of 'up' calls in the data set, which was defined as the number of manually detected 'up' calls. We designated an acceptable missed call threshold of 20%, and defined 'optimal' detection parameters as those that minimized false detections while missing fewer than 20% of calls. We set this missed call threshold because right whale calls were rare in our data set and we wished to detect a substantial majority of them; although this caused an increase in false detections, reviewing and discarding false detections was still a simple and relatively fast process for an analyst compared to thoroughly manually processing the entire recording. Optimal parameters from trials using short recordings were included in detector trials run on intermediate-length recordings, and the optimal parameters from trials using intermediate recordings were used to process the week-long recording.

3. RESULTS

For ease of interpretation, we separated automated detection results for short (minutes-long) recordings into results using a single synthetic kernel, and those using different kernel types with varying slopes and numbers of segments. The automated detector that performed best on the short recordings used a 1 s, 100-150 Hz synthetic kernel (Table 1, Figure 6). The optimal parameters (resulting in fewer than 20% missed calls and minimal false detections) with this single kernel type resulted in 19% missed detections (5 of 26 calls) and 25% false detections (7 of 28 total detections) (Figure 6, Table 2). A large proportion (86%) of false detections contained other biological sounds.

Table 3 shows the detection parameters used with synthetic kernels that consisted of one or more segments of varying duration and start/end frequencies. The corresponding ROC curves for those parameters were plotted in Figure 7. The optimal synthetic kernel in this case (resulting in fewer than 20% missed calls and minimal false detections), consisted of 2 segments: the first 1 s and 100 to 150 Hz, and the second 0.5 s from 150 to 180 Hz. These parameters resulted in 19% missed detections and 42% false detections (Figure 7, Table 4), 80% of which were other biological sounds. The varied synthetic call kernels that we tested did not perform as well as the single-segment 1 s, 100-150 Hz kernel.

Detection parameters and results for intermediate-length recordings are shown in Table 5, Figure 8, and Table 6. In addition to varying the same parameters as in short-recording trials, we used spectrogram equalization (time-averaging to smooth background noise) in some trials; this was not done for short recordings because averaging over seconds was inappropriate for recordings lasting tens of seconds. For the same acceptable level of missed detections (20%), the optimal detection parameters resulted in 69% false detections and 19% missed calls. 31% of these false detections in intermediate-length recordings were other biological sounds. (Figure 8, Table 6). Although we tested varying synthetic kernels, the optimal detection parameters were again based on a single 1 s, 100-150 Hz segment, and did not employ spectrogram equalization.

The detection parameters used for the week-long recording were the optimal parameters resulting from trials using hour-long recordings. The detection results using the week-long recording are summarized in Table 7 and displayed as a single data point on Figure 8a. False detections comprised 98% of the total number of detections, and approximately 38% of detectable calls were missed. Of the false detections, 10% were other biological sounds. Figure 9 compares the number of manual and automated detections of right whale 'up' calls over the first three days (when most of the right whale calls were detected) of the week-long ARP recording. We defined a calling 'bout' as at least 2 calls within a ten-minute time span; although not all calls in a single bout were detected, the automated detector missed only one of 18 total bouts in the week-long recording, and missed 3 calls occurring singly.

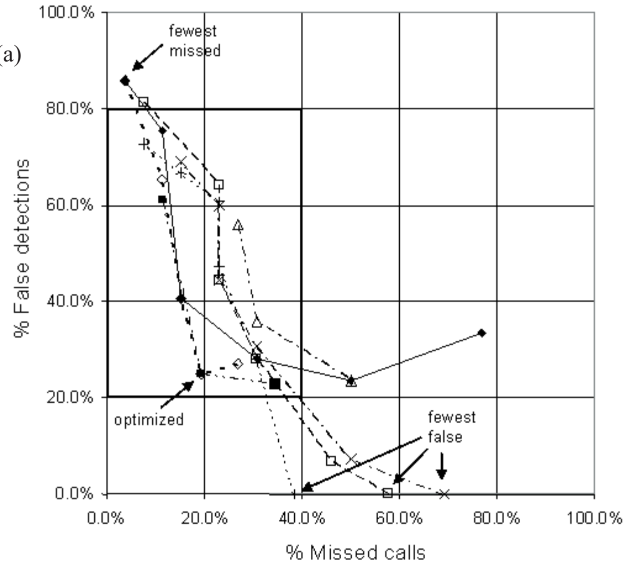
To investigate whether false detection rates were related to acoustic noise levels, we compared noise levels in the recordings by calculating average spectral levels between 100 and 150 Hz over 1-minute time intervals in hour-long recordings and 10-minute intervals in the week-long recording (time intervals were shorter for the hour-long recordings to give better graphical resolution). The percentage of false detections during the intermediate-length test recordings differed significantly between each of the four ARPs, and was highest on ARP A (average false detection proportions: A=89.8%, B=57.0%, C= 59.8%, D= 77.3%; ANOVA, p<0.05), which also had the highest average noise level over the hour of recording (Figure 10).

Symbols in Figure 6:	◆	■	◇	□	△	×	+
Kernel width (Hz)	10	10	10	10	10	**7-12**	**9-14**
Detection threshold	5	6	**3-7**	**2-8**	**3-5**	4	5
Minimum duration above threshold (s)	**0.2-0.7**	**0.3-0.5**	0.4	0.5	0.6	0.5	0.5
Maximum duration above threshold (s)	2	2	2	2	2	2	2

Table 1. Detection parameters tested in short recording trials; the synthetic call kernel in all of these tests was a 1 s, 100-150 Hz line segment as in Figure 5. The ranges of varying parameters are shown in bold type. Symbols correspond to markers in Figure 6.

Noise levels varied more over one week on an individual instrument (ARP C) than they did between instruments during the hour recorded in the intermediate-length test data (Figure 10). During the week recorded on ARP C, a semidiurnal tidal signature was apparent during the first three days of recording, and an overall rise in noise during days 280-282 was caused by a storm. Peaks in noise on days 279 and 280 were related to passing ships—closer inspection of spectrograms revealed long, continuous tones at 60 Hz and higher harmonics typical of engine-related noise.

(a)



(b)

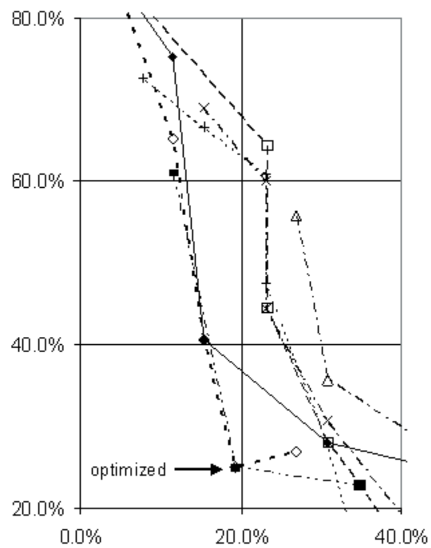


Figure 6. a) Results of automated detection trials using short recordings, and parameters and symbols from Table 1. Each curve is the result of varying one detection parameter and measuring resulting rates of false detections and missed calls. False detections are expressed as a percentage of the total number of automated detections; missed calls are expressed as a percentage of the total number of manually detected calls. Results for 'optimized', 'fewest missed', and 'fewest false' data points are given in Table 2. b) Area within thickened line in 6a is expanded in Figure 6b.

	Optimized (<20% missed)	Fewest missed	Fewest false (38% missed, 0% false)
Kernel width (Hz)	10	10	10
Detection threshold	6	3	3-7
Minimum duration above threshold (s)	0.4	0.4	0.4
Missed detections out of 26 calls	5	1	10
False detections: total	7	152	0
False detections: other call types/species	(6)	(61)	(0)
Total number of detections	28	177	16

Table 2. Detection parameters and results for the 'optimized' data point (using a predefined threshold of 20% missed calls), 'fewest missed' calls, and 'fewest false' detections (Figure 6) using short recordings and synthetic kernel of 1 s, 100-150 Hz. False detection total includes other biological sounds, which are reported in parentheses.

4. DISCUSSION

Using spectrogram correlation with manually optimized detection parameters, the automated detectors we tested performed best on the short (minutes-long) sound recordings, with increasing proportions of false and missed detections as the recording duration increased. The increase in the proportion of false detections with the recording length was expected, because the longer recordings contained longer periods of noise relative to the number of right whale calls present and provided more opportunities for the detector to produce false detections. The short- and intermediate-length recordings were used to optimize detection parameters and consequently represented relatively high rates of right whale calling (approximately 2 calls/minute in the minute(s)-long recordings and 0.3 calls/min in the hour-long recordings),

Symbols in Figure 7:	◆	■	▲	◇	□	△	×	+	—	▫
Number of segments	1	1	1	1	1	1	1	3	2	1
Segment length (s)	1	0.5	0.5	0.5	0.6	**0.5-1**	1	0.3	0.5	0.7
Sweep rate (Hz/s)	60	50	50	50	42	**42-50**	60	57	70	86
Start Frequency (Hz)	100	100	125	**110-125**	100	100	90	100	90	90
End frequency (Hz)	160	125	150	**135-150**	125	**150-180**	150	151	160	150
Kernel width (Hz)	**9-11**	**8-10**	**8-10**	**9-10**	**8-9**	**8-10**	**9-10**	10	10	10
Detection threshold	**4-5**	**3-4**	3	**3-3.5**	**3-4**	**3-4**	4	3	3	4
Minimum duration above threshold (s)	**0.4-0.5**	0.5	0.5	**0.4-0.5**	0.5	0.5	0.5	0.5	0.5	0.5
Maximum duration above threshold (s)	2	2	2	2	2	2	2	2	2	2

Table 3. Range of detection parameters tested in short recording trials when varying the structure of the synthetic call kernel. The ranges of varying parameters are shown in bold type. Symbols correspond to markers in Figure 7.

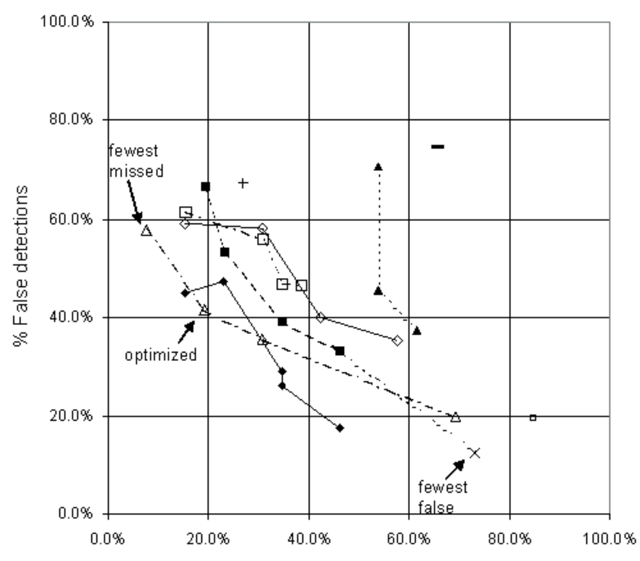


Figure 7. Results of automated detection trials using short recordings and varying the synthetic kernel structure. Symbols as in Table 3, and terminology in Figure 6. Some of the 'curves' here consist of a single point. Results for 'optimized', 'fewest missed', and 'fewest false' data points are given in Table 4.

whereas the week-long recording contained 0.02 calls/min. Because the longer data sets contained more calls in total (72 calls in intermediate-length data set and 146 calls in week-long data set), there was increased potential for variation among calls, possibly contributing to the higher proportion of missed detections caused by a mismatch between calls and the synthetic kernel.

The automated detection trials also resulted in high rates of detection of other biological sounds: over 80%, 31%, and 10% of the false detections were biological sounds for short, intermediate, and long recordings, respectively. These other sounds included upswept calls from humpback whales, as well as other call types (down-swept calls, moans, pulses) that potentially could have been made by humpbacks or right whales. Although these were classified as false detections (because they were not right whale 'up' calls), a human analyst in practice would likely be interested in reviewing these sounds as well, especially if the goal is to correctly detect and classify each rare right whale call during the post-processing of a large data set.

The automated detector produced over 90% false detections and missed over one-third of the right whale 'up' calls in the week-long data recording. These results were poor compared to some other marine mammal acoustic detection studies, in which automated detection software missed relatively fewer calls, categorized a greater proportion of calls correctly, and produced a smaller percentage of false detections (Mellinger and Clark 2000; Niezrecki *et al.* 2003; Mellinger *et al.* 2004a,b). Some factors contributing to the high missed call rate in our study were variability among calls (McDonald and Moore 2002), distortion resulting from waveform dispersion (Wiggins *et al.* 2004), and high acoustic noise levels resulting in decreased signal-to-noise ratios (SNR) of calls.

Acoustic noise recorded by hydrophones in the Bering Sea was often high due to strong tidal currents and frequent storms (Figure 10b). The lack of detections in the week-long recording during approximately days 280-282, when the noise level was highest (Figure 10), could have been due to masking by that noise or to an actual lack of whale calls. A rise in noise level may decrease the acoustic detection range and could explain the lack of detected calls. High

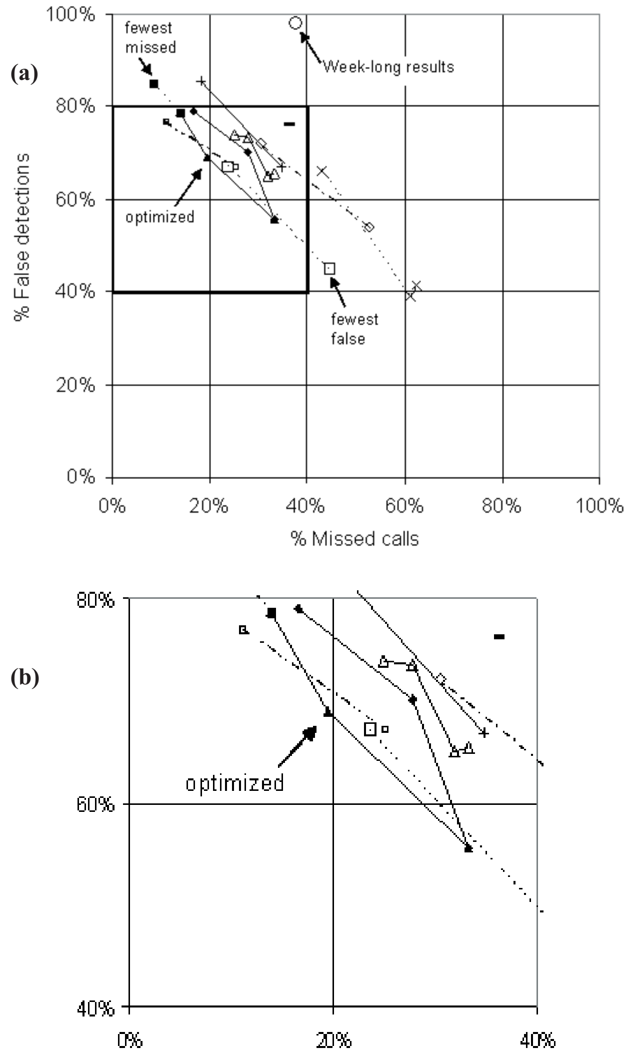


Figure 8. a) Results of automated detection trials using intermediate-length (symbols in Table 5) and week-long (marked by single open circle) recordings. Terminology same as in Figure 6. Some of the 'curves' here consist of a single point. Results for intermediate-length points labeled 'optimized', 'fewest missed', and 'fewest false' are given in Table 6. Results from week-long data set (open circle) given in Table 7. b) Area within thickened line in 8a is expanded in Figure 8b.

	Optimized (<20% missed)	Fewest missed	Fewest false
Number of segments	2	2	1
Segment durations (s)	1, 0.5	0.6, 0.5	1
Start-middle-end frequency (Hz)	100-150-180	100-125-150	90-150
Kernel width (Hz)	10	9	9
Detection threshold	4	3	4
Minimum duration above threshold (s)	0.5	0.5	0.5
Missed detections out of 26 calls	5	2	19
False detections: total	15	33	1
False detections: other call types/species	(12)	(17)	(1)
Total number of detections	36	57	8

Table 4. Detection parameters and results for the 'optimized' data point (using predefined threshold of 20% missed calls), 'fewest missed' calls, and 'fewest false' detections (Figure 7) using short recordings and varying the synthetic kernel structure. False detection total includes other biological sounds, which are reported in parentheses.

