New Zealand Acoustics

Volume 26, 2013 / #2

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2nd Quarter

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New Zealand Acoustics

Volume 26, 2013 2nd Quarter

Features

Regulars

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Contributions to the Journal are encouraged, and may be sent directly to the Editor either by email, or by post c/o the Acoustical Society of New Zealand Incorporated, PO Box 1181, Auckland.

From the President and Editor

From the President

Dear Members,

I trust you're all holding up well despite the bitter southerly trying to ruin things (and, let's be honest... succeeding in a few places!)

It's been a busy month or two for the ASNZ council. We've been putting the finishing touches on our proposed Continued Professional Development (CPD) scheme.

Our Society Rules state (in Clause 5(vi)) that Members must satisfy any requirements for CPD in order to retain their grade of Membership (lest they be relegated!). This is a key part of Membership, because it obliges us to keep learning and studying acoustics, and also to contribute to the society. You will be able to earn points through endeavours like writing papers for NZ Acoustics (and other journals), attending and presenting at the ASNZ Biennial conference (and other conferences), and attending ASNZ Branch meetings. This last one is especially important, because I'm hoping very much that it will prompt all branches to organise the meetings! This is something that has been lacking in the Society for a number of years. The organisers will get extra points, so get your thinking caps on!

By the time you read this, all current Members and Affiliates will have received a copy of the proposal for comment. Please do comment so we can get the scheme working for all of us.

Second thing: I'd like to remind members of (or in some cases, introduce them to) the National Foundation for the Deaf. The NFD is an organisation

going from strength to strength, lobbying and raising awareness of hearing impairment in New Zealand. You may have seen Lance Cairns on the telly in March talking about his hearing loss. That's them. Lance is NFD's

Publication Dates and Deadlines

New Zealand Acoustics is published quarterly in March, June, September, and December.

The Deadline for material for inclusion in the journal is 1st of each publication month, although long articles should ideally be received at least 2 weeks prior to this.

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To join the society, visit www.acoustics.ac.nz or contact the Secretary.

Foundation Ambassador.

ASNZ is one of eight member groups of NFD with Dr George Dodd and I representing us on the NFD Council. We attend several meetings a year and give project advice on acoustics as required. One such project is the Good Soundz Safe Sound Indicator – a traffic light based monitor which has been installed in hundreds of schools and early learning centres. It gives a visual signal based on the sound level in the space (red light means too loud!). It's a management tool for teachers, and allows children to learn how their behaviour affects noise levels.

I'll be adding NFD news to my columns from time to time, and I understand their CEO Louise Carroll has provided some content for this issue. Also, you can visit their website www.nfd.org.nz.

Third thing: Canterbury Earthquake Recovery Minister Gerry Brownlee wrote an opinion piece in The Press recently explaining why, in his opinion, the Christchurch Town Hall should be torn down.

The opinion is called "Modern city needs a new Town Hall" and you can read it on the press.co.nz website. I urge you to do so.

To paraphrase, Mr Brownlee claims that the Town Hall is badly torn apart and sits on some of the worst land in the central city. He says that it's old and worn out, and the praise it received when it opened should be viewed only in the context of that time. He compares it to the Sydney Opera house, which has undergone heavy renovations recently (because it had average acoustics to start with... but he doesn't mention that), and suggests that old halls like Christchurch need to be brought into the modern age in order to be any good.

I find this comment disturbing and lacking logic. The excellence of a good concert hall doesn't change with age! If that were true then the Großer Musikvereinssaal (1870) and Concertgebouw (1888) would be among the worst sounding halls in the world, and should be stripped out and updated (**eds. note**: a decision to retain and refurbish the hall has now been made).

The demands on concert venues have indeed changed over the years. It's very rare these days that an acoustician's brief is limited to providing for 'just choral' or 'just orchestral' music. Modern spaces need to be dynamic and deliver a range of acoustic environments, because it maximises their chances of being booked out every week. These modern halls don't supercede the old ones... they enhance them, by giving them context. We shouldn't be tearing the old ones down, we should be protecting them and treasuring them. And saving them.

Keep warm this winter and spring, I look forward to your CPD feedback. Just a reminder that the new membership year starts on 1 July, so subs are due.

Yours faithfully,

James Whitlock

Editor's Ramble

Dear Readers,

I apologize for yet another delayed issue. I had hoped to bring you more information about the revised building code, however, I have received the following response:

"I have been advised that the amendments to the Building Code have not been delayed but the team are still working through finalising the provisions and proposals to go to Cabinet. While we are unable to give you an exact time when we expect the amendments to come into place, we can advise that it is unlikely to be this calendar year. " (Rebecca Kraakman, Business Support Communications, Strategy & Governance, Ministry of Business, Innovation & Employment).

As James notes, we have included the annual report for the NFD along with three features, an article on noise identification, one on cooling of data centres and one on cochlear implants.

We also have a review of a recent lecture on the subject of Tinnitus, and I note that the next international conference on Tinnitus is taking place in Auckland next March.

Feedback is also being sought on a number of acoustics-related ISO standards; you can find a list on page 26.

All the best,

John Cater ¶

National Foundation for the Deaf: Annual Report 2012

Dear Friends and Colleagues,

2012 was a great vintage and top billing for the year has to go to John Harwood, Deputy Chair of the NFD Council and Past Chairperson of the National Hearing Association. He has done superlative work representing people who are Hearing Impaired and ensuring our voice is heard in many arenas. I believe our sector has been very fortunate to have him working with us - thank you so much John!

Other achievements include, we had the presentation of "Voices of the Hearing Impaired" at Parliament and our sincere thanks go to David Kent; John Harwood; Bill Allison and Leonie Wilson, all of whom spoke from the heart about what it is like to live with Hearing Impairment; Cochlear Implants or be a parent to children with Auditory Processing Disorder.

Our sincere thanks and recognition go the Oticon Foundation New Zealand for their support which enabled our representation at the International Federation for Hard of Hearing Persons (IFHOH) Congress in Norway. This was a vital opportunity for us to build global links and we are delighted to report, that as a direct consequence of receiving this grant, we are now a full voting General Member of the IFHOH.

We also worked closely with Sprint and CSD, to ensure the smooth introduction of captioned telephony or CapTel into New Zealand. This technology has dramatically opened up verbal/captioned telephone communications for the hearing impaired and is being enjoyed by many of us. Adam Paterson and Chris Peters were instrumental in delivering this work to the regions and they did a good job.

Our brilliant Development Group for the Foundation's Silent Leadership Challenge was formed in 2012 and they have proven to be a group of innovative thinkers, enabling us to forge ahead with the development of this unique event. Nick King, John Shaw and I steadily worked to ensure this Group and the project as a whole, was well informed and able to function effectively. We are very excited at the development of this project and hope that the message of how to prevent noise induced hearing loss will be heard by community and corporate leaders whilst they work to raise funds to support our essential advocacy services.

Also, John Shaw coordinated the delivery of our second Major Gift Donor Recognition Event too which was a positive and celebratory event that was enjoyed by all.

The other significant Working Group that the Foundation provided secretariat and event planning support for in 2012 was the Captioning Work Group and the Inaugural Captioning Awards Event. This Group was ground breaking in that the Deaf and Hearing Impaired worked collaboratively and achieved significant inroads on the lack of captioning for our communities but there is a lot of work yet to be done.

The Captioning Awards Event, with the beautiful prizes of framed paintings, as painted and donated by Robyn Carter, was an event that recognised the superlative efforts made by Member of Parliament Mojo Mathers on behalf of our sector and the efforts of Tony O'Brien and Sky TV to caption 17 more channels. Also recognised was Wendy Youens and the Team at Access Services/TVNZ who continue to do the best they can, working within a very limited budget. Our thanks too go to the legendary Lance Cairns and to David Rutherford, the Chief Human Rights Commissioner for presenting these Inaugural Awards and to NZ On Air and Sky TV for funding this event.