Symbols in Figure 8:	◆	■	▲	◇	□	△	×	+	—	▫
Number of segments	1	1	1	1	1	1	1	1	2	1
Segment duration (s)	1	1	1	1	1	1	1	1.1	1, 0.5	1
Sweep rate (Hz/s)	50	50	50	50	50	50	50	**45-55**	50,60	55-60
Start Frequency (Hz)	100	100	100	100	100	100	100	100	100	100
End frequency (Hz)	150	150	150	150	150	150	150	**150-160**	180	155-160
Kernel width (Hz)	10	11	**10-11**	**9-10**	**10-11**	**10-11**	10	10	10	11
Detection threshold	**5-6**	**5.5-6**	6	4	5	**5-6**	**4-5**	5	4	5.5
Minimum duration above threshold (s)	0.4	0.4	0.4	0.5	0.5	0.4	0.5	0.4	0.5	0.4
Maximum duration above threshold (s)	2	**1.5-2**	2	2	2	2	2	2	2	2
Equalization constant (s)	None	None	None	None	None	**3-5**	**2-3**	None	None	None

Table 5. Detection parameters tested in intermediate-length recording trials. The ranges of varying parameters are shown in bold type. Symbols correspond to markers in Figure 8.

acoustic noise levels also contributed to high false detection rates; during the hour-long recording, ARP A had both the highest false detection rate and highest average noise level in the call frequency band (Figure 10). It is not clear whether the relatively higher noise on ARP A was due to differences in instrument calibration or actual differences in acoustic noise. Noise levels varied more over a long duration of time on a single instrument than between instruments during the same short time period (Figure 10); therefore any effects of ARP calibration on detector performance were probably overshadowed by the much larger fluctuations in acoustic noise over time due to events such as tides, storms, and passing ships.

Despite the high rates of false and missed detections, automated call detection by spectrogram correlation was nevertheless useful for our complete ARP data set. Although a human analyst reviewed all of the automated detections, this process was considerably more time-efficient than thoroughly scanning the entire data set manually. In our trial using the week-long recording, the detection parameters we used missed only one of 18 right whale calling 'bouts' (Figure 9). Automated spectrogram correlation, optimized for a low number of missed detections, was thus helpful in directing a human analyst to periods in the data when additional calls

	Optimized (<20% missed)	Fewest missed	Fewest false
Kernel width (Hz)	10.5	11	10
Detection threshold	6	5.5	5
Minimum duration above threshold (s)	0.4	0.4	0.5
Maximum duration above threshold (s)	2	1.5	2
Equalization time constant	None	None	3
Missed detections out of 72 calls	14	6	44
False detections: total	129	376	18
False detections: other call types/species	(40)	(88)	(12)
Total number of detections	187	376	46

Table 6. Detection parameters and results for the 'optimized' data point (using predefined threshold of 20% missed calls), 'fewest missed' calls, and 'fewest false' detections (Figure 8) using intermediate-length recordings. The synthetic kernel in all three cases was 1 s, 100-150 Hz, although alternative synthetic kernels were also tested. False detection total includes other biological sounds, which are reported in parentheses.

Results for week-long recording:	
Missed detections out of 146 calls	55
False detections: total	4566
False detections: other call types/species	(458)
Total number of detections	4657

Table 7. Detection results for week-long recording. Detection parameters are same as 'optimized' parameters from trials using intermediate-length recordings (Table 6).

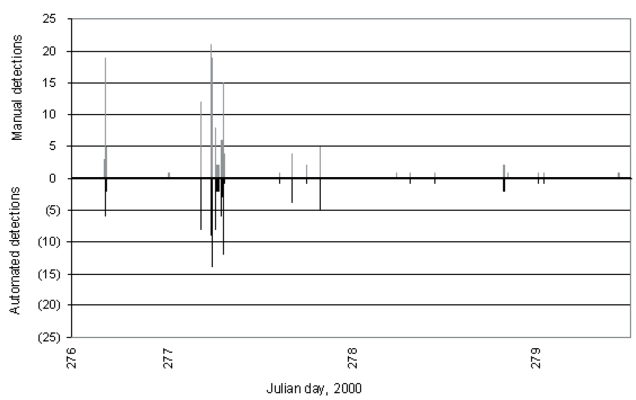


Figure 9. Manual detections per ten-minute time bin (gray bars, upper half of plot) in the first three days of the week-long recording, and automated detections (black bars, lower half of plot) within the same recording, using 'optimized' parameters from intermediate-length recording trials. In this recording, one 'bout' of calls, defined as at least two calls per ten-minute span, was missed on day 276, out of 18 bouts total within the entire week. Four single calls were also missed by the detector on days 277-279. On day 282 (not pictured), two calls were detected manually, one of which was detected automatically.

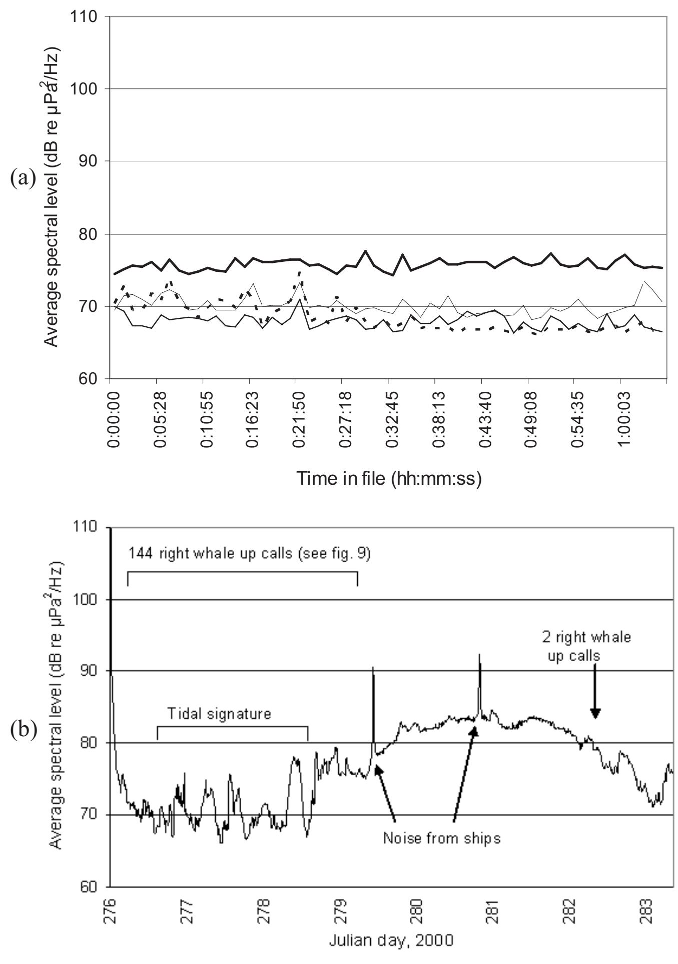


Figure 10. a) Noise levels between 100-150 Hz on each ARP during intermediate-length (65-minute) recordings, recorded simultaneously on each instrument. b) Noise levels between 100-150 Hz on ARP C during week-long recording. Tidal signature and spikes in noise from ships are labeled, as are days of right whale calls. Overall increase in noise on days 280-282 due to storm. Intermediate-length recordings taken from day 277, hour 0400-0505.

were likely to be found near the automated call detection. The combination of automated detection with manual verification and focused searching has been used effectively in detecting North Pacific right whale calls in the Gulf of Alaska (Waite *et al.* 2003, Mellinger *et al.* 2004b), as well as in other long-term right whale data sets (Clark *et al.* 2000).

Due to the paucity of data on right whales in the eastern North Pacific, our primary goal in developing an automated right whale call detector was to maximize the number of right whale calls detected, and the concomitant increase in high false detection rates was acceptable during this study. Detection techniques other than spectrogram cross-correlation, such as neural networks (Mellinger 2004), may become more feasible as we increase the set of known calls recorded in the presence of North Pacific right whales. Current and future deployments of passive acoustic recorders in the Gulf of Alaska and Bering Sea will provide new data that will require efficient processing and benefit from improved automated detection techniques. For the ARP data set described in this study, automated detection using spectrogram correlation was useful to direct a human analyst to potential right whale calling bouts and was more time-efficient than manual call detection.

ACKNOWLEDGEMENTS

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WHOLE-BODY VIBRATION IN MILITARY VEHICLES: A LITERATURE REVIEW

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ABSTRACT

Military personnel are exposed to high levels of whole-body vibration in armoured vehicles. Since command and control operations are likely to become more mobile in the future, it is of interest to understand the effects of whole-body vibration exposure on human performance and communication. This paper is a review of the effects of whole-body vibration on hearing and cognitive performance. Exposure to vibration has been shown to exacerbate noise-induced hearing loss, which may have implications for radio communication and speech understanding. Vibration does not appear to affect performance for simple cognitive tasks, but it may degrade performance on more complex cognitive tasks, particularly if the exposure is of long duration. This could be of key importance in a command and control situation, in which operators are under high cognitive load. The severity of vibration that is experienced in armoured vehicles makes it difficult to perform realistic experiments in the laboratory, meaning that future studies of its effects on cognitive performance and communication will likely have to be performed in the field.

SOMMAIRE

Le personnel militaire est exposé à des niveaux élevés de vibrations globales du corps dans les véhicules blindés. Étant donné que les opérations de commandement et de contrôle seront de plus en plus mobiles dans l'avenir, il est important de comprendre les effets de l'exposition aux vibrations globales du corps sur la communication et le rendement humains. Le présent document est une étude des effets des vibrations globales du corps sur l'ouïe et le rendement cognitif. Il a été démontré que l'exposition aux vibrations exacerbe la perte auditive induite par le bruit, ce qui peut avoir des répercussions sur la communication radio et la compréhension de la parole. L'exposition aux vibrations ne semble pas altérer le rendement dans les tâches cognitives simples contrairement aux tâches plus complexes, en particulier si l'exposition est d'une longue durée. Ce facteur pourrait être d'une importance capitale dans le cadre des opérations de commandement et de contrôle, qui comportent une lourde charge cognitive pour les opérateurs. Compte tenu de l'intensité des vibrations auxquelles les conducteurs sont exposés dans les véhicules blindés, il est difficile de mener des expériences réalistes en laboratoire, ce qui signifie que les futures études des effets de l'exposition aux vibrations sur le rendement cognitif et la communication devront être menées sur le terrain.

1. INTRODUCTION

Exposure to vibration is inevitable in many occupational settings. Whole-body vibration occurs when the body is supported by a vibrating surface. The amount of vibration exposure depends on a number of factors, including the type and design of the vehicle, the speed at which the vehicle is travelling, the environmental conditions and the posture of the operator. Military personnel experience high levels of vibration in armoured vehicles. Command and control operations will likely become more mobile in the future, which will increase the cognitive and sensory demands on personnel while inside the vehicles (23). Clear communications and sharp situational awareness are essential for effective performance and, ultimately, survival during missions. It is thus of interest to understand the effects of vibration on hearing and cognitive function.

Guidelines for the measurement and evaluation of human exposure to whole-body vibration are defined by the International Organization for Standardization (ISO) in ISO 2631-1 (14). The frequency range that is most often associated with whole-body vibration is approximately 0.5 to 100 Hz (8). Vibration magnitude is generally measured in units of acceleration rather than the velocity or displacement between peak-to-peak movements. The preferred International System (S.I.) unit for vibration magnitude is meters-per-second-per-second (m/s^2), and measurements are often expressed as root-mean-squared (rms) values rather than peak values. The rms values are frequency-weighted according to weighting curves defined in ISO 2631-1, and averaged over time and frequency; this is the basic method for evaluation of whole-body vibration (14). Vibration signals that are measured in vehicles are usually complex in nature, containing occasional or repeated shocks (sudden, high acceleration vibration events). The basic evaluation method may underestimate the severity of vibration exposures that contain multiple shocks; other methods for assessing vibration of this type are given in ISO 2631-1 and ISO 2631-5 (14,15).

Translation vibration, or linear vibration, is generally measured in the fore-to-aft (x-axis), lateral (right to left side, y-axis) and vertical (z-axis) directions. The defined positions of the axes relative to the human body depend on whether the person is seated, standing or recumbent, and may differ slightly among published standards. In most cases, vibration is more significant in the z-axis than the horizontal axes. Maximum transmission of vertical vibration to the body typically occurs around 5 Hz. Human performance has thus been found to be affected the most when there is significant z-axis vibration at 5 Hz, and most laboratory investigations have studied the effects at this frequency. ISO 2631 states that vertical vibration levels of less than 0.315 m/s^2 rms are perceived as "not uncomfortable," while levels of greater than 2.0 m/s^2 rms are thought to be "extremely uncomfortable" (14). Vibration levels that are encountered in practice are often much higher than 2.0 m/s^2 rms (see for example, 23), which suggests that there are implications for adverse effects on human performance.

There are numerous review papers that discuss experiments on human performance in vibration, but to the author's knowledge, none have focussed on the effects on hearing and cognition. This review focuses on hearing and cognitive performance during exposure to whole-body vibration in the interest of communication and performance issues in armoured vehicles.

2. HUMAN PERFORMANCE IN VIBRATION

Experiments on human performance in vibration have historically sought to study the effects on physical, cognitive and sensory functions. The major themes of research in the 1960's and 1970's were tracking performance (manual control) and visual acuity in vibration. The results of such studies have been well-documented and summarized by a number of authors (4, 5, 7, 27), and will only be mentioned briefly in this paper. In the 1980's and 1990's, the attention turned towards the effects of combined stimuli (e.g. vibration in combination with noise and/or heat) on hearing and cognitive function. However, the effects of vibration on communication and complex cognitive task performance are still unclear. It is important to understand the effects of vibration on hearing and communication for the design and use of communication systems. Emphasis in this section will be placed on studies of hearing and cognition in vibration.

2.1 Visual Acuity and Manual Tracking Performance

In the past, the emphasis of human performance studies in vibration has been on visual acuity and manual tracking performance. Following a series of experiments that were performed from 1976 to 1985 (7), design guides for visual displays and manual tasks in vibration environments were written by Moseley and Griffin (21) and McLeod and Griffin (20).

When vibration is transmitted to the eye or the visual display, the result is usually a blurred image. In terms of reading performance, humans have been found to be sensitive to z-axis vibration between 5 and 11 Hz, and maximally sensitive to x-axis vibration at 5.6 Hz. Vibration in the y-axis does not have a significant effect on reading performance compared to the other two axes. Visual acuity is especially affected at viewing distances of less than 1.5 m. The use of collimated displays significantly improves visual resolution during vibration exposure (21).

For the purpose of discussing the effects of vibration on manual task performance, McLeod and Griffin described three types of tasks:

Type A: continuous, in which the subject controls their hand(s) freely in space;
Type B: continuous, in which the subject uses their hand(s) to operate a fixed controller;
Type C: discrete, in which a single operation is performed (such as pressing a button).

For simple Type A and B tasks, tracking error increases with vibration magnitude. In the case of Type B tasks, the use of arm supports may help to reduce the adverse effects of vibration. Little is known about the effects of vibration on Type C tasks. For z-axis vibration, disruption in task performance occurs for frequencies that are in the range of the body resonances, which occur between about 2 and 10 Hz. The greatest amount of manual task disruption has been found to occur between 4 and 6 Hz (3, 10, 11, 12, 28, 29). Body resonances in the x- and y-axes have been found to typically occur below 3 Hz (20).

2.2 Hearing

Since vibration is often accompanied by other stressors such as noise, heat or heavy physical activity, the effects of vibration on hearing are difficult to isolate. Studies on the effects of combined noise and vibration on hearing have been reviewed by Hamernik *et al*. (9). It has been suggested that whole-body and segmental (hand-arm) vibration tends to exacerbate low-frequency hearing loss in mining, forestry and lumber industry workers. However, the working environments that were studied are among the noisiest and most stressful of all industries. It is thus difficult to isolate the effects of vibration on hearing.

The effect of vibration on temporary hearing loss, or temporary threshold shift (TTS), was investigated in an experimental study performed by Okada *et al*. (22). Five male test subjects were seated on a vibrating table and exposed to 0.7 m/s^2 rms (2, 5 and 10 Hz), 3.5 m/s^2 rms (5, 10 and 20 Hz) and 7.1 m/s^2 rms (10 and 20 Hz) vertical vibration for a total of 60 min. The noise stimulus was recorded factory noise at 101 dB, and the subjects wore earplugs and earmuffs throughout the experiment. Hearing thresholds at 1 and 4 kHz were measured before the vibration exposure, after 20 min of exposure and at the conclusion of the experiment. When exposed to vibration alone, the greatest amount of TTS occurred for the 5 Hz vibration at 3.5 m/s^2, although it was considerably less than the TTS caused by noise exposure alone. When the 5 Hz vibration and noise were combined, the TTS was greater than with either stressor alone. The authors concluded that noise-induced hearing loss was aggravated by exposure to vibration.

Manninen studied TTS in men who were exposed to multiple stressors. The effects of both sinusoidal (5 Hz) and stochastic (bandwidth 2.8 to 11.2 Hz) vertical vibration on hearing were investigated in combination with noise and dynamic muscle work (18), and noise, heat and competition-type psychic load (19). The magnitude of vibration was 2.12 m/s^2 rms, and the noise stimulus was broadband noise of 90 dBA. Ninety subjects in the first study and 108 subjects in the second study were exposed to the stressors for 60 min. In both studies, the combination of noise and vibration was found to have an effect on TTS at 4 and 6 kHz. There were no clear differences in TTS when the subjects were exposed to sinusoidal versus stochastic vibration in the absence of other stressors. Seidel *et al*. (29) investigated mid- and high-frequency TTS (4, 6, 10 and 12 kHz) on subjects who were exposed to broadband noise of 92 dBA and 1.0 m/s^2 rms vertical vibration of 4 Hz. Six male test subjects were exposed to the stressors for a total of 90 min. The combined noise and vibration induced higher TTS at 4, 6 and 10 kHz compared to noise alone. The results of these studies support the conclusion made by Okada *et al.* (22) that vibration exacerbates noise-induced TTS at 4 kHz.

Voice communication was one of several performance measures studied by Grether *et al*. (6) during exposure to heat, noise and vibration. Ten test subjects were instructed to repeat a five-word phrase that was presented over a communication headset. The vibration test conditions were: 1) 5 Hz, 2.1 m/s^2 rms vertical vibration, 22^{o}C ambient temperature, 80 dB broadband noise and 2) 5 Hz, 2.1 m/s^2 rms vertical vibration, 48.9^{o}C ambient temperature, 105 dB broadband noise, for a duration of 35 min. Neither of the conditions had a significant effect on the percentage of words that were correctly repeated. However, since all of the hearing studies mentioned above found that vibration exacerbated noise-induced TTS at 4 kHz, which is known to be crucial to speech understanding (1), it is possible that prolonged exposure to vibration could impair communication. To the author's knowledge, there have been no long-duration studies of communication in vibration.

2.3 Cognitive Performance

In a 1971 review, Grether noted that little attention had been paid to the effects of vibration on intellectual functions (5). The studies that had been performed prior to Grether's review did not find any performance deterioration for reaction time, auditory and visual vigilance and pattern recognition during vibration exposure. Buckhout, for example, found that pattern recognition and reaction time were not affected by exposure to 5, 7 and 11 Hz vibration (2). In an experiment reported by Grether *et al*., subjects did not show any performance decrement on a mental arithmetic test while being exposed vertical vibration of 5 Hz (6).

Experiments that have been performed since Grether's 1971 review have used more complex cognitive tasks. Harris and Shoenberger studied the effects of combined noise and vibration on cognitive performance using a complex counting task (10). The task involved keeping a simultaneous count of the flashes of three lights that flashed at different frequencies. Twelve subjects were exposed to 65 or 100 dBA broadband noise and 3.5 m/s^2 rms vibration composed of 2.6, 4.1, 6.3, 10 and 16 Hz sinusoids. When exposed to noise alone, the subjects performed better in 65 dBA noise than 100 dBA; however, when exposed to both noise and vibration, the subjects performed better in 100 dBA noise. Overall, the subjects performed the best when exposed to 65 dBA noise alone, and the worst when exposed to combined 65 dBA noise and vibration. The results suggested that the effects of noise and vibration on cognitive performance are interactive, but not necessarily additive.

Sherwood and Griffin investigated the effects of exposure to 1.0, 1.6 and 2.5 m/s^2 vertical vibration of frequency 16 Hz on a short-term memory task (25). Measurements were made of reaction time, number of attention lapses and number of errors using 16 test subjects. Impairment of short-term memory resulting from vibration exposure was indicated by all of the evaluation parameters, especially for the 1.0 m/s^2 vibration. In a subsequent experiment, the same authors studied learning and recall for 16 Hz vibration at 2.0 m/s^2 (26). In the first session, the 40 test subjects were asked to learn the names of members of an imaginary team. A week later, the subjects performed the same task with the same names, to assess long-term memory and re-learning ability. The results of the first session showed that the static subjects performed consistently better than the vibrated subjects. After the second session, it was found that the subjects could recall information that was learnt in one environment (static or vibratory) equally as well in the other environment.

Following the 1990 study of Sherwood and Griffin (25), Ljungberg *et al*. studied short-term memory using the same vibration conditions with the addition of helicopter noise (17). For the memory test, a Sternberg paradigm was used, in which sets of 2, 4 or 6 letters were presented to the subject for 1, 2 or 3 seconds respectively. The letters were then removed, and a probe letter appeared after a pause of 1 second. The subject gave a "yes" response if the probe letter had appeared in the set that was just presented, or "no" if it had not. Memory performance was assessed by speed of response. The test subjects were exposed to one of three intensity conditions: low (77 dBA noise, 1.0 m/s^2 rms vibration), medium (81 dBA, 1.6 m/s^2 rms vibration) or high (86 dBA, 2.5 m/s^2 rms vibration). There were no significant differences in response times due to intensity.

It is difficult to generalize the results of the studies

Table I: Rankings of test performance for the Schipani *et al.*'s field study on cognitive test performance (23).

Test Name (type of task)	Performance among tests (difficulty)		Performance change within tests over time (endurance)	
	% correct (1 = highest, 6 = lowest)	Completion time (1 = fastest, 6 = slowest)	% correct (1 = smallest decrease, 6 largest decrease)	Completion time (1 = smallest increase, 6 = largest increase)
Selective attention (continuous recall)	1	1	4	2
Inductive reasoning (mathematical processing)	3	5	4	4
Time sharing (grammatical reasoning)	2	2	6	5
Memorization (Sternberg's memory task)	5	4	1	1
Spatial orientation (route planning)	6	6	3	3
Speed of closure (missing items)	4	3	2	6

mentioned above to a workplace environment. Military personnel are exposed to multiple stresses that are often complex in nature, and combinations of stresses can have different effects on cognitive performance. Performing experiments in the field rather than the laboratory might produce findings that are more meaningful. One such experiment was performed by Schipani *et al*. (23). A battery of cognitive tests was administered to subjects as they conducted a field exercise similar to a mobile command and control situation. Four tests were chosen from the Criterion Task Set (CTS) and two from the Complex Cognitive Assessment Battery (CCAB) (23). The cognitive concepts tested were (with the type of task in parentheses): selective attention (continuous recall), inductive reasoning (mathematical processing), time sharing (grammatical reasoning), memorization (using Sternberg's paradigm described above), spatial orientation (route planning) and speed of closure (missing items). The M113 tracked armoured personnel carrier (APC) used for the experiment was driven on off-road terrain at 0, 10 and 20 mph to produce different vibration levels. The approximate vertical vibration levels for the three vehicle speeds (quantified by the most dominant frequency) were 0.3 m/s^2 at 12.5 Hz, 6.4 m/s^2 at 4 Hz and 8.6 m/s^2 rms at 3 Hz, respectively. The tests were performed 8 times in contiguous 40-minute segments. The performance on each test in terms of accuracy and completion time is shown by rank in Table I.

The general finding of Schipani *et al*.'s study was that the combination of increased vibration levels and increased amount of time spent inside the vehicle (endurance) significantly impaired performance. Noise levels were also measured, but the effect on performance was found to be small compared to vibration and endurance. Comparing the results among tests (test difficulty), the subjects performed the spatial orientation (route planning) test the most slowly and with the least accuracy. The subjects achieved the highest percent correct and fastest completion times on the selective attention (continuous recall) test. Comparing the results across sessions (endurance), performance on the time sharing (grammatical reasoning) test suffered the greatest decrease in accuracy over time, and the speed of closure (missing items) test was the worst in terms of increased completion time. Performance on the memorization (Sternberg's memory task) was affected the least for both percent correct and completion time. Performance on all of the tests decreased significantly from the baseline when the vehicle was driven at 20 mph (highest vibration exposure). The results of these studies suggest that exposure to vibration alone does not affect the ability of humans to perform simple cognitive tasks. Impairment of cognitive performance appears to occur when 1) the task is complex, 2) vibration is combined with another stressor such as noise and 3) the vibration exposure is of long duration. The last two cases are important, because military vehicle operators are inevitably exposed to multiple stressors while on duty, and are sometimes required to drive for more than 12 hours at a time. Vibration-induced fatigue may be a factor in the decrement of cognitive performance over time.

3. DISCUSSION

Armoured vehicles are designed to be well-protected, durable and functional in adverse environmental conditions. This leaves little to no room for human factors engineering. As a result, whole-body vibration in armoured vehicles is different from the vibration that is experienced in other occupations such as truck drivers, construction workers and pilots. Passenger seatbelts are not always available or used when they are available. Lack of constraints causes the upper body movement of the passengers to be unpredictable and difficult to quantify, because both translational and rotational vibration in a moving coordinate system are occurring. There is also the issue of the crew commander, who often stands on

Table II: Exposure to vibration and repeated shock requiring attendance of a physician or medical doctor from ISO 13090-1 (18).

Duration of exposure in any one 24 h period	16 min	1 h	4 h	8 h
Acceleration magnitude, m/s^2 (frequency-weighted r.m.s. acceleration	2.2	1.6	1.1	0.9

the seat with their upper body exposed through the hatch. In this case, the vibration exposure is affected by bended knees and any contact of the upper body with the frame of the hatch. The adverse effects of the vibration exposure are further exacerbated by fumes, exposure to extreme temperatures, and, in the case of the passengers in the back of the vehicle, lack of an external field of view. These additional factors can contribute to disorientation, fatigue, nausea and dizziness.

The complex environment inside armoured vehicles makes it very difficult to replicate similar conditions in the laboratory. The International standard for experiments involving human exposure to vibration and shock (ISO 13090-1:1998 [16]) does not impose exposure limits, but gives limits for which the experiments can be performed without the presence of a physician or medical doctor; these are listed in Table II. Given these guidelines, experiments performed in the past in which subjects were exposed to high levels of vibration (22), or moderate levels of vibration for very long time periods (11, 13), would likely not be approved by an ethics committee today. As shown by Schipani *et al*. (23), the actual vibration levels in a vehicle can be very high (e.g. 8.6 m/s^2 at 3 Hz for the M113 travelling at 20 mph), making it impossible to expose test subjects to similar conditions in the laboratory. It may only be possible to study the effects of vibration in the field. However, in the field it would be difficult to isolate the effects of vibration from the effects of other stressors such as noise and heat.

There have been few studies on the effects of vibration exposure on communication. Previous research on the combined effects of noise and vibration on hearing have shown that vibration increased the amount of noise-induced TTS at the 4, 6 and 10 kHz octave bands (18, 19, 22, 24). Since the 4 kHz octave band is known to be crucial to speech understanding (1), this could have implications for speech intelligibility, and thus the use of communication systems. Helmet mounted systems used in military vehicles should be tested for combined exposure to noise and vibration for long durations, to assess any decline in speech intelligibility over time. The combination of the communication system with different types of hearing protection (ANR headsets, earplugs, etc.) should be considered, and both normal hearing and hearing impaired individuals should be tested.

While a number of studies have been done on cognitive task performance in vibration, the effects remain unclear. With the exception of the study by Schipani *et al*. (23), it seems that little attention has been paid to the effects of vibration on complex cognitive functions. Some problems with previous experiments that led to equivocal results were the variety of tasks used, differences in the mindset of the test subjects and inconsistent methods of evaluating cognitive performance. The use of defined tasks for performance evaluation of specific cognitive functions, such as the CTS and CCAB test batteries used by Schipani *et al*. (23), can help to reduce ambiguity. The test subjects should be encouraged to perform to the best of their abilities throughout the test sessions in order to eliminate lack of motivation or boredom as causes of performance degradation. Previous experiments have used one or both of accuracy and reaction or completion time as evaluation methods for cognitive tasks. Since performance on a given task can differ depending on which evaluation method is used, a combined result of the two measures might give an idea of the overall performance on the task.

4. CONCLUSION

It has been well-established that exposure to whole-body vibration has adverse effects on visual acuity and manual task performance. Design guides for visual displays and manual tasks in vibration environments have been written by Moseley and Griffin (21) and McLeod and Griffin (20). Although studies have been performed on whole-body vibration and hearing, the effects of vibration exposure on communication have not been investigated extensively. Since studies have indicated that vibration exposure may contribute to hearing loss when combined with noise, vibration effects should be considered in the design and evaluation of communication systems in vehicles and aircraft. For evaluating cognitive performance in vibration environments, well-defined cognitive tests should be used (i.e. from standardized test batteries), to avoid ambiguities in the interpretation of the results. Since is it difficult to produce realistic vibration stimuli in the laboratory, and acceptable vibration exposure levels for human subjects are much lower than what is encountered in practice, future human vibration experiments might have to be performed in the field. While they are less controlled, field experiments would likely give a more realistic evaluation of human performance in vibration environments.

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NOISE EXPOSURE GROUP SURVEYS - NUMBER OF DAYS TO SAMPLE

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ABSTRACT

A study to determine the number of noise exposure measurements days required to be performed on a group of workers, so as to obtain reliable results was conducted. In all 13 groups from two different sites were involved, with sample sizes ranging from 3 to 24 employees (average 12.5). Surveys were performed for four consecutive days. The reports from the surveys included the results from each one of the four days of testing ($L_{Trade,8}$) and of the corresponding $L_{Trade,32}$. The daily $L_{Trade,8}$ were compared with the corresponding $L_{Trade,32}$ using the Student's t-Test. Results show that for the samples being tested, there were no significant differences in 88.5% of the cases. It was concluded that one day of testing is probably sufficient. However, because of the difficulty in determining a "typical" day, it is recommended that testing be performed for two days.

SOMMAIRE

Cette étude a été conduite afin de determiner combien de jours sont nécessaires pour obtenir des résultats fiables lors de la mesure à l'exposition au bruit d'un groupe de travailleurs. En tout, 13 groupes provenant de deux différents sites ont été étudiés. L'échantillonnage variait entre trois et 24 employés avec une moyenne de 12.5 employés. On a mesuré l'exposition au bruit pendant quatre jours consécutifs. Le rapport inclus les résultats quotidiens obtenus ($L_{Trade,8}$) et le $L_{Trade,32}$ correspondant, en utilisant le Student's t-Test. Les résultats obtenus avec l'échantillonnage testé ont démontré qu'il n'existait pas de différences significatives dans 88,5% des cas. On a donc conclu qu'une journée de test est suffisant. Par contre, puisqu'il est difficile d'identifier une « journée-type », il est recommandé d'effectuer des mesures pendant deux jours.

1. INTRODUCTION

The CSA Z107.56-94 Standard: "Procedures for the Measurement of Occupational Noise Exposure" (1) provides all the information needed for measuring and calculating the occupational noise exposure level $L_{eq,T}$ of employees exposed to potentially harmful noise levels. A new edition of the standard was to have been released in 2004. From the $L_{eq,T}$ the normalized $L_{Ex,T}$ can also be calculated. The main body of the Standard deals with testing on individuals. However, there are situations, where many employees work in the same acoustical environment and the measurement of each individual's noise exposure may not be economical, or feasible. In such cases, recourse may be made to determining the exposure of employees in a group.

A group is defined as employees who work in similar acoustical environments and are assumed to experience similar noise exposures. The number of employees to be tested (sample size, **n**) depends on the total number of employees in the group (population size, **N**), the standard deviation of the measurement results and on the desired precision of the results.

Appendix B "Noise Exposure of Groups" provides procedures to be followed to determine L_{Trade}, the arithmetic noise exposure level of the group, for the prescribed time period T. The procedure of Appendix B allow for determination of whether the group is over-exposed or not, using the results of daily noise exposures $L_{Ex,T}$. An individual is defined as overexposed when his $L_{Ex,8} > 85$ dBA. The calculation is done taking into account the required precision.

Specifically, the following is determined:

a) sample size, for a given precision
b) $L_{Trade,}$ and
c) Precision of the calculated L_{Trade}

Five tables in the Appendix B of the Standard show the sample number **n** for a given situation. For example, for a precision of +/- 2, a standard deviation of 8 and a population of 50, the number of employees to be tested will be 24. For the same **N** = 50, a precision of +/- 6 and a standard deviation of 2, this number (**n**) drops to only 3.

No specification on the required number of samples for each individual (for how many days should he be tested) are contained in the Standard, nor for how long (how many hours) the samples should be taken.