Our Human Rights Class Action advocacy for and on behalf of people affected by the changes to ACC legislation continued in 2012 and we hope the Human Rights Review Tribunal Hearing will proceed in 2013. Dara McNaught assisted with this work and helped the Project HIEDI group which NFD is now supporting in-house.

But, the outstanding work of NFD in 2012 remains our continued drive to respond to all who approached us for assistance and we received in excess of 6,000 calls or emails of enquiry by year end. Unfortunately funding this service has proven to be a real struggle and in 2013 we have been forced to reduce staff hours, though we are very grateful to all who supported us with much needed and appreciated donations through 2012.

I would also like to make mention here of Tessa Copland, who works tirelessly on our magazine as sub-editor as she does an excellent job. The magazine is published twice a year, to coincide with Hearing Week and Deaf Awareness Week and is now very much the flag ship of our work. We are also very grateful to the New Zealand Lottery Grants Board for their substantial funding of our work and this magazine and the companies who purchase advertising; thereby ensuring we are able to keep producing this magazine.

Also Lisa Noonan and Stephanie Maitland, both of whom, as part-time contractors, worked successfully to establish our grants application programme. They were both extremely professional and a delight to work with and sadly, in 2013, our resources are such that we could not renew their contracts.

2012 was a great vintage that bought with it a series of trials and tribulations due to the financial recession and it is our goal for 2013 to be a year of financial recovery.

Thank you too, to the NFD Council and Board members for their work in 2012.

Louise Carroll QSO, JP, GDPPA, MPM

Chief Executive Officer

The National Foundation for the Deaf Inc.

PO Box 37729, Parnell, Auckland 1151

Noise Source Identification Techniques: Simple to Advanced Applications

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This paper was previously presented at the 21st Biennial ASNZ Conference, Wellington, NZ

Abstract

The number of techniques available to engineers working on noise, vibration and harshness problems has increased considerably in recent years. The choice of the most appropriate technique depends upon the application and the information required. This paper reviews techniques for noise source identification and quantification ranging from simple hand-held sound intensity systems, hand-held array systems to large ground based microphone arrays. The methods include Beamforming, Spherical Beamforming and Acoustic Holography. Guidelines are given to help the engineer choose a suitable technique based on the frequency range of interest, the distance from the measurement ar-ray and the test object and the resolution required. Practical application examples ranging from hearing aids to wind turbines are presented to illustrate the various NSI techniques.

1. INTRODUCTION

Noise source identification (NSI) techniques are used to optimise the noise emission from a wide range of products including vehicles, household goods, wind turbines and hearing aids. The goal of NSI is to identify the most important sub-sources on an object in terms of position, frequency content and sound power radiation. Ranking of the sub-sources can then be used to identify where design changes will most effectively improve the overall noise radiation. With a considerable number of techniques available, NVH engineers might have need of an overview to help select the most appropriate solution. This paper gives some guidelines to help the selection together with some practical applications of NSI techniques. Emphasis is placed on the useful frequency range and the resolution of the various methods.

2. NSI TECHNIQUES

A number of NSI techniques use just one or a few transducers. Examples are sound mapping based on sound pressure, sound intensity and selective intensity.

Array based techniques using a dozen to up to hundreds of microphones are where the greatest developments are taking place. The main methods are:

- Near-field Acoustic Holography related techniques (STSF, Non-Stationary STSF, SONAH)
- Beamforming (Phased Array technique)
- Refined beamforming (deconvolution methods)
- Moving source beamforming
- Spherical beamforming

The technique selected by the user will depend on the required frequency range, the measurement distance, the required resolution and the area covered by the measurement.

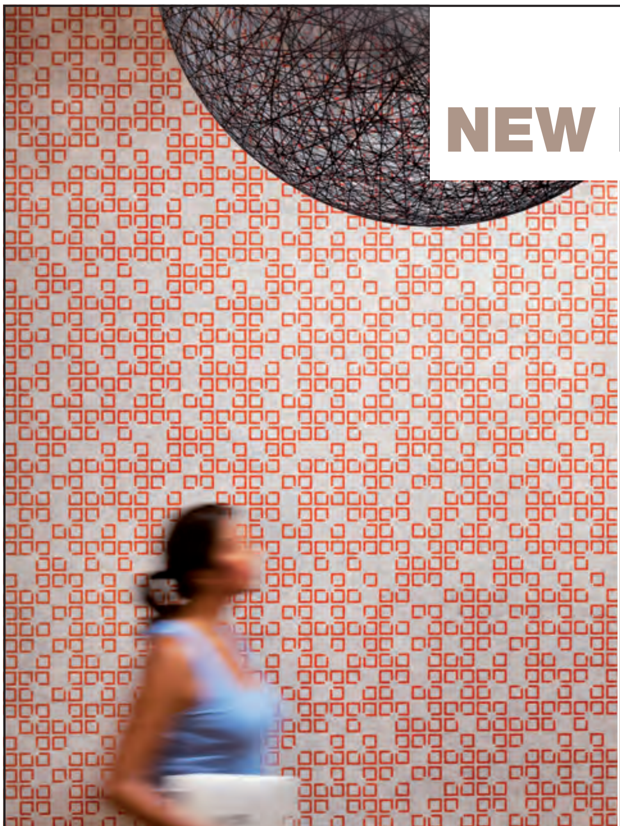
3. SOUND MAPPING

The most straightforward method to detect a noise source is to map the Sound Pressure Level (SPL) at various locations around the noisy product. The SPL is measured with a single channel FFT or 1/3 octave analyser at each point of a defined grid then the measured data is used to produce a contour map that gives a rough idea of the location and characteristics of the source. The method is rarely used nowadays as it has mainly been superseded by sound intensity mapping. The main benefit of sound pressure mapping is the low cost involved. The limitations are that the method is time consuming, is particularly susceptible to the influence of background noise and can only be applied to stationary noise sources.

Since the 1980's the sound intensity technique based on a phase-matched pair of microphones, has been used to measure the acoustic energy flow. This yields not only the amplitude but also the direction of the sound energy. The method has been incorporated into a number of international standards to determine sound power.

Sound intensity mapping involves the measurement of sound intensity spectra at a number of discrete points on a grid close to the object under test. A contour plot is then produced and superimposed on a photograph to enable identification and documentation of the noise sources. To speed up the process a robot is often used to move the sound intensity probe from position to position.

The main benefit of sound intensity compared to sound pressure is that it is a vector quantity. The acoustic field can thus be represented with a magnitude and a direction. Thus it is possible to determine sound power of a source even in the presence of background noise. The technique is now mature so that complete sound intensity mapping systems are available as a 2 channel sound level meter. The spatial resolution of a sound intensity map is limited by the wavelength of sound and the distance between the measurement points in the mapping grid.