This paper describes a study performed in the former Ontario Hydro several years ago. It was designed to determine the required number of days the noise exposures should be tested, so as to obtain reliable results. Noise exposure surveys were performed for a week, (5 consecutive days), for a whole-shift noise exposure (L_{eq40}). Later on, a study was done to find if L_{eq32} (4 days average) survey is as representative as the

L_{eq40}. For that purpose, the Student t-test was applied to L_{eq40} and L_{eq32} calculated from results from several noise exposure surveys. No statistically significant differences were found between both results. Consequently, it was decided that surveys should be performed for four consecutive days and the resulting L_{eq32} should be used to calculate the L_{Trade}.

After several years of practice, a question was raised, if one-day exposure (L_{eq8}) could be used for the same purpose. If that proved to be true, the length and the cost of a noise exposure survey would be greatly reduced. To test this hypothesis, results from several noise exposure surveys were analyzed. This paper presents the results and conclusions from the study.

2. MATERIALS AND METHOD

Results from two noise exposure surveys were used for this study. They were performed at a large construction site (during the construction of Darlington Nuclear Generation Plant) and at an existing large nuclear plant (Bruce "A"). All together, 13 groups were involved, with sample sizes ranging from 3 to 24 employees (average 12.5). Surveys were performed for 4 consecutive days. The reports from the surveys included the results from each one of the 4 days (the $L_{Trade,8}$) of testing and of the corresponding $L_{Trade,32}$.

The L_{Trade} for each of the four days was calculated, as the average of the L_{eq8} of the members of the sample population. Therefore, there were four L_{Trade} calculated one for each day and one $L_{Trade,\ 32}$ calculated over the four days. All L_{Trade} were calculated at the 95 Upper Confidence Level.

The method used here, consisted of testing the significance of differences between the $L_{Trade,\ 32}$ (L_{Trade} calculated over the four days) with each of the four the L_{Trade}'8 (L_{Trade} calculated from only one day) for each trade. The significance was tested using the Students t-test.

If the outcome of the study showed that the differences were statistically not significant, then one-day testing will be equivalent to that of a complete week and the four-days testing will be replaced by only one-day of testing.

3. RESULTS

Tables 1 and 2 (Darlington and Bruce "A", respectively) contain details from the surveyed groups as well of the results.

The first column in each table lists the names of the groups (trades) being tested. The next contains the sample sizes of the group that was tested during each of the four days.

Following are the results for each of the four days of

TABLE 1
RESULTS FROM DARLINGTON NGS CONSTRUCTION

TRADE	NUMBER TESTED		DAY1	DAY 2	DAY 3	DAY 4	4-DAY AVERAGE
Electrician	14	LTrade	87.0	86.8	86.4	84.4	88.2
		Std Dev	7.9	4.2	7.8	4.7	6.3
		UCL95%	90.8	88.8	90.4	87.2	91.1
		Signif	N	N	N	N	
Boiler-makers	14	LTrade	90.0	88.5	88.1	88.5	89.9
		Std Dev	5.9	5.0	7.3	6.6	6.0
		UCL95%	92.9	91.1	91.7	91.7	92.6
		Signif	N	N	N	N	
Painters	14	LTrade	91.3	90.2	90.8	92.6	91.9
		Std Dev	7.0	9.9	6.3	7.6	7.3
		UCL95%	95.0	95.9	89.7	91.9	94.9
		Signif	N	N	N	N	
Pipefitters	13	LTrade	91.3	90.2	90.2	92.6	91.9
		Std Dev	3.8	5.2	4.5	4.2	3.6
		UCL95%	93.1	92.9	93.0	94.7	93.6
		Signif	N	N	N	N	
Mech.Instrum.	14	LTrade	83.4	86.0	86.5	86.4	86.7
		Std Dev	2.7	3.3	3.2	4.2	1.9
		UCL95%	84.7	87.6	88.0	88.4	87.7
		Signif	Y	N	N	N	
Pre Fab Shop	5	LTrade	90.1	89.3	88.6	89.0	89.4
		Std Dev	4.8	3.7	2.9	2.5	3.3
		UCL95%	92.9	89.3	88.6	89.0	89.4
		Signif	N	N	N	N	

TABLE 2
RESULTS FROM BRUCE NGS-A

TRADE	NUMBER TESTED		DAY1	DAY 2	DAY 3	DAY 4	4-DAY AVERAGE
Control Maintenance	20	LTrade	83.2	83.1	83.2	80.6	84.2
		Std Dev	6.8	5.1	5.8	5.1	4.8
		UCL95%	85.7	85.1	85.4	82.4	86.0
		Signif	N	N	N	Y	
Mechanical Maintenance	24	LTrade	86.7	88.5	87.2	89.4	89.0
		Std Dev	4.8	5.1	3.8	5.4	4.1
		UCL95%	88.2	90.1	88.4	91.6	90.4
		Signif	N	N	N	N	
Building Mechanics	8	LTrade	85.6	87.9	87.4	89.5	87.9
		Std Dev	4.6	2.8	4.2	5.9	3.2
		UCL95%	87.6	89.1	89.5	95.4	90.0
		Signif	N	N	N	Y	
Service Maintenance	6	LTrade	88.1	89.1	86.3	88.0	88.5
		Std Dev	4.8	6.0	2.6	4.3	4.4
		UCL95%	90.5	92.1	87.6	90.8	92.1
		Signif	N	N	N	N	
Chemical Technician	3	LTrade	86.3	82.0	84.1	86.4	86.5
		Std Dev	5.1	1.7	9.4	2.6	1.3
		UCL95%	86.3	82.0	84.1	86.5	87.7
		Signif	Y	Y	N	N	
Assistant Operator and 2nd Operator	14	LTrade	85.8	84.9	87.3	88.5	88.6
		Std Dev	8.2	6.8	5.8	4.5	4.3
		UCL95%	89.6	88.1	90.1	90.6	90.6
		Signif	N	N	N	N	
Handyperson	14	LTrade	86.4	85.4	85.9	84.1	87.0
		Std Dev	2.9	3.5	8.6	3.3	6.5
		UCL95%	87.6	86.9	89.5	85.8	90.1
		Signif	N	N	N	Y	

testing (DAY 1, 2, 3, 4) and for the 4 days average. For each trade, the tables shows the calculated $L_{Trade,8}$, the Standard Deviation ("Std Dev"), the 95% Upper Confidence Level of L_{Trade} ("UCL95") and the result from the Students t-Test ("Signif") as "Y" (yes) or "N" (not). All data were calculated using all $L_{eq,8}$ for each one of the 4 days of testing. The $L_{Trade,32}$ (4-DAY AVERAGE) was obtained as the arithmetic average of the four $L_{Trade,8}$. The significance of the difference between a given $L_{Trade,8}$ and the $L_{trade,32\ as}$ was tested using the UCL95 of the corresponding $L_{Trade.}$

4. DISCUSSION

Using a limited measurement time duration (one day or one week) to assess yearly exposures level implies the following assumptions:

a) Noise levels workers are exposed to are more or less steady, and
b) They do not change significantly over the year.

This, of course, is an assumption very difficult to prove. However, on the other hand, to prove it one way or other is a very costly and practically impossible task to be performed. Consequently, a successful noise exposure survey requires a great deal of common sense and knowledge of the tasks performed by the workers, provided in general by workers supervisors. In essence, surveys should be performed in representative working conditions. This may require more than one day of testing, to assure that the day was really "typical."

One limiting factor in this study is that it was performed for trades from only two activities: electrical generation and construction. A follow-up study using different workgroups will be extremely useful to confirm or reject the hypothesis.

Results from Darlington indicate that with one exception (Mechanical Instrumentation, Day 1) there is no statistically significant difference between L_{Trade} calculated using daily and weekly averages. (Rate of success 96%).

This was not the case in Bruce "A", where the rate of success was 86%, with statistically significant differences in the case of Control Maintenance, Day 4; Building Mechanics, Day 4; Chemical Technician, Day 2; and Handyperson, Day 4). No satisfactory explanation was found for the above discrepancies.

5. CONCLUSIONS

No statistically significant differences were found between L_{Trade} calculated using one day and four days calculations in 96 % of the cases in Darlington and 86 % in Bruce "A". Therefore, it appears that there is no additional benefit in testing for 4 days, instead of one.

However, testing for two days, may allow for a control of how representative a "typical" day is, especially, when the survey is done on a trade that has not been previously tested.

ACKNOWLEDGMENTS

Critical examination of the manuscript by Stuart Eaton, WCB, BC and Tim Kelsall, Hatch Associates, is greatly appreciated.

REFERENCES:

1) CSA Z107.56-94 Standard: "Procedures for the Measurement of Occupational Noise Exposure", Canadian Standard Association, 1994.

Place Eckel AD Here

Discrete-time Speech Signal Processing: Principles and Practice
By Thomas F. Quatieri
Pearson Prentice Hall Inc.,2001.
xix + 781 pp. Price: US$100 (hardcover) ISBN: 0-13-242942-X

Speech signal processing is a very active research area with topics such as speech coding, speech and speaker recognition, speech enhancement, and speech synthesis continue to be "hot". There are surprisingly few books on the topic of speech signal processing and the book by Dr. Quatieri is a refreshing addition to the speech signal processing book club.

Quatieri, a senior staff member at the Lincoln Laboratories, an affiliate of M.I.T, has extensive experience in speech signal processing as evidenced by numerous publications in reputed journals and conferences. This textbook is an outgrowth of the lecture notes used for Quatieri's MIT graduate course. It has already been adapted as the main textbook for graduate-level speech signal processing courses at several other U.S., Canadian and international universities – an indication of its excellent readability and coverage of speech signal processing topics.

The book contains fourteen chapters in total. It begins with an Introduction chapter that briefly summarizes the speech communication pathway and the applications of speech analysis/synthesis techniques. It also provides the outline of the textbook and lists relevant textbooks and journal articles.

Chapter 2 presents an easy-to-read review of the digital signal processing fundamentals that are relevant to speech signal processing. Concepts related to sampling, linear time-invariant discrete-time systems, discrete Fourier transform, and Z transform are discussed, although not in too greater a detail.

Chapter 3 provides an excellent description of the anatomy and physiology of speech production. It introduces the concepts behind spectrographic analysis of speech – an important tool in any speech signal processing application. The chapter then details the various categories of speech sounds (vowels, fricatives, plosives etc), providing waveform and spectrographic examples of each sound token. The chapter concludes with a brief discussion of prosody in speech and an even briefer discussion of the aspects of speech perception.

Chapter 4 concentrates on speech acoustics. Starting with the wave equation, this chapter delves into acoustic models of speech production. Topics discussed in this chapter include the uniform tube model of speech production (both lossless and lossy cases), the concatenated tube model, and the interactions between vocal folds and vocal tract.

Chapter 5 describes the transfer function approach to modeling speech production. Linear prediction modeling is discussed in detail along with the covariance and autocorrelation methods of computing the linear prediction coefficients. The chapter also provides details on pole-zero modeling and pitch-synchronous estimation of linear prediction parameters – a topic that is not usually covered in other speech signal processing textbooks.

Chapter 6 is dedicated to homomorphic signal processing techniques applied to speech analysis/synthesis. The chapter includes an in-depth treatment of homomorphic filtering and cepstral analysis/synthesis techniques. The theory presented in this chapter is backed by examples, which allows the reader to build the basis for understanding cepstrum-based speech processing techniques such as the computation of mel-frequency cepstral coefficients (main features used in speech and speaker recognition), and cepstral mean subtraction and RASTA processing for speech enhancement.

Chapters 7 and 8 detail the application of short-time Fourier transform (STFT) techniques to speech analysis/synthesis applications. Alternative representation of the STFT as a filter bank is presented very well here, together with several examples. Pertinent topics such as overlap-add synthesis, phase vocoder, constant Q filter banks and wavelets, and aspects of auditory modeling are discussed in enough detail.

Chapter 9 is the longest chapter in the textbook and deservedly so. This chapter provides an excellent presentation of the sinusoidal analysis/synthesis technique pioneered by the author. It provides an in-depth theoretical treatment of sinusoidal modeling backed up by practical examples.

Chapter 10 describes several methods of pitch estimation from speech waveforms. In addition to traditional methods such as correlation-based pitch estimators, this chapter provides more details on pitch estimation based on sinewave modeling. In addition, topics such as glottal pulse onset estimation and multi-band pitch and voicing estimation are covered in adequate detail.

Chapter 11 deals with a topic that is rarely discussed in speech signal processing textbooks – nonlinear processing of speech. This chapter begins with a discussion on the need for nonlinear speech signal processing tools. Details are then provided on bilinear time-frequency analysis, nonlinear aeroacoustic modeling, and the application of Teager energy operator to speech signal processing.

Chapters 12 to 14 are concerned with the applications of speech signal processing techniques. Chapter 12 is dedicated to speech coding where techniques from scalar and vector quantization to linear prediction based coding are discussed in adequate detail. Chapter 13 presents various speech enhancement techniques including Wiener filtering, spectral subtraction, enhancement based on auditory modeling, and time-frequency temporal processing. It is probably worthwhile to note that the chapter covers only single-microphone noise reduction algorithms and does not deal with dual or multi-microphone speech enhancement. Chapter 14 outlines several speaker recognition algorithms. The chapter includes a solid discussion of the features required for speaker recognition (mel-cepstrum, sub-cepstrum) along with different classification paradigms (minimum distance classifier, Gaussian mixture model classifier etc). Effects of linear and nonlinear channel distortions on speaker identification are also discussed.

In summary, this is a well written and well organized text book on speech signal processing. It provides comprehensive coverage of several signal processing techniques and their use in a variety of speech applications. As noted by the author in the preface, the book does not cover the topic of speech recognition. In addition, objective methods for assessing speech quality – which are very useful in speech coding and speech enhancement applications – are not discussed. In addition, it would have been nice if details of formant frequency and bandwidth estimation methods are included, either as an extension to an existing chapter or as a separate chapter.

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Introduction to Acoustics
By Robert D. Finch, Pages 653
Pearson Prentice Hall Inc. 2004
ISBN 0-02-337570-1, US$122.00

As someone whose acoustic learning has been grounded in three memorable textbooks by Morse, Morse and Ingard, and Kinsler and Frey, I always compare other books against those benchmarks. I have added Alan Pierce's and L.L. Beranek's books to the above collection. However, one is always on the lookout for new books with current materials such as active noise control, sound quality, etc. That is why my attention perked up when I received a copy of the book by Prof. Robert Finch. It is a large tome with 17 diverse topics.

The seventeen chapters of the book are: 1) Vibration; 2) Linear Systems; 3) Waves in Fluids; 4) Pipes and Horns; 5) Audio Frequency Generators; 6) Sensors: Microphones and Accelerometers; 7) Piezoelectric Transducers; 8) Instrumentation and Signal Processing; 9) Basic Acoustic Measurements; 10) Plane Waves in Large Enclosures; 11) Series Solutions and Scattering; 12) Vibration of Structural Elements; 13) Propagation in Solids; 14) Damping, Attenuation and Absorption; 15) Non-linear Acoustics; 16) Noise Control and 17) Acoustic Systems. The book also includes 11 appendices and a copious index.

How can one review such a diverse book? There is an old Sanskrit adage: Enumerate all the good things first before embarking on the negative critical comments. This book's main usefulness is in the compilation of basic formulations of diverse acoustical topics such as waves in fluids, sound sources, signal processing etc. There you have it. That is all the good one can say about this book.

The main drawback of this book is the chaotic way it is organized from sub-section to sub-section and from chapter to chapter. If this book was supposed to have been a collection of lecture notes, one would have some sympathy. But, even a set of course notes would have wonderful organization behind it.

One must explain the reasons for a quick dismissal of a 653-page-long textbook. The following thought processes must stand out in any new offering to be considered valid: it must have new material or some new ways of presenting old material; clear and concise progression from beginning to end; and satisfy the aims of the new offering as professed in the preface. The textbook by Prof. Finch fails on all counts.

One cannot explain the ideas and thoughts that went into the chapter organization of this book. It needs substantive editing. The sub-sections of Chapter 1 (vibrations) are: phasors; single degree of freedom oscillators; forced oscillation; two degree of freedom oscillators; multi-degree of freedom systems; vibration of a one-dimensional continuum waves. Chapter 2 jumps to Linear Systems with following sub-sections: Fourier analysis; complex form of Fourier series; Fourier integral theorem; pulses and wavetrains; phase and group velocity; Laplace transform; simple results with Laplace transforms; transients; Use of Lapalce transform; stability; linear electro-mechanical transducer. Each chapter ends with references and problems. One cannot fathom the reasons why transform techniques would be needed at such an early stage of an introductory text book. The same chaos permeates throughout the book and seems to infect even each sub-section of a single chapter. One cannot but wonder why the last section of Chapter 2, where a student was introduced to transform techniques, would talk about transducers, when he is yet to be told about instrumentations.