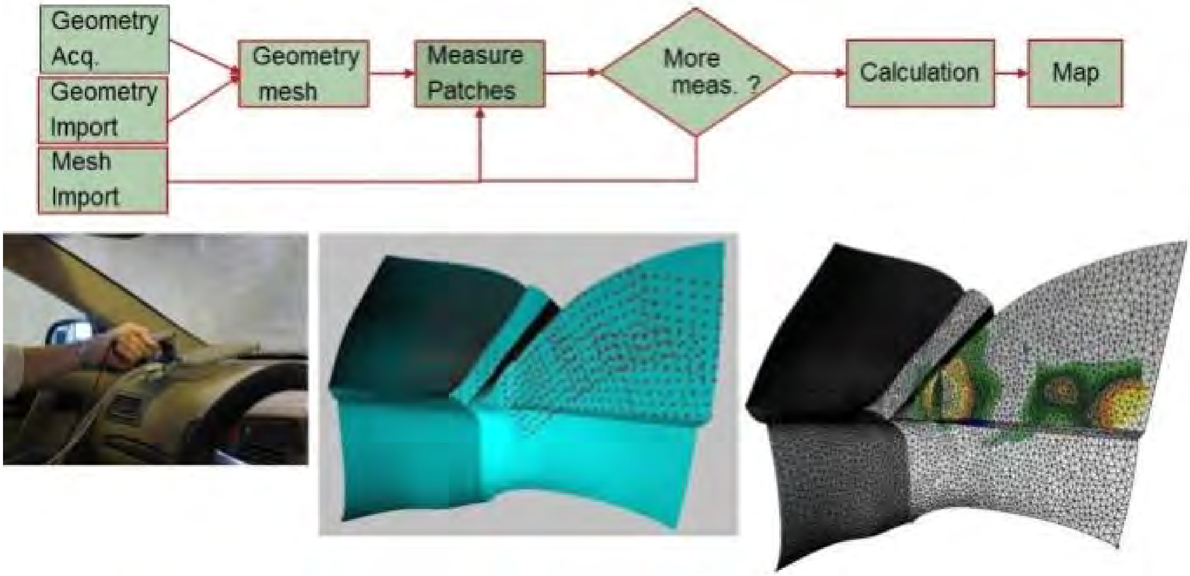


Figure 1. Conformal mapping workflow: Import or acquisition of the geometry, mesh generation, patch measurements, calculations and displays.

Selective intensity calculates that part of the full measured sound intensity that is coherent with a specific reference signal. If, for example, the vibration of a specific component is suspected to be the main cause of the radiated noise, then an accelerometer mounted on that component can be use to provide a reference signal for the selective intensity calculation. If the suspicion is correct then the selective intensity will be close to the full sound intensity observed. The reference signal may be of any nature: acoustic, vibration, force, electrical etc, whichever provides the cleanest and least noisy representation of the suspected cause. The benefit of selective intensity compared to traditional sound intensity measurement is that it permits a more precise localization of the sound source.

4. NEARFIELD ACOUSTIC HOLOGRAPHY

Spatial Transformation of Sound Fields (STSF) was one of the first commercially available noise source identification techniques based on nearfield acoustic holography [1]. The technique requires a regular grid of microphones together with a number of references transducers. Measurements of autospectra and cross spectra are made over a plane which completely covers the test object. Using principal component decomposition techniques, a model of the acoustical field is generated from which all acoustical parameters (pressure, particle velocity, intensity, power) can be calculated both closer to and further away from the test object. The calculations are based on 2D FFT and are very fast. However, there are limitations due to the fact that unless the test object is measured entirely, artefacts occur in the resulting mapping. For sources which are not stationary in character, a transient method in the time domain was developed known as Non-Stationary STSF.

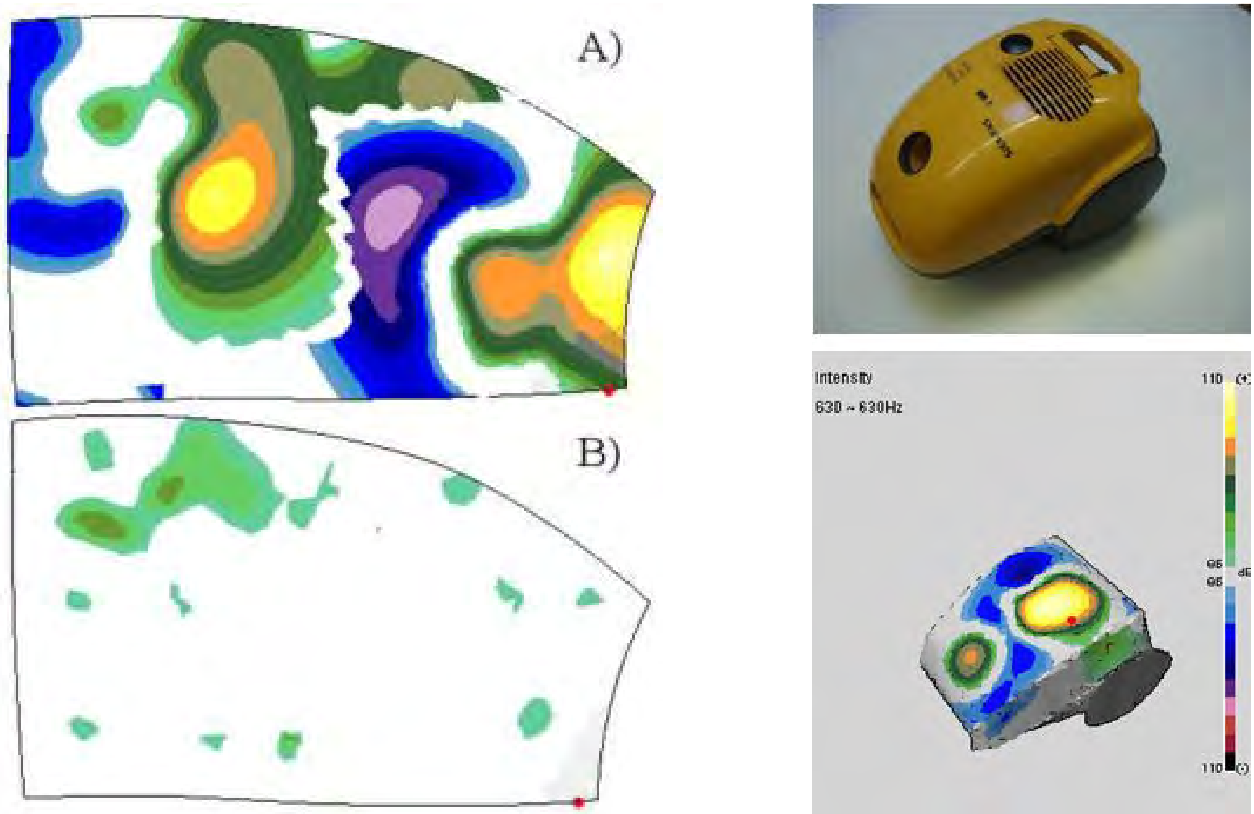


Fig. 2: Left: Measurements on a car window during wind tunnel tests. A: with mirror, B without mirror, intensity at 125 Hz 1/3rd octave. Right: Vacuum cleaner, intensity 630 Hz 1/3rd octave.

5. SONAH

The STSF and Non-Stationary STSF methods have been further developed to overcome some of their practical limitations. A resultant technique is known as Statistically Optimised Nearfield Acoustical Holography (SONAH) [2, 3]. The idea consists in fitting a plane wave model to the measurements using a linear decomposition. In the case of a double layer of sensors, it is also possible to differentiate between sources in front and behind the microphone array.

The main benefits of SONAH, compared to standard NAH, are the possibility to use a non-uniform grid of microphones, a low sensitivity to sources outside of the calculation plane and better performance at low frequencies.

The low sensitivity to sources outside of the calculation plane makes it possible to perform local measurements; therefore with SONAH, there is no need to use an array which entirely covers the object under test, as is required for traditional NAH. Furthermore, the applicability of SONAH to an irregular grid of microphones provides more flexibility. In particular, different microphone array techniques can be combined in the same system. For example, combining SONAH with beamforming processing with the same microphone array system provides an extended frequency range.

5.1 Conformal Calculations

Local measurements using SONAH open up the possibility to perform conformal calculations. This means that quantities such as sound pressure, intensity or velocity can be calculated on the surface of the test object.

For even more accurate conformal mapping, following the surface details of the object, it is necessary to acquire a model (importing or digitizing) of the test object on one hand, and on the other a precise location of the microphone array. In order to reduce the preparation time and to simplify the measurement process, a tracking system based on infrared sensors is attached to the microphone array handle, to obtain real-time positions and the orientations of the array during the measurements.

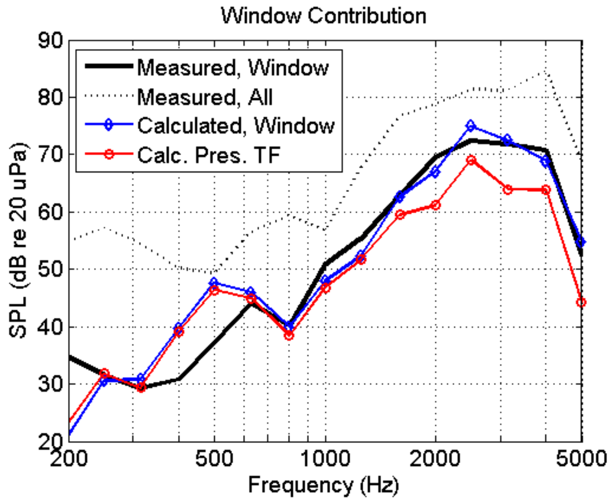


Fig. 3: Pressure contribution at the driver's ear position of a flat loudspeaker attached on a window of a car cabin. The measured true contribution corresponds to solid black curve, the calculated contribution correspond to solid blue curve.

The work-flow is summarized in figure 1. In this process, it is necessary to assume that the noise source characteristics are stationary [3].

Using conformal maps reduces the risk of misinterpretation of the data. Figure 2 shows two examples of applications.

5.2 Panel contribution

Noise source identification techniques, can be used beyond their traditional use, namely localizing acoustic sources or estimating the distribution of acoustic quantities on extended areas. One example is panel contribution based on SONAH.

The purpose of this technique [4] is to estimate the contributions of some areas to the acoustic pressure at a chosen point in a cabin. A practical case is for example the acoustic contribution of the different inner parts of a car cabin to the sound pressure level at the ear of the driver.

Panel contribution based on SONAH estimates the contribution of a panel ΔS to the acoustic pressure at a target point using pressure and sound velocity [4].

Two steps are required. Firstly, the transfer functions between a source at a target position and the panel ΔS using SONAH are measured. Secondly, the operational sound intensities are obtained using SONAH again.

To illustrate this technique, figure 3 shows the contribution of a flat loudspeaker attached to a window of a car cabin, in presence of background noise. Agreement between the true and calculated contributions is good, except below 630 Hz, where the signal level provided by the flat loudspeaker is too low.

5.3 Entering intensity

A different example of application using SONAH is the determination of the entering intensity in a cabin configuration [5]. The purpose is to distinguish between the different intensity components close to walls.

In particular, it is of interest to estimate what is actually entering into the cabin from outside the vehicle. Another interesting aspect is the estimation of the panel absorption.

It is assumed that the sound fields due to radiation (entering intensity) on one hand and due to absorption on the other hand are mutually incoherent. This incoherence assumption can be reasonable in the case of a very large number of incoherent excitations, such as, for example, those created by a turbulent flow around an aircraft fuselage.

A sound intensity probe cannot distinguish these different components, but will measure instead the total intensity. Using SONAH with a double layer microphone array (DLA), it is possible to separate these different contributions [5].

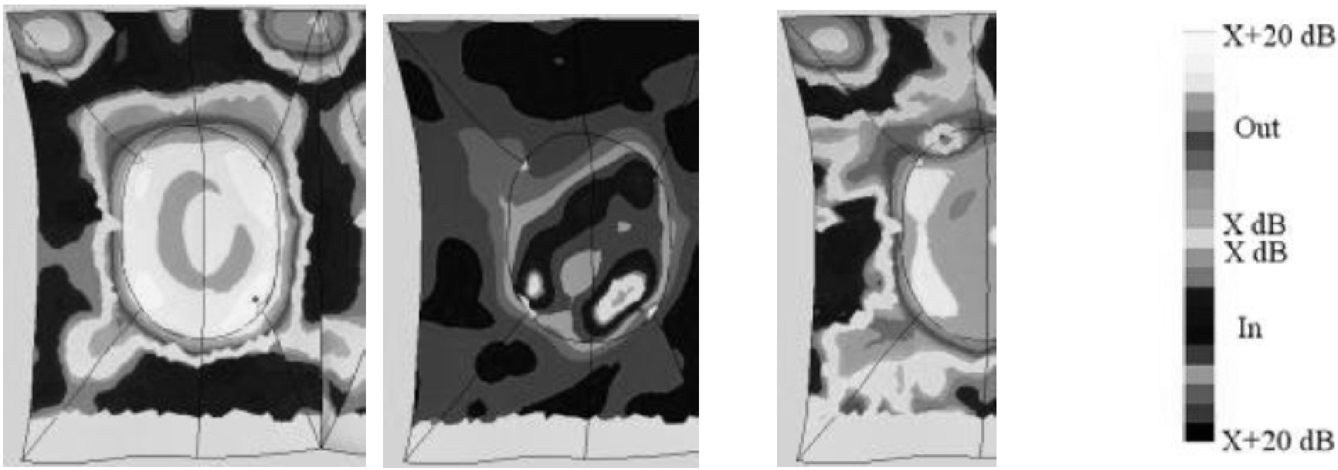


Fig. 4: SONAH calculations. Left: Transmission loss noise without emission from loudspeakers (reference). Middle: Transmission loss with emission from loudspeakers. Right: Transmission loss with emission from loudspeakers, but with Entering Intensity processing applied.

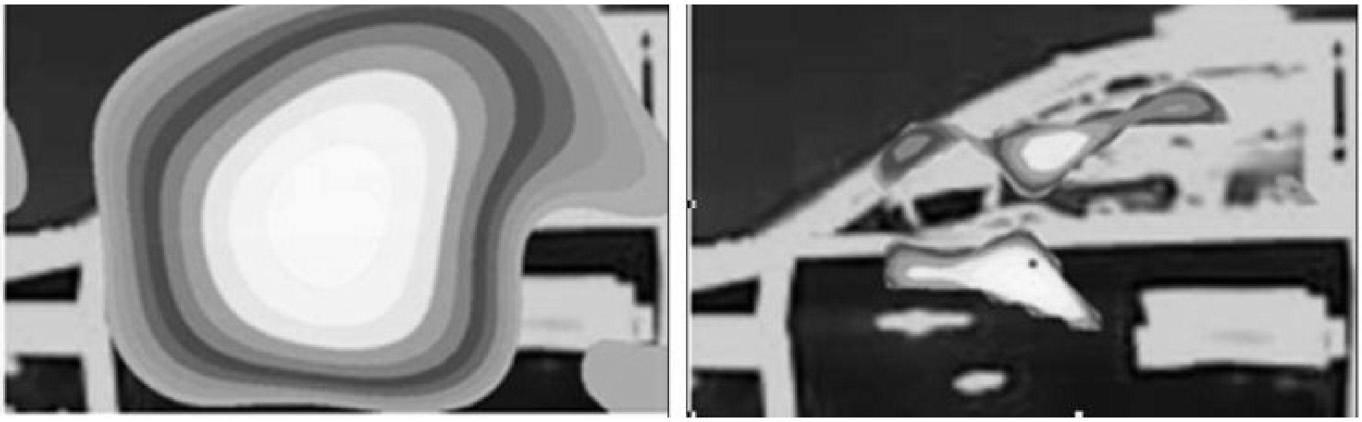


Fig. 5: Sound Intensity maps based on beamforming measurements in a wind tunnel. Left: delay and sum method. Right: Refined beamforming method.