Prof. Finch's book does not contain any new material. All of the material can be obtained from earlier textbooks, published during the last 40 years. Prof. Finch, in his Preface, claims that this book could be useful to practicing engineers as a reference. This is highly unlikely since practicing acousticians would find this book too esoteric to be useful. A case in point. Chapter 16 titled, "Noise Control." It begins with a 15-page description of the ear and the human voice. Cursory information is given about noise control methods. Section 16.8 talks about treatment at source and provides a solitary example of a reactive muffler. How can one consider attaching a muffler to a duct system as treatment at source? Even though dissipative muffler is mentioned in passing, no details are forthcoming. Finally, there are no worked examples in any of the chapters to assist the students.

If one wants a compilation of diverse topics under one broad canvas, this the book to peruse. As a textbook on introductory acoustics, it has no value.

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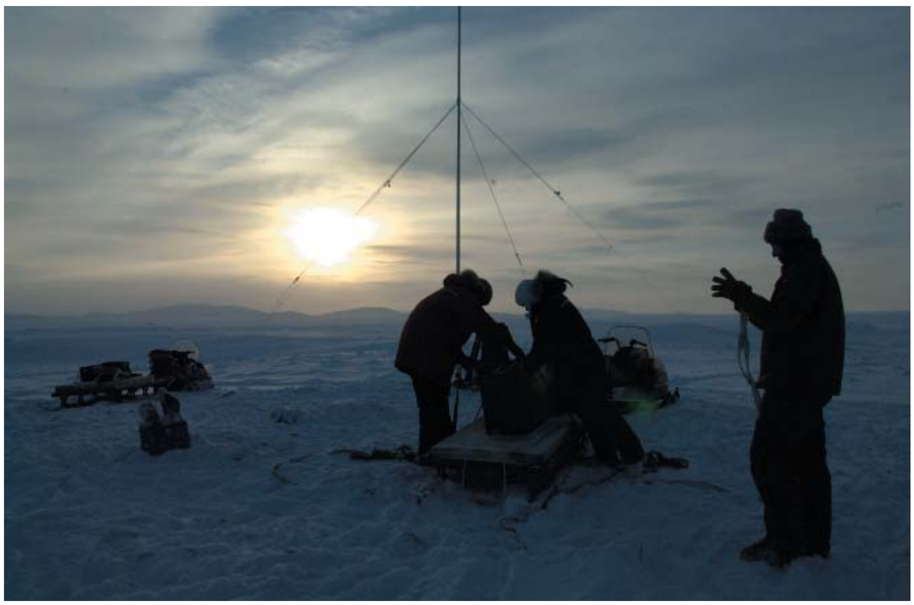
CANADIAN NEWS..../NOUVELLES CANADIENNES....

Acoustics in Canada

Gilles Daigle - National Research Council, **Stan Dosso** - University of Vicoria,
Garry Heard - Defence R&D Canada Atlantic, **Murray Hodgson** - University of British Columba,
Tim Kelsall - Hatch Associates, **Douglas O'Shaughnessy** - Institute National de la Researche Scientifique,
and **Kathy Pichora-Fuller** - University of Toronto

Editor's Note: *The above article, by Daigle et. al., orginally appeared in the Spring 2005 issue of Echoes (The newsletter of the Acoustical Society of America) and is reproduced here with permission.*



DRDC personnel establish a radio repeater on a hilltop on northern Ellesmere Island

Writing about acoustics in Canada is not unlike writing about acoustics in the US - every technical area of acoustics is covered except that there are a lot less people doing it. With the exception of a few larger university groups and government labs, research is usually conducted by isolated individuals scattered from coast to coast. It is not possible to provide a comprehensive summary of acoustics research in Canada and no attempt has been made. Instead we have attempted to provide a cross-section highlighting our diversity in acoustics applications, geography, and institution type and size.

Research in Underwater Acoustics is found both on the Atlantic and Pacific coast. As an agency of the Department of National Defence, DRDC's mission is to ensure that the Canadian Forces are technologically prepared and operationally relevant. Since the formation of the organization sixty years ago, underwater acoustics has been a major component of the DRDC applied research program. Considerable successes have been achieved that have addressed every term in the sonar equation, the boundaries of the acoustic wave-guide, transducers, noise generation, and the physical properties of the ocean environment from Tasmania to the Arctic.

Current research in underwater acoustics includes inversion problems and associated global optimization techniques. Modeling methods for propagation, reverberation, and systems are being developed. New transducers and applications for existing transducers are an on-going field of expertise. Underwater communications is a relatively new field of effort that is experiencing growth. Sonar signal processing including tracking, data fusion, and the man-machine interface, provides support to a large number of projects. All of these activities and many others are combined to support large demonstration projects such as the Towed Integrated Active Passive towed-array system, the Rapidly Deployable Systems autonomous surveillance project, the airborne IMPACT processor, and the Remote Mine-hunting System.

In addition to underwater acoustics research conducted in-house, DRDC funds significant effort in Industry and Universities. DRDC and NSERC (Natural Sciences and Engineering Research Council) were the primary sponsors of the Ocean Acoustics Chair Program established at the School of Earth and Ocean Sciences at the University of Victoria in 1995. NSERC, Satlantic Inc., and DRDC sponsored the Dalhousie University Chair in Acoustics in 1998. Collectively, these research chairs include effort in high-frequency sediment acoustics and bottom classification, hydrodynamic measurements, marine mammal tracking, gas hydrate deposits, matched field inversion, geoacoustic inversion, array element localization, and Arctic ice geoacoustics. International collaborative activities with the USA, United Kingdom, Australia, New Zealand, and NATO countries also broaden the extent of the acoustics research.

In 1929 the first Director of the Division of Applied Physics of the National Research Council (NRC) brought with him a strong interest in ultrasonics thereby opening a line of research activity in the field of acoustics that has grown in scope and breadth ever since. Currently, research in acoustics is active within six NRC Institutes.

The NRC Industrial Materials Institute is developing forefront laser ultrasonic technology for probing materials and structures remotely without contact. This novel technology is based on the use of lasers for the generation and detection of ultrasound and can be used to measure thicknesses, detect and image surface or bulk flaws in complex structures, and characterize material microstructure in service or during processing. Applications that have been transitioned to industry include in particular the on-line measurement of the wall thickness of tubes at high temperature (> 1000 degrees C) and the detection of delaminations in polymer-matrix composites used in aerospace. The Institute has also developed ultrasonic buffer rods without reverberation echoes for sensing at elevated temperature with PZT transducers. It is also developing transducers made by a sol-gel process that can be painted on parts or structures for permanent ultrasonic sensing.

The NRC Institute for Microstructural Sciences investigates the acoustical factors affecting the performance of communication systems such as wireless handsets, portable e-mail devices, automatic speech recognition systems, handsfree telephony, and systems meant to assist individuals with hearing impairments. Microphone array technology, directional microphones and loudspeakers, and signal processing strategies are currently being studied. In addition, the Group also maintains specialized acoustical facilities.

The NRC Institute for National Measurement Standards maintains primary acoustical standards, performs calibrations, provides technical consultation and laboratory certification, and maintains and periodically upgrades calibration facilities. Primary calibration of microphones, accelerometers and ultrasound power are disseminated to regulatory agencies, government departments, and the industry, trade, and health sciences sectors.

The NRC Institute for Research in Construction carries out acoustics research projects as part of the Indoor Environment Program. Current research areas include sound insulation of wall and floor assemblies, flanking transmission in framed buildings, and acoustics of indoor spaces (especially classrooms, open-plan offices and auditoriums). Facilities are available for measurements of airborne sound transmission loss of walls, windows, doors, etc., airborne and impact sound transmission through floor assemblies, and to study the effects of structureborne transmission via wall/floor connections on flanking transmission.

The NRC Institute for Aerospace Research (IAR) conducts research in aeroacoustics and structural dynamics for a broad range of aerospace applications. Activities in active noise control are focused on noise reduction in aircraft. IAR's expertise in the active control of flexible structures comprises closed-loop control using classical, optimal, and adaptive control algorithms. IAR has a specialized high-intensity noise testing facility, with two reverberant chambers and a progressive wave tube.

The NRC Institute for Information Technology deals with several aspects of language technology, including development of a Speech Extractor, capable of extracting key phrases from spoken documents of variable audio quality.

Speech research is active at several institutions in eastern Canada. Perhaps most active is the Montréal region, where INRS-EMT (Université du Quebec), ETS (Ecole de Technologie Supérieure) and CRIM (Centre de Recherche en Informatique de Montréal) all have researchers working on automatic speech recognition (ASR), partly in collaboration with industry, e.g., ScanSoft. Projects include medium and large vocabulary voice dictation, keyword detection, text alignment, Text-To-Speech, and Speaker Verification. Also in Québec, the Université de Sherbrooke, where much of the algorithms driving today's cellphone technology were developed, has research in auditory signal processing and computational neuroscience.

There are also several centers in Ontario active in speech. Queen's University has a collaborative project with ATR Human Information Processing Research Laboratories (Kyoto, Japan) for an X-Ray Film Database to preserve archival cineradiographic vocal tract footage. The University of Toronto's Artificial Perception Lab works on Microphone Arrays for Robust Speech Localization, Enhancement, and Recognition. SITE (School of Information Technology and Engineering - University of Ottawa) has research activities on speech enhancement, auditory processing, speaker verification, speech recognition, wideband speech coding, speech packet loss concealment, and voice activity detection. The University of Western Ontario is active in speech areas, including neuroimaging studies focusing on uncovering the neural substrates of basic speech processing in humans.

A new Language Technologies Research Centre is a partnership between NRC-IIT, Université du Québec en Outaouais, Translation Bureau of Canada and the Language Industry Association (AILIA). In Alberta work is focused on a pattern-recognition approach to phonetic and phonological effects in speech recognition.

At the University of British Columbia (UBC) in Vancouver, research activity is concentrated in the Acoustics and Noise Research Group in the School of Occupational and Environmental Hygiene (SOEH) and in the Department of Mechanical Engineering. This work focuses on architectural, industrial and environmental acoustics and noise control. Current activities include: development and validation of room prediction models by ray/beam-tracing, radiosity, empirical and other approaches; investigation of noise problems in schools, effect of renovation on the acoustical quality of university classrooms, prevalence, nature and risk factors for teacher voice problems, measurement of the acoustical properties of classroom surfaces, development of the ClassTalk system for predicting, visualizing and auralizing speech in noise in classrooms; propagation of low-frequency noise in workrooms, its prediction and active control; empirical prediction of workroom fitting densities, development of the PlantNoise system for predicting, visualizing and auralizing industrial noise; characterization of aircraft run-up noise radiation, active control of propeller aircraft run-up noise, effect of realistic meteorological conditions and grounds on active control; acoustics of eating establishments and their optimal acoustical design. In SOEH, there is also research on the non-auditory effects of industrial noise and the effectiveness of hearing-conservation programs. In the Institute for Hearing Accessibility Research (IHEAR) inter-disciplinary research is conducted to improve access of normal and hard of hearing people to acoustical environments. Activities in other UBC departments include modeling the human vocal-tract, in Electrical Engineering, and stringed instrument acoustics, in Physics.

DRDC personnel Garry Heard, Gordon Ebbeson, and Lloyd Gallop record data in a tent on the ice of the Lincoln Sea while Stan Dosso of UVic watches.

Moving eastward, the Groupe d'Acoustique de l'Université de Sherbrooke probably has the most sizeable effort in noise and vibration control. The areas of research include the characterization and design of materials, vibroacoustic design, active control, experimental methods, numerical simulations, and transducers.

Canadian research in Psychological Acoustics has been conducted in labs at universities and hospitals, as well as by researchers working in industry (e.g., Bell Northern Research and later Nortel in Ottawa) and in government facilities (e.g., Defence Research & Development Canada in Toronto). On the west coast, at the University of British Columbia, in the School of Audiology and Speech Sciences, early research was conducted on cochlear mechanics related to critical bandwidth and combination tones, and in the Department of Psychology auditory attention bandwidth was measured. On the east coast, seminal research at Dalhousie University in Halifax has helped scientists and clinicians alike to understand central auditory processes by differentiating types of auditory temporal processing. Between the discoveries about auditory spectral coding on the west coast, and the discoveries about auditory temporal coding on the east coast, psychoacoustic researchers in central Canada have been busy over the last couple of decades trying to understand the spectro-temporal complexities of real-world hearing. At McGill University in Montreal pioneering research launched "auditory scene analysis". At Toronto's Mount Sinai Hospital psychoacoustics has been used to study noise-induced hearing loss. Psychoacoustics research applied to hearing loss has also been advanced by researchers at the University of Western Ontario, at the University of Ottawa, and at the Université de Montréal. Researchers in the Department of Psychology at the University of Toronto have advanced signal detection theory and methodology, while colleagues at the Mississauga campus focused on lifespan changes in hearing, with researchers charting the course of normal infant auditory development, and later exploring binaural and temporal auditory processing by older listeners. Recently, new facilities have been established at the National Centre for Audiology at the University of Western Ontario and at the Centre for Research on Biological Communication Systems based at the University of Toronto at Mississauga. From coast to coast, from theory to practice, from young to old, from healthy to pathological, Canadian psycho-acousticians have made significant contributions over the last four decades and they continue to do so.

Music research has been conducted on infants at the University of Toronto at Mississauga and on adults at the University of Prince Edward Island, but McGill University has lead the country in this area, especially with the recent establishment of a new facility at the Centre for Interdisciplinary Research in Music Media and Technology (CIRMMT). Applied and basic research on auditory physiology and electrophysiology has been conducted in university labs and associated hospital labs at the University of Toronto and also at the University of British Columbia, the University of Calgary, the University of Ottawa, McGill University, and Dalhousie University.

The Acoustics Division of Health Canada provides and implements standards for protection against occupational and environmental noise. Using a state-of-the-art acoustics chamber, measurement methods are developed for use in standards to reduce machinery noise. Information is also generated on the health effects of noise that can be used by both the public and regulatory authorities for risk management. The purpose is to reduce the incidence of noise-induced hearing loss and other non-auditory health effects of noise in Canada. Standards and guidelines are also provided for the licensing of medical ultrasound devices and monitor and enforce compliance of these devices.

Many Canadian acousticians are active in acoustical standards, in Canada, the US and internationally. A good deal of this work is coordinated through the Canadian Standards Association (CSA) Acoustics and Noise Control Committee. It is made up of the chairs of various subcommittees. Some, such as the Industrial Noise Subcommittee, are actively writing and looking after a stable of Canadian acoustical standards.

The most widely used Canadian standard is Z107.56 on Employee Noise Exposure Measurement, which was also the basis for an early draft of ANSI S12.19. The Transportation Noise Subcommittee is responsible for Z107.9 on Highway Noise Barrier Design, which formed the basis for the noise barrier section in the US FWHA Highway Noise Barrier Design Handbook, making Z107.9 the de-facto North American standard on highway noise barriers.

Other CSA subcommittees have no standards of their own and act as liaison with other standards organisations, including ANSI, ASTM, ISO and IEC. The latter two are separate committees which review international standards for the Standards Council of Canada and appoint Canadian representatives on ISO and IEC working groups.

CSA is currently looking at developing an omnibus standard describing CSA, ANSI, ASTM, ISO and other standards that are reviewed for their utility in Canada. It is hoped that this will be faster and more useful than formal adoption. More and more Canadian standards work is directed at participating in developing and using international and US standards, because it is more cost effective and simplifies harmonization and trade. For example, there is a joint CSA / ANSI working group looking at a North American adoption of ISO 9613(2).

The Canadian Acoustical Association (CAA) serves as a unifying body for acoustics activity within Canada, analogous to the ASA in the United States. The CAA is an interdisciplinary professional organization that fosters interaction between people working in all areas of acoustics, promotes the growth and practical application of acoustics knowledge, and encourages education, research, protection of the environment and employment in acoustics. The CAA also provides an umbrella organization through which general issues in acoustics can be addressed at a national and multidisciplinary level. These objectives are addressed primarily though three avenues: the CAA's journal, annual meeting, and awards program.

The CAA's quarterly journal, *Canadian Acoustics,* features refereed papers and news items on all aspects of acoustics. Papers present new results/methods in acoustics or report case studies and practical applications, and are published in either English or French. Papers submitted from outside of Canada are common. The journal strives to publish papers within six months of initial receipt, including a rigorous review procedure.