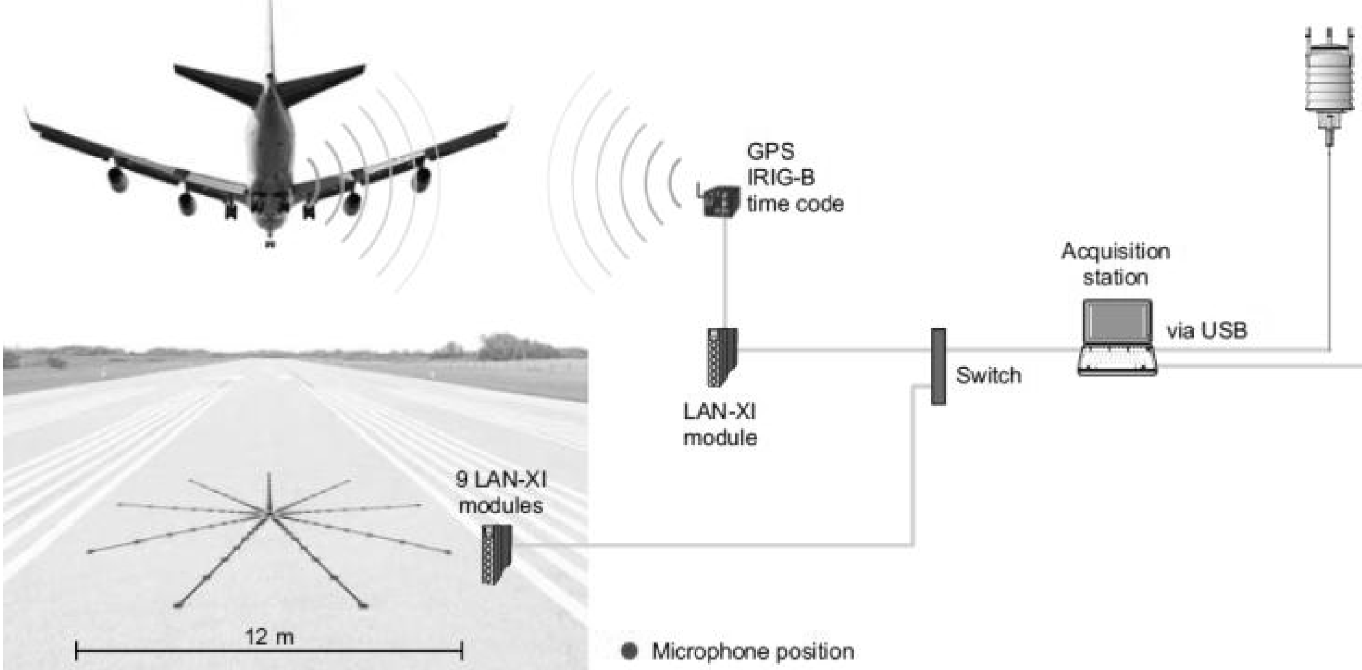


Fig. 6: Typical system for measurement and data acquisition for Noise Source Identification during flyover of passenger aircraft using Moving Source Beamforming.

To evaluate the Entering Intensity technique, tests were performed in a transmission suite facility, emulating the noise conditions around an aircraft window.

In the figure 4 (same scale, for a single octave band), the middle display shows a high level of absorbed power compared to the radiated power. The right plot shows that the result is close to the reference case when applying the Entering Intensity technique.

6. BEAMFORMING

Beamforming has become a popular technique for noise source identification for exterior vehicle noise (cars, trains and aeroplanes) and also in wind tunnels on both models and full sized vehicles.

Beamforming is somewhat similar to a camera in that an array of microphones behaves as a lens. The technique is based on a delay and sum principle, where an array of microphones is used to capture the plane wave [6]. The array itself is usually plane although a funnel shaped array may be used in order to suppress back-ground noise arriving from the rear of the array. The signals are then connected to a signal processor to determine the directional characteristics of the incoming sound.

The beamforming array is most sensitive to sound arriving from a particular direction. This region is known as the main lobe. Sound from other directions will also be detected to a certain degree; these regions are known as the side lobes. A good array design is characterized by having a large difference in the sound levels measured at the mainlobe and at the highest side lobes. The greater this difference, (known as the Maximum Sidelobe Level) the better the array is at reducing spurious peaks known as ghost images. Arrays with a regular grid of microphones are notorious in producing ghost images when the spacing between the microphones is larger than half a wavelength. Ideally, the array should have the microphones randomly distributed but this is not feasible for a practical system. A useful compromise is to build an array with identical segments, each segment containing a random distribution of microphones in order to optimize the performance of the beamformer over a wide frequency range.

7. REFINED BEAMFORMING

Delay and sum beamforming has a resolution of about a wavelength. However, if the source under test can be modelled by a finite number of non-correlated point sources, a refined beamforming technique based on deconvolution algorithms such as NNLS (Non-negative least squares) and DAMAS (Deconvolution Approach for Mapping Acoustic Sources) [7] can be used to improve the spatial resolution by a factor of three.

8. MOVING SOURCE BEAMFORMING

The moving source beamforming method can be employed when the source under test is in motion, such as a vehicle or train pass-by, an aircraft fly-over or a wind turbine [8]. In these situations, it is necessary to allow for the Doppler effect, turbulence effects and industry specific representation of the results. Where large ground based areas are employed, for example for air-craft fly-over, the correlation length between the microphones needs to be considered; a frequency dependent shading is useful in these cases to utilize the entire array area at low frequencies and a reduced central area at high frequencies.

For open sources such as lorries and trucks, special line displays and sliced cubes have been employed to locate sources on the vehicles. Moving source beamforming measurements have been successfully added to standardised pass-by measurements on test tracks, thus enabling type testing and research and development work to be run in parallel.