The CAA general conference, *Acoustics Week in Canada*, is held annually at different locations across the country, and offers an opportunity for scholarly, professional and social interaction with Canadian colleagues in acoustics. Meetings usually involve 100+ presentations/posters, an exhibit hall, local technical tours, and a social program. A proceedings issue of *Canadian Acoustics* is dedicated to summary papers of all presentations.

The CAA awards a total of 11 annual prizes (>$8000/year) to encourage and recognize excellence in the study of acoustics in Canada. These include awards at the post-doctoral, graduate, undergraduate, and high-school levels, as well as student awards for CAA presentations and papers. Travel subsidies to the annual CAA conference, and to other acoustics conferences, are also available.

NEWS / INFORMATIONS

CONFERENCES

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 stevenb@aciacoustical.com

2005

1-3 June: 1st International Symposium on Advanced Technology of Vibration and Sound. Hiroshima, Japan. Web: http://dezima.ike.tottori-u.ac.jp/vstech2005

15-17 June: ISCA Workshop on Plasticity in Speech Perception. London, UK. Web: www.psp2005.org.uk

20-23 June: IEEE Oceans05 Europe. Brest, France. Web: www.oceans05europe.org

23-24 June: 2nd Congress of the Alps-Adria Acoustics Association (AAAA2005). Opatija, Croatia. Web: http://had.zea.fer.hr

27-29 June: Managing Uncertanties in Noise Measurements and Predictions. Le Mans, France. Web: www.uncertainty-noise.org

28 June - 1 July: International Conference on Underwater Acoustic Measurements: Technologies and Results. Heraklion, Crete, Greece. Web: http://UAmeasurements2005.iacm.forth.gr

04-08 July: Turkish International Conference on Acoustics 2005. Web: www.tica05.org/tica05

11-14 July: 12th International Congress on Sound and Vibration (ICSV12). Lisbon, Portugal. Web: www.icsv12.ist.utl.pt

18-22 July: 17th International Symposium on Nonlinear Acoustics (ISNA 17). Pennsylvania State University, PA, USA. Web: http://outreach.psu.edu/c&i/isna17

6-10 August: Inter-Noise, Rio de Janeiro, Brazil. Web: www.internoise2005.ufsc.br

28 August - 01 September: World Congress on Ultrasonics Merged with Ultrasonic International (WCU/UT05), Web: www.ioa.ac.cn/wcu-ui-05

28 August – 2 September: Forum Acusticum Budapest 2005, Budapest, Hungary. Fax: +36 1 202 0452; Web: www.fa2005.org; E-mail: sea@fresno.csic.es

31 August - 03 September: 6th Pan European Voice Conference. London, UK. Web: www.pevoc6.com/home.htm

4-8 September: 9th Eurospeech Conference, Lisbon, Portugal. Contact: Fax: +351 213145843. Web: www.interspeech2005.org

4-8 September: 9th Eurospeech Conference (EUROSPEECH2005). Lisbon, Portugal. Web: www.interspeech2005.org

5-9 September: Boundary Influences in High Frequency, Shallow Water Acoustics. Bath, UK (Details to be announced later)

11-15 September: 6th World Congress on Ultrasonics (WCU 2005). Beijing, China. Web: www.ioa.ac.cn/wcu2005

CONFÉRENCES

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 courriel à stevenb@aciacoustical.com

2005

1-3 juin: 1st Symposium International sur Advanced Technology de Vibration et Sound. Hiroshima, Japan. Web: http://dezima.ike.tottori-u.ac.jp/vstech2005

15-17 juin: ISCA Workshop on Plasticity in Speech Perception. London, UK. Web: www.psp2005.org.uk

20-23 juin: IEEE Oceans05 Europe. Brest, France. Web: www.oceans05europe.org

23-24 juin: 2nd Congress de l'Association Acoustique Des Alps-Adria (AAAA2005). Opatija, Croatia. Web: http://had.zea.fer.hr

27-29 juin: Managing Uncertanties in Noise Measurements and Predictions. Le Mans, France. Web: www.uncertainty-noise.org

28 juin - 1 juillet: Conference Internationale sur Underwater Acoustic Measurements: Technologies and Results. Heraklion, Crete, Greece. Web: http://UAmeasurements2005.iacm.forth.gr

04-08 juillet: Turkish International Conference sur Acoustics 2005. Web: www.tica05.org/tica05

11-14 juillet: 12th Congress Internationale sur Sound et Vibration (ICSV12). Lisbon, Portugal. Web: www.icsv12.ist.utl.pt

18-22 juillet: 17th Symposium Internationale sur Nonlinear Acoustics (ISNA 17). Pennsylvania State University, PA, USA. Web: http://outreach.psu.edu/c&i/isna17

6-10 août: Inter-Noise, Rio de Janeiro, Brésil. Web: www.internoise2005.ufsc.br

28 août - 01 septembre: World Congress on Ultrasonics Merged with Ultrasonic International (WCU/UT05), Web: www.ioa.ac.cn/wcu-ui-05

28 août – 2 septembre: Forum Acusticum Budapest 2005, Budapest, Hongrie. Fax: +36 1 202 0452; Web: www.fa2005.org; E-mail: sea@fresno.csic.es

31 août - 03 septembre: 6th Pan European Voice Conference. London, UK. Web: www.pevoc6.com/home.htm

4-8 septembre: 9e Conférence d'Eurospeech, Lisbon, Portugal. Contact: Fax: +351 213145843. Web: www.interspeech2005.org

4-8 septembre: 9th Eurospeech Conference (EUROSPEECH2005). Lisbon, Portugal. Web: www.interspeech2005.org

5-9 septembre: Boundary Influences in High Frequency, Shallow Water Acoustics. Bath, UK (Details to be announced later)

11-15 septembre: 6th World Congress sur Ultrasonics (WCU 2005). Beijing, China. Web: www.ioa.ac.cn/wcu2005

14-16 September: Autumn Meeting of the Acoustical Society of Japan. Sendai, Japan. Web: www.asj.gr.jp/index-en.html

18-21 September: IEEE International Ultrasonics Symposium. Rotterdam, The Netherlands. Web: www.ieee-uffc.org

20-22 September: International Symposium on Environmental Vibrations. Okayama, Japan. Web: http://isev2005.civil.okayama-u.ac.jp

27-29 September: Autumn Meeting of the Acoustical Society of Japan. www.asj.gr.jp/index-en.html

12-14 October: Acoustics Week in Canada. London, Ontario, Canada. Web: http://caa-aca.ca

17-18 October: Wind Turbine Noise: Perspectives for Control. Berlin, Germany. Web: www.windturbinenoise2005.org

17-21 October: 150th Meeting of the Acoustical Society of America JOINT with NOISE-CON 2005, Minneapolis, Minnesota. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

19-21 October: 36th Spanish Congress on Acoustics and 2005 Iberian Meeting on Acoustics. Terrassa-Barcelona, Spain. Web: www.ia.csic.es/sea/index.html

25-26 October: UK Institute of Acoustics Autumn Conference 2005. Oxford, UK. Web: www.ioa.org.uk

27-28 October: Autumn Meeting of the Swiss Acoustical Society. Aarau, Switzerland. Web: www.sga-ssa.ch

27-29 October: Meeting of the International Society on Therapeutic Ultrasound. Boston, MA, USA. Web: www.istu2005.org

04-05 November: Reproduced Sound 21. Oxford, UK. Web: www.ioa.org.uk

09-11 November: Australian Acoustical Society Meeting "Acoustics in a Changing Environment". Busselton, WA, Australia. Web: www.acoustics.asn.au/divisions/2005-conferenece.shtml

14-18 November: XVI Session of the Russian Acoustical Society. Moscow, Russia. Web: www.akin.ru

07-09 December: Symposium on the Acoustics of Pro-Elastic Materials. Lyon, France. Web: http://v0.intellagence.eu.com/sapem2005

2006

15-19 May: IEEE International Conference on Acoustics, Speech, and Signal Processing (IEEE ICASSP 2006). Toulouse, France. Web: http://icassp2006.org

5-7 June: 6th European Conference on Noise Control (Euronoise2006). Web: www.acoustics.hut.fi/asf

5-9 June: 151st Meeting of the Acoustical Society of America, Providence, Rhode Island. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org

26-28 June: 9th Western Pacific Acoustics Conference. Seoul, Korea. Web: www.wespac8.com/WespacIX.html

14-16 septembre: Autumn Meeting de la Society Acoustical du Japan. Sendai, Japan. Web: www.asj.gr.jp/index-en.html

18-21 septembre: IEEE International Ultrasonics Symposium. Rotterdam, The Netherlands. Web: www.ieee-uffc.org

20-22 septembre: International Symposium on Environmental Vibrations. Okayama, Japan. Web: http://isev2005.civil.okayama-u.ac.jp

27-29 septembre: Autumn Meeting de l'Acoustical Society du Japan. www.asj.gr.jp/index-en.html

12-14 octobre: Acoustics Week in Canada. London, Ontario, Canada. Web: http://caa-aca.ca

17-18 octobre: Wind Turbine Noise: Perspectives for Control. Berlin, Germany. Web: www.windturbinenoise2005.org

17-21 octobre: 150e rencontre de l'Acoustical Society of America AVEC NOISE-CON 2005, Minneapolis, Minnesota. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél.: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org

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27-28 octobre: Autumn Meeting de l'Acoustical Society Swiss . Aarau, Switzerland. Web: www.sga-ssa.ch

27-29 octobre: Meeting de l'International Society sur Therapeutic Ultrasound. Boston, MA, USA. Web: www.istu2005.org

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26-28 juin: 9e Conférence Western Pacific Acoustics. Seoul, Korea. Web: www.wespac8.com/WespacIX.html

3-7 July: 13th International Congress on Sound and Vibration (ICSV13). Vienna, Austria. Http://info.tuwien.ac.at/icsv13

17-19 July: 9th International Conference on Recent Advances in Structural Dynamics. Southampton, UK. Web: www.isvr.soton.ac.uk/sd2006/index.htm

13-15 September: Autumn Meeting of the Acoustical Society of Japan. Web: www.asj.gr.jp/index-en.html

17-21 September: Interspeech 2006 - ICSLP. Web: www.interspeech2006.org

18-20 September: International Conference on Noise and Vibration Engineering (ISMA2006). Leuven, Belgium. Web: www.isma-isaac.be

18-21 September: INTERSPEECH 2006 - ICSLP. Pittsburgh, PA, USA. Web: www.interspeech2006.org

28 November – 2 December: 152nd meeting, 4th Joint Meeting of the Acoustical Society of America and the Acoustical Society of Japan, Honolulu, Hawaii. Contact: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tel: 516-576-2360; Fax: 516-576-2377; E-mail: asa@aip.org; Web: asa.aip.org
3 - 6 December: INTER-NOISE 2006, Honolulu HA, USA (Same Hotel at ASA meeting the week preceeding)

2007

17-20 April. IEEE International Congress on Acoustics, Speech, and Signal Processing (IEEE ICASSP 2007). Honolulu, HI, USA

9-12 July: 14th International Congress on Sound and Vibration (ICSV14). Cairns, Australia. Email: n.kessissoglou@unsw.edu.au

27-31 August: Interspeech 2007. E-mail: conf@isca-speech.org

2-7 September 19th International Congress on Acoustics (ICA2007), Madrid Spain. (SEA, Serrano 144, 28006 Madrid, Spain; Web: www.ia.csic/sea/index.html)

9-12 September: ICA2007 Satellite Symposium on Musical Acoustics (ISMA2007). Barcelona, Spain. Web: www.ica2007madrid.org

2008

23-27 June: Joint Meeting of European Acoustical Association, Acoustical Society of America, and Acoustical Society of France. Paris, France E-mail: phillipe.blanc-benon@ec-lyon.fr

28 July - 1 August: 9th International Congress on Noise as a Public Health Problem. Mashantucket, Pequot Tribal Nation, (CT, USA). Web: www.icben.org

3-7 juillet: 13th Congress Internationale sur Sound et Vibration (ICSV13). Vienna, Austria. Http://info.tuwien.ac.at/icsv13

17-19 juillet: 9th International Conference sur Recent Advances in Structural Dynamics. Southampton, UK. Web: www.isvr.soton.ac.uk/sd2006/index.htm

13-15 septembre: Autumn Meeting de l'Acoustical Society du Japan. Web: www.asj.gr.jp/index-en.html

17-21 septembre: Interspeech 2006 - ICSLP. Web: www.interspeech2006.org

18-20 septembre: International Conference sur Noise et Vibration Engineering (ISMA2006). Leuven, Belgium. Web: www.isma-isaac.be

18-21 septembre: INTERSPEECH 2006 - ICSLP. Pittsburgh, PA, USA. Web: www.interspeech2006.org

28 novembre – 2 decembre: 152e rencontre, 4e Rencontre acoustique jointe de l'Acoustical Society of America, et l'Acoustical Society of Japan, Honalulu, Hawaii. Info: Acoustical Society of America, Suite 1NO1, 2 Huntington Quadrangle, Melville, NY 11747-4502; Tél.: 516-576-2360; Fax: 516-576-2377; Courriel: asa@aip.org; Web: asa.aip.org
3 - 6 December: INTER-NOISE 2006, Honolulu HA, USA (Same Hotel at ASA meeting the week preceeding)

2007

17-20 avril. IEEE Congress Internationale sur Acoustics, Speech, et Signal Processing (IEEE ICASSP 2007). Honolulu, HI, USA

9-12 juillet: 14th Congress Internationale sur Sound et Vibration (ICSV14). Cairns, Australia. Email: n.kessissoglou@unsw.edu.au

27-31 août: Interspeech 2007. E-mail: conf@isca-speech.org

2-7 septembre 19e Congrès international sur l'acoustique (ICA2007), Madrid Spain. (SEA, Serrano 144, 28006 Madrid, Spain; Web: www.ia.csic/sea/index.html)
9-12 septembre: ICA2007 Satellite Symposium sur Musical Acoustics (ISMA2007). Barcelona, Spain. Web: www.ica2007madrid.org

2008

23-27 juin: Rencontre jointe de l'European Acoustical Association, l'Acoustical Society of America, et l'Acoustical Society of France. Paris, France E-mail: phillipe.blanc-benon@ec-lyon.fr

28 juillet - 1 août: 9th International Congress sur Noise as a Public Health Problem. Mashantucket, Pequot Tribal Nation, (CT, USA). Web: www.icben.org

NEWS

We want to hear from you! If you have any news items related to the Canadian Acoustical Association, please send them. Job promotions, recognition of service, interesting projects, recent research, etc. are what make this section interesting.

EXCERPTS FROM "*WE HEAR THAT*", IN *ECHOS*, ASA

ASA fellows **James Lynch** and **William Leach** have been elected Fellows of the Institute of Electrical and Electronics Engineers IEEE). Lynch, at the Woods Hole Oceanographic Institution, was cited "for contributions to sound transmission in shallow coastal waters for mapping bottom boundary layer characterizations." Leach, at Georgia Institute of Technology, was cited "for contributions to electroacoustics and near-field antenna measurements."

ASA Fellow **Manfred Schroeder** was awarded the 2004 ISCA Medal of the International Speech Communication Association "for his significant scientific achievement in speech communication science." The award was made during the annual meeting of the association in Korea. Schroeder also received the Technology Prize of the Rhein Foundation for "lifetime achievement in architectural acoustics, psychoacoustics, computer graphics and speech coding, especially linear prediction." The award, which carries a $65,000 stipend, was made at the Deutsches Museum in Munich.

Six students from five schools each received **Newman Medals**, a $200 honorarium and a set of books from the Robert Bradford Newman Student Award Fund in 2004, bringing to 163 the total number of Newman medals awarded which are named for Robert Bradford Newman.

EXCERPTS FROM "*SCANNING THE JOURNALS*", IN *ECHOS*, ASA

"**Quantum whistling** in superfluid helium-4" is the title of a brief communication in the 27 January issue of *Nature*. The authors induced oscillatory motion by forcing superfluid helium-4 through an array of nanometer-sized apertures. The oscillations, which were detected as an audible whistling sound that passed from high to low frequency (an audio recording is available at *Nature's* website). The oscillations appear to follow the so-called Josephson frequency relation. The authors comment that the discovery of this property in helium-4 at the relatively high temperature of 2 K (2000 times higher than a related phenomenon in helium-3) may pave the way for a new class of rotation sensors of unprecedented precision.

For the first time, researchers have **restored hearing** in deaf mammals, according to a paper in the 14 February issue of *Nature Medicine*. By inserting a corrective gene with a virus, the team induced the formation of cochlear hair cells in the ears of artificially deafened adult guinea pigs. The key to the generation of hair cells is a gene called Atoh1, first discovered in fruit flies in 1998. During fetal development, the gene converts some cells in the ear into hair cells, while its activity is suppressed in supporting cells.