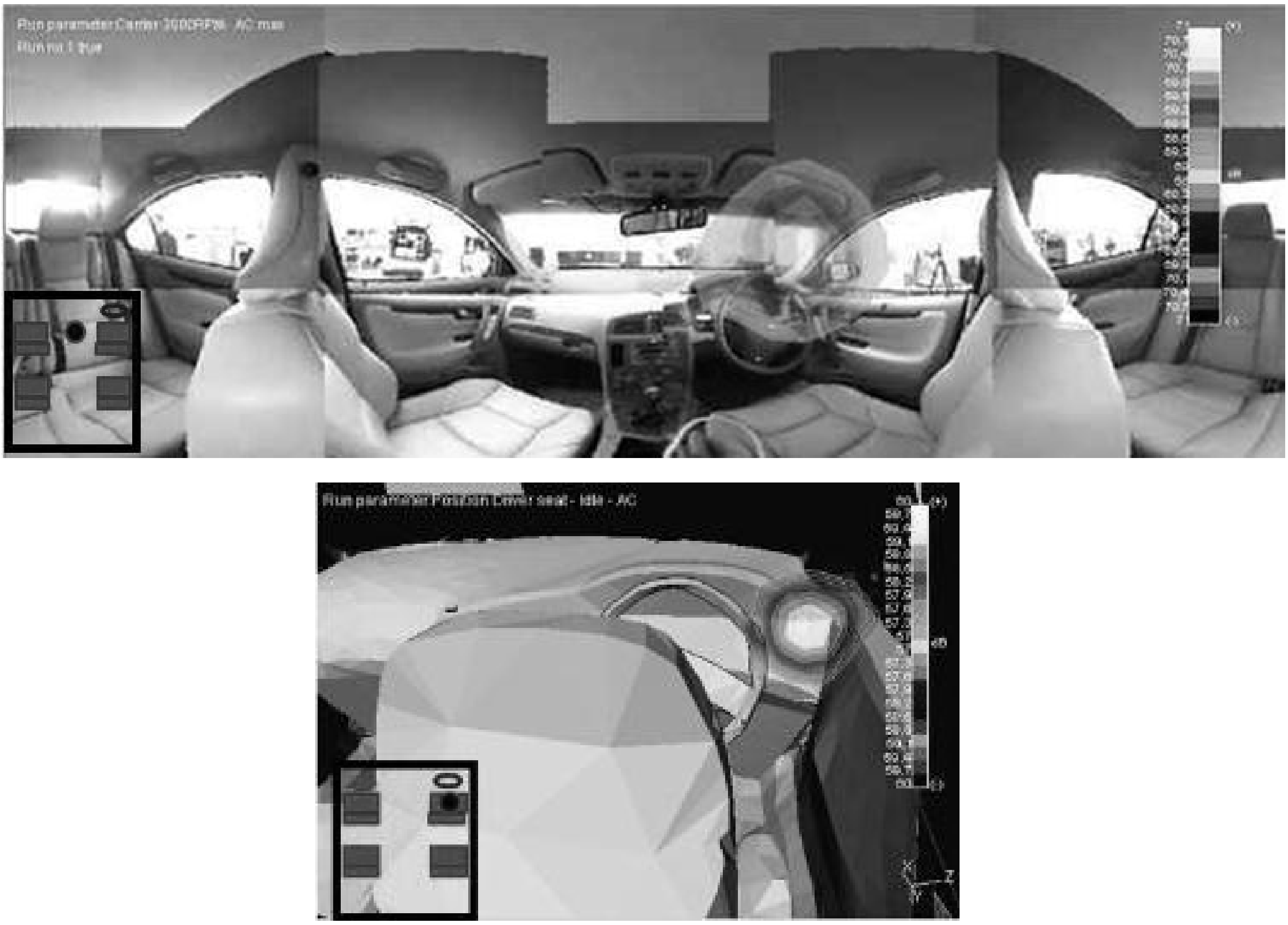


Fig. 7: Pressure contribution based on Spherical Harmonics Beamforming measurements in a car cabin. Air conditioning noise Top: Engine at 3000 RPM, alignment based on pictures. Bottom: Idle condition, conformal Spherical Beamforming based on the cabin model.

9. SPHERICAL BEAMFORMING

Spherical beamforming is the extension of planar beamforming to spherical arrays. Thanks to the array shape, no preferential directions are considered; therefore we are able to look at all directions around the sphere. This makes this type of array eminently suitable for enclosures, such as rooms or cabins. Obviously, it can be applied to free-field conditions as well.

Different types of techniques are applied to process the signals on the microphones. One typical and robust technique is based on spherical harmonic functions; usually referred to as called Spherical Harmonics Beamforming [9]. The sound field is sampled by the microphones on the sphere, and decomposed into spherical harmonics functions of different orders. Based on this decomposition, a directional function can be derived, to estimate the contribution from a specific direction. Applying this process to all directions around the sphere provides the acoustic map.

As for the (planar) beamforming technique, limitations occur in terms of resolution and dynamic range. The resolution is mainly governed by the sphere's radius: the larger the sphere, the better is the resolution for a given frequency. To increase the resolution for a selected radius, a hard (closed) sphere is preferable. In the context of Spherical Harmonics Beamforming, a hard sphere makes the processing more stable. The dynamic range, related to the highest sidelobe level, is determined by the number of microphones and their distribution on the sphere. Examples are presented in figure 7.

10. SOUND QUALITY METRICS MAPPING

Mapping sound intensity permits the localization of noise sources. However, to understand the effect of the noise source on a person, it is usually more appropriate to map sound quality metrics such as loudness, sharpness or impulsiveness [10]. The arrays required for such mapping are the same as for SONAH or beamforming, only extra processing needs to be added.

11. SELECTION OF AN NSI TECHNIQUE

Beamforming techniques assume that the sound field can be modelled by typically plane waves or point sources, whereas NAH using an array and sound map-ping using a single probe make no such assumptions. Therefore, broadly speaking, at measurement distances far from the source (several wavelengths), beamforming techniques can be used, whilst close to the source (fractions of a wavelength) NAH techniques are applicable.

Technique	Lower limit, fmin, Hz	Upper limit, fmax, Hz
NAH	c/D	c/(2dx)
SONAH	c/(8D)	c/(2dx)
Beamforming	Lc/(DR)	See note
Spherical Beamforming	> c/(aR_θ)	See note

c = speed of sound; D = diameter of array;
dx = average spacing between measurement points
R = resolution; R_θ = resolution in radians
L = distance of array from source; a= radius of array
Note: upper limit can be improved by processing. Optimisation of microphone positions can improve the Maximum Side Lobe level which determines the fmax.

Fig. 8: Lower & upper frequency limits of arrays.

The lower and upper limiting frequency of interest gives an indication of the techniques which can be used (Fig.8).

Roughly speaking, the lower the frequency of interest, the larger the array must be. The upper frequency limit is set by the average spacing between the microphones. However, the upper limit for Beamforming and Spherical Beamforming can be increased by using different algorithms and by an optimization of the microphone positions to adjust the Maximum Side Lobe pattern.

The resolution obtainable for NAH/SONAH depends on the average spacing between the microphones as there needs to be at least 2 microphones per wavelength. For Beamforming, the resolution depends on the wavelength, the nature of the sound source (coherent or non-coherent), on the algorithm employed and also on the size of the array (Fig.9). For the classical delay and sum algorithm, resolution is about one wave-length. This can however be improved by employing a deconvolution technique such as refined beamforming [7].

Another factor to be considered is the measurement area covered by the array (Fig. 10). For NAH, the array must be large enough so that virtually all acoustical energy passes through the array area. In practice this means that the array must often be of greater dimensions than the object under test. For SONAH, even though the array only covers part of the source, good representation of the sound field can be obtained. For spherical beamforming with omnidirectional directivity, provided that the measurement distance is more than about twice the radius of the spherical array (to avoid near field effects), there is no limitation to the area covered.

Technique	Planar Combo Array Spatial resolution, R, metres	Handheld Array Spatial resolution, R, metres	Spherical Array Angular resolution, R_θ degrees
NAH/SONAH	Average spacing between micro's	Average spacing between micro's	Average spacing between micro's
Beamforming Coherent sources	= max(λ, Lλ/D)	= max(λ, Lλ/D)	180/ka
Beamforming Non-coherent sources	= max(0,7λ, Lλ/D)	= max(0,7λ, Lλ/D)	180/(1,4ka)
Refined Beamforming Non-coherent sources	= 0,3λ	= 0,3λ	—

k = wavenumber; a = radius of array; λ = wavelength
L = distance to source; D = diameter of array

Fig. 9: Resolution of various acoustical arrays.

12. SELECTION OF AN ARRAY DESIGN

Once the engineer has decided upon an NSI technique, there is still the question of selecting the best array design. If NSI needs to be performed inside a vehicle cabin, then it could be advantageous to use a double layered array for SONAH in order to minimize the effects of the reverberant field or a spherical array for Beamforming. In engine test cells and other nearly free field situations, a planar array would be adequate; if such an array is designed to be used with both SONAH and Beamforming, it is usually termed a Combo array. Outdoor measurements, such as measurements on wind turbines and trains, are prone to interference from extraneous sources. In such cases a foldable array in the form of a funnel, can be used to reduce the influence of sound arriving from the rear of the array. For some outdoor measurements such as large wind turbines and fly-over beamforming, the necessary array is so large that it has to be mounted on the ground. Each micro-phone should be situated on a hard reflective surface (e.g. the runway tarmac or large hard plate) to avoid the effects of ground impedance as a function

Technique	Measurement area covered by the array	Measurement distance, L
NAH	≤ 0,9 x Area of array (see note)	= dx
SONAH	≈ area of the array	= dx
Beamforming	≈ +/- 30 degrees from array axis	≥ 0,7D
Spherical Beamforming	No limitation	≥ 2a

D = diameter of array; a = radius of array
dx = average spacing between measurement points
Note: when the NAH array is larger than the source under test

Fig. 10: Measurement area & distance.

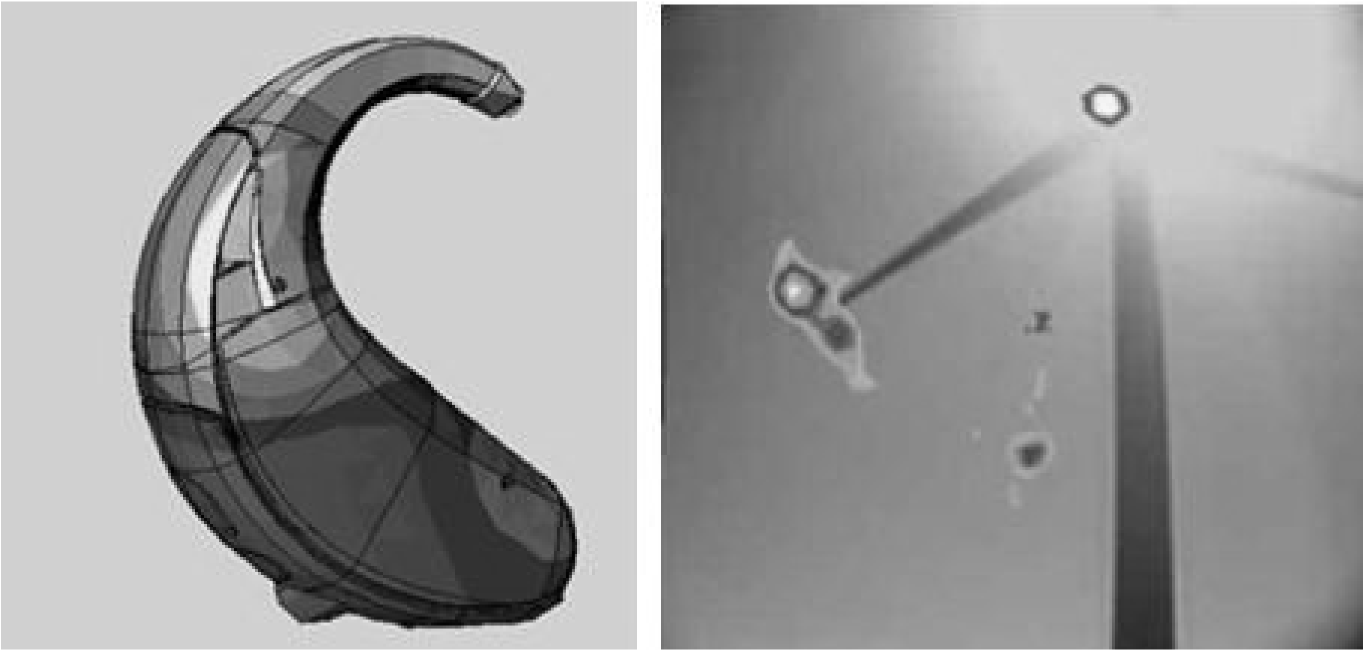


Fig.11. Left: Conformal sound intensity map on a hearing aid at 2400Hz. Right: refined beamforming sound intensity map on wind turbine at 4000Hz

of the angle of incidence of the sound. For measurements on small objects such as hearing aids and dental drills, the array could consist of no more than two microphones: a stationary reference microphone and a probe microphone moved from position to position in a very fine mesh by means of a robot.

CONCLUSION

The list of techniques available for the NVH engineer to perform noise source identification is continually expanding. This article reviewed and compared the most common techniques together with guidelines as to how and when they can be employed. For the engineer to optimally exploit the techniques the implementation should be simple; superfluous parameters should be hidden from view and engineering expertise should be embodied in the solution so that the engineer can concentrate on the task in hand: noise source identification.

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Institute of Acoustics
Musical Acoustics Group News

Michael Wright MIOA (Chair of the Musical Acoustics Group)

Institute of Acoustics

3rd Floor St Peter's House, 45-49 Victoria Street, St. Albans, Hertfordshire, AL1 3WZ, UK

I am writing to you as Chair of the Institute of Acoustics Musical Acoustics Group. The IOA is the UK member of ICA and this message has been copied to all members and observers that were shown on the November 2011 listing that currently appears on the ICA website. I believe that some of the Member Organisations of the ICA, including observers may be interested to know of the current status, activities and interests of the IOA Musical Acoustics Group. The following extract from the Institutes profile will explain more. The attached notice of a recent successful meeting in London and extract below will give further insight of the recently revitalised Musical Acoustics Group.

The Institute of Acoustics is the UK's professional body for those working in acoustics, noise and vibration. It was formed in 1974 from the amalgamation of the Acoustics Group of the Institute of Physics and the British Acoustical Society (a daughter society of the Institution of Mechanical Engineers). The Institute of Acoustics is a nominated body of the Engineering Council, offering registration at Chartered and Incorporated Engineer levels.

The Institute has some 3000 members from a rich diversity of backgrounds, with engineers, scientists, educators, lawyers, occupational hygienists, architects and environmental health officers among their number. This multidisciplinary culture provides a productive environment for cross-fertilisation of ideas and initiatives. The range of interests of members within the world of acoustics is equally wide, embracing such aspects as aerodynamics, architectural acoustics, building acoustics, electroacoustics, engineering dynamics, noise and vibration, hearing, speech, underwater acoustics, together with a variety of environmental aspects. The lively nature of the Institute is demonstrated by the breadth of its learned society programmes.

Further details can be can be found on www.ioa.org.uk

The Institute of Acoustics Musical Acoustics Group has a very important part to play in the understanding and research of many aspects of acoustics. The obvious connections between music and acoustics include the design of opera, concert and recital performance venues, studio and practice room acoustics and design.

However, aspects such as musical instrument design, music technology, music therapy, musical perception, the singing voice, the use of electronics in musical performance and reproduction also encompass a wide field of acoustical knowledge.

The mission of the Institute of Acoustics Musical Acoustics Group is as follows:

- To encourage closer working with professionals in related disciplines such as architects, musical instrument designers and builders, sound engineers, performing musicians and composers, musical education, music in health and wellbeing.
- To be a forum for members and other professionals with an interest in all aspects of musical acoustics.
- To promote a wider understanding of musical acoustics to academics, professionals in all related fields and increase public awareness.
- To hold regular meetings (with access available to related professional disciplines) for the interchange of information and experiences.

Musical Acoustics is a specialised aspect and deserves more attention by acousticians. I believe that knowledge sharing is most important. By encouraging international interest including participation in meetings and conferences, awareness of new publications etc, this could contribute to raising general awareness.

This is an informal message and I am aware that it is being circulated in English. However, I also emphasis that I would welcome interest from all representatives of organisations in ICA, regardless of location who may have an interest in Musical Acoustics. I would be grateful if this message is also circulated to members that have joined ICA since 2011.

Yours sincerely,

Michael Wright MIOA

(Chair of the Musical Acoustics Group) ¶

IoA News: Turbine Noise Guide

The Institute of Acoustics has published a good practice guide on wind turbine noise assessment.

Following an extensive consultation exercise last year after the publication of a draft guide, the Institute's working party has completed the redrafting of the document officially launched on 21 May.

The document, "provides significant support on technical issues to all users of the ETSU-R-97 method for rating and assessing wind turbine noise".

Working group chairman Richard Perkins said: that the scope required an examination of "the technical elements of the methodology" but did not allow a consideration of the noise limits, which "are a matter for government".

Source: http://www.ioa.org.uk/about-us/latest-news.asp


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Data Centre Cooling Strategies

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This paper was previously presented at the 21st Biennial ASNZ Conference, Wellington, NZ

Abstract

Strategies for upgrading cooling systems for two existing data centres have been explored. The systems are located in a challenging noise environment. The ability of the systems to withstand conventional noise control treatment was explored. For one system, a conventional noise control solution has been adopted. For the second system a more unusual solution is being considered using only outdoor air. The project is ongoing.

1. INTRODUCTION

Two data centres A and B are located in a high-rise office building. Both data centres are cooled using DX indoor process coolers and air-cooled condensers. Air is circulated under the raised computer floor, drawn up through the enclosed computer racks, and drawn back in through the top of the process coolers. Refrigerant is piped from the indoor process coolers to external condensers located on a raised outdoor platform.