Noise-canceling headphones are the subject of the Working Knowledge column in the February issue of *Scientific American.* The headphone ear cup and ear seal attenuate high frequency sound, while low-frequency sound that penetrates the seal is cancelled by using a small loudspeaker to create inverse sound waves. Some of the best headphones passively reduce noise by 15 to 25 decibels, and active circuitry can cut another 10 to 15 decibels from low-frequency tones. Actively attenuating frequencies above 1000 Hz remains difficult.

For some children who go blind, parts of their brains that would otherwise handle visual tasks end up **localizing sound**, according to an article in the 29 January issue of *New Scientist*. Scientists administered positron-emission tomography to 7 sighted adults and 12 adults who lost their vision during childhood. Five of the blind volunteers who showed a keen ear for sound sources, showed prominent blood flow (signalling neural activity) in two areas deep within the visual cortex at the back of the right brain.

An electromechanical force produced by the **organ of Corti** exhibits a broad resonance which significantly extends the frequency range of the organ's displacement response according to a paper in the December issue of the *Proceedings of the National Academies of Science*. To measure the mechanical impedance of the organ up to 70 kHz an innovative technique involving application of a known force to an atomic force cantilever was used (see *Biophys*. **87**, 1378 (2004)). The results are important for understanding the nanomechanical nature of hearing mechanisms.

Earthquake warning systems are the subject of a News Focus article in the 24 December issue of *Science*. Early warning systems detect actual quakes near their source and issue warnings to automated systems and humans up to several hundred kilometers away. Electronic signals travel faster than seismic waves moving through the earth. The faster moving primary (P) waves radiate directly outward from the epicenter. The secondary (S) waves, which cause the oscillating motions responsible for the most damage, lag by tens of seconds over a distance of a few hundred kilometers. "The P waves carry information; the S waves carry energy." Two early warning systems were put in place in the early 1990s in Mexico and Japan. A network of 12 instruments was installed along Mexico's Pacific coast where seismologists think a magnitude 8 earthquake is overdue. If the system works as intended, residents of Mexico City, 280 km away, could get a 70 second warning, enough to save many lives. Skepticism about earthquake warnings seems greatest in the United States, in part because the most dangerous faults are close to urban areas.

Hair bundles of **outer hair cells** can produce force on a submillisecond time scale, according to a paper in the 24 February issue of *Nature*. This mechanism could contribute significantly to hearing at high frequency. The fast force generator in the outer hair cells apparently does not suffer from the speed limitation of being voltage dependent as does the mechanism based on the motor protein prestin.

Canadian Acoustical Association

Minutes of the Board of Directors Meeting

17 May 2005
Hyatt Hotel, Vancouver, BC

Present: S. Dosso, D. Giusti, D. Quirt, C. Buma, M. Hodge, A. Behar, M. Cheng, C. Giguère, J. Bradley

Regrets: N. Collison, R. Ramakrishnan, V. Parsa, R. Panneton

The meeting was called to order at 7:30 p.m. Participants identified 3 issues to be added to the agenda under Other Business. Minutes of the previous Board of Directors meeting on 5 October 2004 were approved as published in *Canadian Acoustics* (December 2004). *(Approval moved by A. Behar, seconded by C. Buma, carried)*

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President's Report

Stan Dosso commented that from his review of current activities, CAA seems to be running well, with gradually increasing membership, strong finances, a series of successful conferences, increased submissions to our journal, and a well-subscribed awards program. He reported briefly on the joint CAA/ASA meeting in Vancouver, which provided the venue for this meeting of the Board. He also confirmed the plan to hold the next spring meeting of the CAA Board by teleconference.

Secretary's Report

David Quirt reported on membership and operation of the Association. Last year's report noted that the paid membership had risen slightly to 335 in mid-May. The numbers have risen further this year to 376. The increase in membership seems to be due to addition of new members at the Ottawa conference, and a steady trickle of new Student Members, boosted by the Vancouver ASA/CAA meeting. Although we still have ~10% non-renewals, most of these members tend to return a year or two later. To promote renewals, stamped return envelopes were included with Canadian invoices, and e-mail reminders were sent in March to members who had not responded to the December invoice. Basically, the membership situation seems quite healthy.

Other administrative issues:

- Payments by VISA have increased to about 40% of the memberships; this is probably contributing to the better renewal rate, but generates some processing problems.
- Circulation of INCE quarterly news magazine *Noise News International* to the Canadian Members and Sustaining Subscribers began as an option in 2004, and continues. Forty-two members have requested the magazine, and the $5 fee covers most of the mailing cost. Unfortunately, bulk transfer from the printer is sometimes late.
- Secretarial operating costs for the first nine months of FY04/05 were $722, for maintaining the address database and mailing expenses such as the annual membership renewal process. The secretarial account balance should cover all expected costs to the end of the fiscal year (31 August).

(Acceptance moved by D. Giusti, seconded J. Bradley, carried)

Treasurer's Report

Dalila Giusti provided an itemized report of the Association's finances, including a summary for the last four years. The report shows a solid financial position. As of 17 May, total assets are $265,824, most of which is invested to fund our awards. Due to low interest rates, continuing management of new expenses is needed, to ensure sufficient funds are available for prizes. In 2004/05, $7700 was distributed for awards, because all the major prizes were awarded.

In the last 4 years, revenues have consistently exceeded operating costs and the same is projected for this fiscal year. Conferences have achieved a financial surplus each year (see further comments under conferences) and the margin last year was significant. Other revenues have also been strong, though there have been some delays in collecting advertising and publication charges. The VISA merchant's account is being used more each year for annual membership dues; despite occasional problems with processing VISA payments, the Board recommended that this approach be continued.

Board members expressed their satisfaction with the way our financial affairs are being handled, and with the clear reporting of our financial trends.

(Acceptance moved by A. Behar, seconded M. Cheng, carried)

Editor's Report on *Canadian Acoustics*

Ramani Ramakrishnan submitted a brief written report on issues related to publication of *Canadian Acoustics.* The increased rate of paper submissions seems sufficient to support larger issues or a move to 6 issues per year. No specific date has been set for a change, but the Board reconfirmed that the Editor may shift to bi-monthly production at his discretion.

The Board discussed the idea of dedicating one issue of Canadian Acoustics each year to French articles. However, it was felt that the present practice of inter-mingling French and English articles throughout the year better supported the bilingual nature of the journal, and would avoid consequent publication delays and possible negative reader and advertiser responses. The idea of occasionally concentrating on acoustics concerns in Quebec was encouraged (like other topic-focused issues). However, it was decided not to adopt an annual French-only issue, but to continue to encourage French articles throughout the year.

Past and Future Conferences

<u>2004 Conference in Ottawa</u>: John Bradley reported that the Ottawa conference was a great success, with full technical sessions, excellent plenary presentations, a strong exhibition, and superior catering for lunches and the banquet. It also was very financially successful, with a surplus of $15,000. There was some discussion of policy for "invited papers" – most preferred to view them as "encouraged papers" with no implication of special recognition in the program or explicit financial differentiation – but no formal decision was made, to maintain operational flexibility for future meetings. John submitted a detailed final report, with many suggestions for future convenors. The Board congratulated the Ottawa team, and thanked them for their outstanding effort.

<u>2005 Conference in London:</u> Good progress was reported on arrangements for the London conference, which Meg Cheesman will convene, with Vijay Parsa as technical chair. The Lamplighter Inn and Conference Centre has been confirmed as the venue, and all sessions, meals, and the banquet will be there. Preparations are advancing steadily for the exhibition, organized sessions, and interesting tours. See the meeting notice on the website and published in this issue (June 2005) of *Canadian Acoustics.*

<u>2006 Conference:</u> A proposal to host the conference in Halifax was received. The

organizing committee includes Nicole Collison (Chair), Francine Desharnais (Technical Chair), David Chapman (Treasurer), Joe Hood (Exhibits), Jim Milne (Logistics) and Dave Stredulinsky (Website). The program will cover all aspects of acoustics, with significant emphasis on underwater sound. The expected site is a downtown hotel in Halifax.

2007 Conference: Possible sites (such as Montreal/Quebec) were discussed. Stan Dosso will investigate and encourage local interest.

Awards

Christian Giguère submitted a report for the Awards Committee. Two or more applicants have applied for most prizes, evaluation committees are proceeding, and winners will be announced in October. Two specific changes were discussed:

- Further updates of award rules and pages on the website are proposed, to clarify the different conditions on the two kinds of student awards (Travel Subsidy and Presentation Awards). Christian will post revised material on the website as soon as possible.
- The Board decided to increase the value of the Hétu book prize, to cover the purchase of an excellent text on acoustics (chosen by the recipient) up to $150.

(C. Buma moved acceptance of awards changes, A. Behar seconded, carried.)

CAA Website

Dave Stredulinsky has agreed to continue as our Webmaster. He submitted a report on recent progress in the CAA website (caa-aca.ca), which identified two major areas of activity or concern:

- The job-posting pages have been quite active. There have been a broad range of jobs, including some related to the recording industry and recording engineers. The Board agreed that the Webmaster should use his own judgment to limit the scope, and commended his efforts to date.
- The online index for Canadian Acoustics needs updating. This could be handled using electronic copies of index pages from the journal, but Dave would like a volunteer to deal with ongoing maintenance of the Access database from which these pages are generated.

The increasing reliance on the website places a duty on all Board members to keep their parts of the information current, by sending updates to the webmaster. Overall, Board members agreed that the website remains the most accessible and complete repository for information about CAA, and there was enthusiastic support for the steady efforts to improve the site.

Other Business

Three items were discussed:

1. Ballot on draft report of Technical Study Group 5 of the International Institute of Noise Control Engineering: This ballot and a link to the full report on the website of I-INCE.org were circulated to the Board in early April. Extended discussion established that (a) several members had technical objections to specific parts of the report, (b) some members are uncomfortable with adopting an advocacy position *(Note that a Board discussion of a policy on advocacy roles has been pending for some time)*, and (c) in the opinion of the Board, the CAA does not have a mechanism to establish a corporate position on such a document. There was consensus that such a ballot should be based on systematic consultation with the membership-at-large, and requires formulation of a detailed response, which would have required much earlier notice; hence, the Secretary was instructed to submit a vote of “Abstain”.

Notwithstanding this decision, the Board agreed the report seems to be a useful source of information, and requested the Secretary to create a brief item for *Canadian Acoustics* and the website, to draw members' attention to these TG reports.

2. Appointment of CAA representative to the August meeting of I-INCE General Assembly in Rio de Janeiro: As the only Board member planning to participate in the Inter-noise 2005 Conference, Dave Quirt was designated as CAA representative.

3. Revision of Canada Corporations Act: The Secretary received notice of Bill C-21, an act concerning replacement of parts of the Canada Corporations Act that deal with federal not-for-profit corporations such as CAA. The web site www.corporationscanada.ic.gc.ca has information on the proposed changes. The revisions seem to affect operating rules, accountability, and liability of Directors, among other things. It was agreed that the Treasurer should obtain the opinion of our Auditor, to clarify practical implications for CAA operations.

Adjournment

A. Behar moved to adjourn the meeting, seconded by C. Giguère, carried. Meeting adjourned at 10:25 p.m.

Special Action Items Arising from the Meeting

S. Dosso: In collaboration with Past President (J. Bradley), identify candidates for expected vacancies in Executive and other Directors. For meetings, confirm that a teleconference satisfies the bylaws as format for Board meeting in May 2006, and seek convener for 2007 conference. Seek volunteer to maintain the online index for *Canadian Acoustics*.

D. Giusti: Collaborate with London conference committee to establish process for payments by VISA and other financial details. Obtain the opinion of our Auditor (or other suitable consultant) on implications for CAA operations arising from proposed revision of the Canada Corporations Act.

D. Quirt: Provide financial and membership data for auditor at end of August. Attend meeting of I-INCE General Assembly in August and report on it to the Board in October. Submit CAA response to ballot on report of I-INCE Technical Study Group 5.

Each Member: Review CAA website contents within agreed areas of responsibility, and send updates to Webmaster periodically.

The Canadian Acoustical Association
L'Association Canadienne d'Acoustique

PRIZE ANNOUNCEMENT • ANNONCE DE PRIX

A number of prizes and subsidies are offered annually by The Canadian Acoustical Association. Applicants can obtain full eligibility conditions, deadlines, application forms, past recipients, and the names of the individual prize coordinators on the CAA Website (http://www.caa-aca.ca). • Plusieurs prix et subventions sont décernés à chaque année par l'Association Canadienne d'Acoustique. Les candidats peuvent se procurer de plus amples renseignements sur les conditions d'éligibilités, les échéances, les formulaires de demande, les récipiendaires des années passées ainsi que le nom des coordonnateurs des prix en consultant le site Internet de l'ACA (http://www.caa-aca.ca).

CAA conference Student Travel subsidies: consult http**://caa-aca.ca/London2005/**
Subventions pour étudiants pour frais de déplacement au congrès annuel de l'ACA : consulter le **http://caa-aca.ca/London2005/**

EDGAR AND MILLICENT SHAW POSTDOCTORAL PRIZE IN ACOUSTICS • PRIX POST-DOCTORAL EDGAR AND MILLICENT SHAW EN ACOUSTIQUE

$3,000 for full-time postdoctoral research training in an established setting other than the one in which the Ph.D. was earned. The research topic must be related to some area of acoustics, psychoacoustics, speech communication or noise. • $3,000 pour une formation recherche à temps complet au niveau postdoctoral dans un établissement reconnu autre que celui où le candidat a reçu son doctorat. Le thème de recherche doit être relié à un domaine de l'acoustique, de la psycho-acoustique, de la communication verbale ou du bruit.

ALEXANDER GRAHAM BELL GRADUATE STUDENT PRIZE IN SPEECH COMMUNICATION AND BEHAVIOURAL ACOUSTICS • PRIX ÉTUDIANT ALEXANDRE GRAHAM BELL EN COMMUNICATION VERBALE ET ACOUSTIQUE COMPORTEMENTALE

$800 for a graduate student enrolled at a Canadian academic institution and conducting research in the field of speech communication or behavioural acoustics. • $800 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche en communication verbale ou acoustique comportementale.

FESSENDEN GRADUATE STUDENT PRIZE IN UNDERWATER ACOUSTICS • PRIX ÉTUDIANT FESSENDEN EN ACOUSTIQUE SOUS-MARINE

$500 for a graduate student enrolled at a Canadian academic institution and conducting research in underwater acoustics or in a branch of science closely connected to underwater acoustics. • $500 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche en acoustique sous-marine ou dans une discipline reliée à l'acoustique sous-marine.

ECKEL GRADUATE STUDENT PRIZE IN NOISE CONTROL • PRIX ÉTUDIANT ECKEL EN CONTRÔLE DU BRUIT

$500 for a graduate student enrolled at a Canadian academic institution and conducting research related to the advancement of the practice of noise control. • $500 à un(e) étudiant(e) inscrit(e) au 2e ou 3e cycle dans une institution académique canadienne et menant un projet de recherche relié à l'avancement de la pratique du contrôle du bruit.

RAYMOND HÉTU UNDERGRADUATE PRIZE IN ACOUSTICS • PRIX ÉTUDIANT RAYMOND HÉTU EN ACOUSTIQUE

One book in acoustics of a maximum value of $100 and a one-year subscription to *Canadian Acoustics* for an undergraduate student enrolled at a Canadian academic institution and having completed, during the year of application, a project in any field of acoustics or vibration. • Un livre sur l'acoustique et un abonnement d'un an à la revue *Acoustique Canadienne* à un(e) étudiant(e) inscrit(e) dans un programme de 1er cycle dans une institution académique canadienne et qui a réalisé, durant l'année de la demande, un projet dans le domaine de l'acoustique ou des vibrations.

CANADA-WIDE SCIENCE FAIR AWARD • PRIX EXPO-SCIENCES PANCANADIENNE

$400 and a one-year subscription to *Canadian Acoustics* for the best project related to acoustics at the Fair by a high-school student • $400 et un abonnement d'un an à la revue *Acoustique Canadienne* pour le meilleur projet relié à l'acoustique à l'Expo-sciences par un(e) étudiant(e) du secondaire.

DIRECTORS' AWARDS • PRIX DES DIRECTEURS

One $500 award for the best refereed research, review or tutorial paper published in *Canadian Acoustics* by a student member and one $500 award for the best paper by an individual member • $500 pour le meilleur article de recherche, de recensement des travaux ou d'exposé didactique arbitré publié dans l'*Acoustique Canadienne* par un membre étudiant et $500 pour le meilleur article par un membre individuel.

STUDENT PRESENTATION AWARDS • PRIX POUR COMMUNICATIONS ÉTUDIANTES

Three $500 awards for the best student oral presentations at the Annual Symposium of The Canadian Acoustical Association. • Trois prix de $500 pour les meilleures communications orales étudiant(e)s au Symposium Annuel de l'Association Canadienne d'Acoustique.

STUDENT TRAVEL SUBSIDIES • SUBVENTIONS POUR FRAIS DE DÉPLACEMENT POUR ÉTUDIANTS

Travel subsidies are available to assist student members who are presenting a paper during the Annual Symposium of The Canadian Acoustical Association if they live at least 150 km from the conference venue. • Des subventions pour frais de déplacement sont disponibles pour aider les membres étudiants à venir présenter leurs travaux lors du Symposium Annuel de l'Association Canadienne d'Acoustique, s'ils demeurent à au moins 150 km du lieu du congrès.

UNDERWATER ACOUSTICS AND SIGNAL PROCESSING STUDENT TRAVEL SUBSIDIES • SUBVENTIONS POUR FRAIS DE DÉPLACEMENT POUR ÉTUDIANTS EN ACOUSTIQUE SOUS-MARINE ET TRAITEMENT DU SIGNAL

One $500 or two $250 awards to assist students traveling to national or international conferences to give oral or poster presentations on underwater acoustics and/or signal processing. • Une bourse de $500 ou deux de $250 pour aider les étudiant(e)s à se rendre à un congrès national ou international pour y présenter une communication orale ou une affiche dans le domaine de l'acoustique sous-marine ou du traitement du signal.

Acoustics Week in Canada 2005
October 12-14
Lamplighter Inn and Conference Centre, London, Ontario

Please join us to participate in three days of papers on diverse areas of acoustics. In addition to the technical sessions, you are invited to attend the exhibits, standards meeting, annual general meeting, and banquet.

Plenary Sessions

Richard Seewald, Canada Research Chair in Infant Hearing, will speak about his work on hearing and hearing loss in infants. Brock Fenton, Professor and Chair of the Biology Department at the University of Western Ontario, will discuss echolocation and bat behavior.

Special Sessions

Several special sessions will be offered that will include invited and contributed papers. Sessions include biomedical acoustics, speech perception, speech production, hearing aids, and biomedical ultrasound. If you are interested in organizing a special session, please contact Vijay Parsa (parsa@nca.uwo.ca).

Associated Events

The Canadian Standards Association (CSA) Committee Z 107 in Acoustics and Noise Control will hold a meeting during the conference. Contact Tim Kelsall (tkelsallhatch.ca), for more information. All interested participants are welcome to attend.

Tours through acoustics-related laboratories in and around the University of Western Ontario will be organized.

Exhibits & Sponsors

An exhibit hall of measurement equipment and other acoustical products will be located across from the meeting rooms. The exhibit area will also be the central coffee break area. Please contact the conference convener for exhibitor information and sponsorship of various aspects of this meeting.

Student Participation

For student members who are presenting papers, there is a travel subsidy that is available upon application. In addition, student members enrolled in Canadian universities may also enter a competition for the best student presentation award.

Abstract submissions

Submission of abstracts may be made electronically on or before June 24, 2005. Abstract submission information and a sample abstract are available on the CAA London 2005 website (http://caa-aca.ca/london-2005.html).

Summary papers
An optional two-page summary paper must be received by August 5, 2005 for inclusion in the conference issue of Canadian Acoustics (September 2005). This conference issue has become the archival record of new acoustical research activities in Canada each year. Complete submission information is available on the CAA London 2005 website (http://caa-aca.ca/london-2005.html).

Registration
Registration forms are available on the conference website. Early registration closes on September 15, 2005. All conference participants must register for the conference. A registration desk will be open throughout the conference.

Venue and Accommodation
The conference will be held at the Lamplighter Inn and Conference Centre in London. London is approximately 2 hours driving distance from Toronto and Detroit and is served by several major airlines. The Lamplighter offers standard rooms (2 queen beds) at a CAA delegate room rate of Cdn$109 (1-888-232-6747; www.lamplighterinn.ca). Please stay at this hotel to be with your colleagues and to support the CAA.

Hospitality
CAA conferences are always an opportunity to meet old friends and to make new ones over a coffee during the conference, or over a drink after the sessions. Many bars and restaurants are nearby and there will be a banquet as part of the conference. The Stratford Theatre Festival is located 45 minutes from the conference site. Information for the Festival can be found at the Festival website (http://www.stratfordfestival.ca).

Contacts
Conference convener: M. F. Cheesman (cheesman@uwo.ca)
Technical chair: V. Parsa (parsa@nca.uwo.ca)

Important Dates	
Deadline for receipt of abstracts by email	June 24
Notice of acceptance of abstracts by email	July 8
Deadline for receipt of summary paper (Electronic submission)	August 5
Deadline for early registration rates	September 15
CAA annual conference – Lamplighter Inn and Conference Centre, London, Ontario	October 12-14

Semaine canadienne d’acoustique 2005
12- 14 octobre
Lamplighter Inn et Conference Centre, London, Ontario

Joignez-vous à nous afin de participer à trois jours de communications scientifiques ayant pour sujets les divers domaines de l'acoustique. En plus des réunions techniques, vous êtes également invités à participer à l’exposition technique, les rencontres de comité de normalisation, l’Assemblée générale annuelles de l’association et le banquet.

Assemblées plénières
Richard Seewald, détenteur d’une chaire canadienne de recherche en pédoaudiologie, discutera de ses travaux concernant l'audition et l'hypoacousie chez les enfants. Brock Fenton, professeur et directeur du Département de biologie à l'université Western discutera pour sa part d'écholocalisation et du comportement des chauves-souris.

Sessions Plénières
Plusieurs sessions spéciales seront offertes et porteront sur les sujets proposés par les délégués: l’acoustique biomédicale, perception de la parole, speech production, aides de suppléance, et l’ultrasonographie médicale. Afin de suggérer un sujet de présentation particulier ou pour organiser une de ces sessions, veuillez communiquer avec Vijay Parsa (parsa@nca.uwo.ca).

Événements associés
Le comité de normalisation Z 107 en acoustique et contrôle du bruit de l’ACNOR tiendra une réunion au cours du congrès. Pour plus d'informations veuillez contacter Tim Kelsall (tkelsallhatch.ca). Tous les participants intéressés à y assister sont les bienvenus. Des visites des laboratoires d'acoustiques de l'université Western Ontario et de ceux situés à proximités de l'université seront également organisées.

Expositions et commandites
Un hall d'exposition sera situé entre les salles du congrès où y seront présentés différents équipements de mesure et certains produits en acoustiques. C’est dans cette aire d'exposition que se tiendra aussi les pauses-café. Veuillez communiquer avec le président de la congrès pour toute question concernant les expositions et les différents aspects des commandites pour ce congrès.

Participation étudiante
Les membres étudiants qui présenteront une communication pourront soumettre une demande de subvention pour frais de déplacement au congrès et pourront se voir mériter l'un des prix récompensant les meilleures présentations étudiantes.

Envoi des résumés
Les résumés de présentation peuvent être soumis électroniquement jusqu'au 24 juin 2005. Un exemple de résumé et l’information requise sont disponibles sur le site de l'ACA London 2005 (http://caa-aca.ca/london-2005.thml).

Actes du congrès

La date d'échéance pour soumettre l'article de deux pages pour la revue Acoustique Canadienne, édition spéciale du congrès, est le 5 août 2005. Cette édition spéciale est un portrait des nouvelles recherches en acoustique de l'année. L'information concernant la soumission de l'article de 2 pages est disponible sur le site de l'ACA London 2005.

Inscriptions

Les formulaires d'inscriptions sont disponibles sur le site internet du congrès. La date limite pour se prévaloir du taux préférentiel d'inscription est le 15 septembre 2005. Tous les participants doivent s'inscrire au congrès. Un bureau d'inscription restera ouvert tout au long du congrès.

Lieu du congrès et hébergement

Le congrès se tiendra au Lamplighter Inn and Conference Centre. London est à environ 2 heures de route de Toronto et Détroit et est déservi par la majorité des compagnies aériennes. L'hôtel offrira des chambres régulières à des tarifs préférentiels pour les délégués du congrès; soit 109$/nuit. Pour réservations ou informations: 1-888-232 -6747 ou www.bestwesternontario.com/french/lamplighter.html . Nous vous invitons à choisir cet hôtel afin de participer pleinement du congrès et d'encourager l'ACA.

Autres attraits

Les congrès de l'ACA sont toujours une excellente occasion de rencontrer d'anciens amis et collègues ou encore d'en rencontrer d'autres autour d'un café durant le congrès, ou d'un verre après les sessions techniques. Plusieurs bars et restaurants sont à proximité et bien sûr, un banquet sera offert durant le congrès. Le festival de théâtre de Stratford est situé à 45 minutes du site du congrès. Les informations concernant ce festival sont disponibles sur le site web du festival (http://www.stratfordfestival.ca).

Personnes ressources

Présidente du congrès : M. F. Cheesman (cheesman@uwo.ca)
Organisateur technique : V. Parsa (parsa@nca.uwo.ca)

Dates à retenir	
Date d'échéance pour la réception des résumés	24 juin
Avis d'acceptation des résumés	8 juillet
Date d'échéance pour la réception des articles de 2 pages (soumission électronique)	5 août
Date d'échéance pour les inscriptions à taux préférentiel	15 septembre
Le congrès annuel - Lamplighter Inn and Conference Centre, London, Ontario	12-14 octobre

INSTRUCTIONS TO AUTHORS FOR THE PREPARATION OF MANUSCRIPTS

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

General Presentation: Papers should be submitted in camera-ready format. Paper size 8.5" x 11". If you have access to a word processor, copy as closely as possible the format of the articles in Canadian Acoustics 18(4) 1990. All text in Times-Roman 10 pt font, with single (12 pt) spacing. Main body of text in two columns separated by 0.25". One line space between paragraphs.

Margins: Top - title page: 1.25"; other pages, 0.75"; bottom, 1" minimum; sides, 0.75".

Title: Bold, 14 pt with 14 pt spacing, upper case, centered.

Authors/addresses: Names and full mailing addresses, 10 pt with single (12 pt) spacing, upper and lower case, centered. Names in bold text.

Abstracts: English and French versions. Headings, 12 pt bold, upper case, centered. Indent text 0.5" on both sides.

Headings: Headings to be in 12 pt bold, Times-Roman font. Number at the left margin and indent text 0.5". Main headings, numbered as 1, 2, 3, ... to be in upper case. Sub-headings numbered as 1.1, 1.2, 1.3, ... in upper and lower case. Sub-sub-headings not numbered, in upper and lower case, underlined.

Equations: Minimize. Place in text if short. Numbered.

Figures/Tables: Keep small. Insert in text at top or bottom of page. Name as "Figure 1, 2, ..." Caption in 9 pt with single (12 pt) spacing. Leave 0.5" between text.

Line Widths: Line widths in techincal drawings, figures and tables should be a minimum of 0.5 pt.

Photographs: Submit original glossy, black and white photograph.

Scans: Should be between 225 dpi and 300 dpi. Scan: Line art as bitmap tiffs; Black and white as grayscale tiffs and colour as CMYK tiffs;

References: Cite in text and list at end in any consistent format, 9 pt with single (12 pt) spacing.

Page numbers: In light pencil at the bottom of each page.
Reprints: Can be ordered at time of acceptance of paper.

DIRECTIVES A L'INTENTION DES AUTEURS PREPARATION DES MANUSCRITS

Soumissions: Le manuscrit original ainsi que deux copies doivent être soumis au rédacteur-en-chef.

Présentation générale: Le manuscript doit comprendre le collage. Dimensions des pages, 8.5" x 11". Si vous avez accès à un système de traitement de texte, dans la mesure du possible, suivre le format des articles dans l'Acoustique Canadienne 18(4) 1990. Tout le texte doit être en caractères Times-Roman, 10 pt et à simple (12 pt) interligne. Le texte principal doit être en deux colonnes séparées d'un espace de 0.25". Les paragraphes sont séparés d'un espace d'une ligne.

Marges: Dans le haut - page titre, 1.25"; autres pages, 0.75"; dans le bas, 1" minimum; latérales, 0.75".

Titre du manuscrit: 14 pt à 14 pt interligne, lettres majuscules, caractères gras. Centré.

Auteurs/adresses: Noms et adresses postales. Lettres majuscules et minuscules, 10 pt à simple (12 pt) interligne. Centré. Les noms doivent être en caractères gras.

Sommaire: En versions anglaise et française. Titre en 12 pt, lettres majuscules, caractères gras, centré. Paragraphe 0.5" en alinéa de la marge, des 2 cotés.

Titres des sections: Tous en caractères gras, 12 pt, Times-Roman. Premiers titres: numéroter 1, 2, 3, ..., en lettres majuscules; sous-titres: numéroter 1.1, 1.2, 1.3, ..., en lettres majuscules et minuscules; sous-sous-titres: ne pas numéroter, en lettres majuscules et minuscules et soulignés.

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Largeur Des Traits: La largeur des traits sur les schémas technique doivent être au minimum de 0.5 pt pour permettre une bonne reproduction.

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Pagination: Au crayon pâle, au bas de chaque page.
Tirés-à-part: Ils peuvent être commandés au moment de l'acceptation du manuscrit.

The Canadian Acoustical Association
l'Association Canadienne d'Acoustique

Application for Membership

CAA membership is open to all individuals who have an interest in acoustics. Annual dues total $60.00 for individual members and $20.00 for Student members. This includes a subscription to ***Canadian Acoustics***, the Association's journal, which is published 4 times/year. New membership applications received before August 31 will be applied to the current year and include that year's back issues of ***Canadian Acoustics***, if available. New membership applications received after August 31 will be applied to the next year.

Subscriptions to *Canadian Acoustics* *or* Sustaining Subscriptions

Subscriptions to ***Canadian Acoustics*** are available to companies and institutions at the institutional subscription price of $60.00. Many companies and institutions prefer to be a Sustaining Subscriber, paying $250.00 per year, in order to assist CAA financially. A list of Sustaining Subscribers is published in each issue of ***Canadian Acoustics***. Subscriptions for the current calendar year are due by January 31. New subscriptions received before August 31 will be applied to the current year and include that year's back issues of ***Canadian Acoustics***, if available.

Please note that electronic forms can be downloaded from the CAA Website at **caa-aca.ca**

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Areas of Interest: (Please mark 3 maximum)

1. Architectural Acoustics
2. Engineering Acoustics / Noise Control
3. Physical Acoustics / Ultrasound
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8. Speech Sciences
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For student membership, please also provide:

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Expiry date ______________________________

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(Signature) (Date)

Mail application and attached payment to:

D. Quirt, Secretary, Canadian Acoustical Association, PO Box 74068, Ottawa, Ontario, K1M 2H9, Canada

l'Association Canadienne d'Acoustique
The Canadian Acoustical Association

Formulaire d'adhésion

L'adhésion à l'ACA est ouverte à tous ceux qui s'intéressent à l'acoustique. La cotisation annuelle est de 60.00$ pour les membres individuels, et de 20.00$ pour les étudiants. Tous les membres reçoivent ***l'Acoustique Canadienne***, la revue de l'association. Les nouveaux abonnements reçus avant le 31 août s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de ***l'Acoustique Canadienne*** de cette année. Les nouveaux abonnements reçus après le 31 août s'appliquent à l'année suivante.

Abonnement pour la revue *Acoustique Canadienne* et abonnement de soutien

Les abonnements pour la revue ***Acoustique Canadienne*** sont disponibles pour les compagnies et autres établissements au coût annuel de 60.00$. Des compagnies et établissements préfèrent souvent la cotisation de membre bienfaiteur, de 250.00$ par année, pour assister financièrement l'ACA. La liste des membres bienfaiteurs est publiée dans chaque issue de la revue ***Acoustique Canadienne***. Les nouveaux abonnements reçus avant le 31 août s'appliquent à l'année courante et incluent les anciens numéros (non-épuisés) de ***l'Acoustique Canadienne*** de cette année. Les nouveaux abonnements reçus après le 31 août s'appliquent à l'année suivante.

Pour obtenir des formulaires electroniques, visitez le site Web: **caa-aca.ca**

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The Canadian Acoustical Association
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The Canadian Acoustical Association gratefully acknowledges the financial assistance of the Sustaining Subscribers listed below. Annual donations (of $250.00 or more) enable the journal to be distributed to all at a reasonable cost. Sustaining Subscribers receive the journal free of charge. Please address donation (made payable to the Canadian Acoustical Association) to the Secretary of the Association.

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 $250.00 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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SNC/Lavalin Environment Inc.
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