Noise complaints from the operation of the outdoor condensers have been received. The daytime noise limit is L_{10} 65 dBA, the night-time noise limit is L_{10} 60 dBA.

The site is surrounded on two sides by adjacent high rise buildings that are within metres of the site boundary. There is an open concrete car park which extends underneath the data centre building. Noise from the condensers is reflected around the concrete carpark and radiates into the vertical gap between the buildings on two sides. In noise control terms the site is challenging.

2. DATA CENTRE A

A noise measurement made in 2009 gave a result of L_{10} 70 dBA, made only metres from the data centre A condensers. Noise control work was implemented by others, however subsequent measurement results in the range of L_{10} 63-65 dBA indicate compliance with the night-time noise limit has not been achieved.

Because of the reflective nature of the site, noise levels do not vary much around the building. We have measured noise levels of L_{10} 61-62 dBA at level 8 of the building - the condensers are located at level 1.

The previous noise control treatment implemented consisted of a “shroud” constructed over the top of the condensers, with internally lined discharge ducts. The underside of the the condensers was left untreated, however intake airflow is obstructed to a degree by other building structure.

Further noise control work would require restricting the airflow around the condensers, especially on the intake side. The ability of the condensers to cope with a further restricted airflow, and the effect of this on the cooling capacity, needed to be explored.

We established that the existing condensers were operating at reduced capacity due to the reduced air flow rate. The addition of the “shroud” on the discharge side, and the already slightly obstructed intake path, meant in reality the condensers would be at full capacity or more, especially in summer months. We concluded that there was no opportunity to reduce the fan speed of the existing condensers to reduce noise.

The condensers could have been enclosed in a ventilated plant room, but space constraints and cooling considerations made this impractical.

Raising the condensers to install additional intake treatment below was also considered. Additional attenuators would need to be very large in order to keep air velocity and pressure drop low. Given site and cost constraints this was not considered to be practical.

The existing condensers were using R22 refrigerant which is being phased out, resulting in a further loss of efficiency.

After due consideration it was decided that the best solution would be to replace the existing condensers with newer quieter models with greater cooling capacity. Because of the excess cooling capacity of the new proposed condensers, fan speed can be reduced to 400-500 rpm. The newer condensers are physically larger but will still fit on the same outdoor platform, with a relatively minor extension.

Overall the replacement condensers have a sound power rating approximately 15 dB less than the existing condensers.

3. DATA CENTRE B

Data centre B is in the same building. Again, cooling is by DX indoor process coolers, but in this instance the external condensers are built into the building façade. Our measurements indicate that noise from these "façade condensers" may be reflecting around the site and contributing to overall measured noise levels.

Analysis again showed the cooling system was operating at or near maximum thermal capacity. The "facade" condenser arrangement added another complication in terms of recycling of warm air between condensers, which is difficult to quantify but more than likely is reducing efficiency.

One option would be similar to the solution adopted for data centre A, i.e. install new "low noise" condensers in an outdoor location. A large new raised condenser platform would be needed.

4. ALTERNATIVE COOLING OPTION

Another option would be to scrap the the existing DX cooling systems and replace it with outdoor air cooling systems

There has been a rapid advancement of outdoor air cooling during recent years, mainly due to the innovation of end users of server equipment such as Google, Facebook & Yahoo driving down cooling energy costs. In most cases advancements in technology precede the end users, in this instance however technology and standards have been updated to keep up with the end users.

A good example of this is the ASHRAE standards for data centre temperatures which have been revised repeatedly to keep up with the end users.

The latest ASHRAE standards for the inlet temperatures to server equipment are shown in the referenced white paper by Microsoft/Intel (1)

As a result of the increased temperature drive by end users, the maximum air temperature into server equipment has been steadily increased by server manufacturers e.g. Dell – refer (2).

Most server manufacturers (CISCO, Dell, HP, IBM etc), now rate their servers at at least 35 ^{o}C air into the servers. This means that keeping modern computer rooms cooled to low temperatures may not be necessary.

There have been several innovative designs by end users to cope with the higher temperatures, such as re-designing servers with power and data cabling in the cold isle.

The term PUE (power usage effectiveness = total data centre power divided by power consumed by servers) is used to define the efficiency of data centres.

Large data centre owners such as Google and Facebook now have data centres that are PUE < 1.1 as compared to DX cooled centres which would be around PUE = 1.5 +.

5. CONSIDERATIONS

The following preliminary design considerations must be taken into account for outdoor air cooling systems for data centres;

The age and thermal capacity of the equipment must be established. Newer equipment with a higher temperature rating is required.

The room must be able to be configured into an alternating "hot aisles" and "cold aisles" layout. Outside "cold" air is drawn through the server racks to the "hot aisle" side, where it is exhausted from the building.

Fans, filters & ducting are required to supply and exhaust the air. There must be sufficient space inside the room for the fans and associated ductwork or silencers.

Benefits

In adopting an outside air solution, cooling systems are replaced with fans (with back-up as needed). The systems are simpler and overall electricity savings can be significant.

We have estimated that if outdoor air systems were implemented for the data centres, costs savings could be of the order of $100,000+ per year due to reduced electricity costs. Payback of the cost of converting to "outside" air would take 1-2 years, thereafter the cost savings would be significant and on-going.

Outside air cooling also increases space and reduces the need for expensive maintenance contracts.

Disadvantages

Studies have shown that there is a slight decrease of performance, increase of server power consumption (mainly due to the increased server cooling fans speed) and increase of noise levels (due to the higher server fan speed). There can also be a slight increase of equipment failure rate, although in New Zealand conditions this is expected to be minimal.

The hot isle in the room will be warmer than traditional "cooled" computer rooms (say 40^{o}+ in summer in the hot isle in New Zealand conditions), and therefore less comfortable.

The noise levels in the room will increase – we measured around 80 dB(A) in the existing data centres, which is already fairly noisy.

Workers inside such data centres should be lightly dressed (in shorts and T shirts!), and wearing ear muffs, as the server fan noise levels will be high depending on the outside air temperatures.

6. CONCLUSION

This study raises a number of interesting points;

Advances in technology are rapid and can trickle-down and effect many aspects of what we do. Keeping up with the technology industry "best practice" is an on-going exercise.

End users can drive innovation and force revision of standards and industry "norms".

Finally, as always, the best noise control is no noise control. Eliminating condensers or chillers entirely is the ultimate "noise control at source". On "difficult" sites it certainly makes the acoustic consultant's job easier, and can also save money.

7. REFERENCES & ACKNOWLEDGEMENTS

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Health Effects of Cochlear Implants

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This paper was previously published in the Journal of the New Zealand Medical Association, 31 May 2013, Vol 126 No 1375

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Abstract

Aim To investigate whether people on a waiting list for cochlear implantation are more likely than those who have cochlear implants to suffer from illnesses which are potentially mediated by stress. **Method** A questionnaire, designed to assess the presence, persistence, and medication use associated with stress-related illnesses, was administered to two groups: those on a waiting list for cochlear implantation and adult users of cochlear implants. **Results** Those on the cochlear implant waiting list had significantly poorer health as indicated by: a greater number of conditions experienced in the past year, longer illness length when affected by a condition, medication use for a greater number of conditions, and poorer mental health. **Conclusion** There are lengthy waiting lists for adult cochlear implantation. The need to wait and the lack of a known date for surgery, in combination with having a profound hearing loss is likely to result in chronic stress. Chronic stress may increase the risk of physical and mental illness via physiological systems which mediate response to environmental threats. Cochlear implantation may alleviate chronic stress in people on the waiting list, and these findings support the hypothesis that this influences physical health.

1. INTRODUCTION

In New Zealand, access to cochlear implantation for adults is limited.[1] Adults must go on a waiting list with no advised date of surgery. Many remain on that waiting list for over a year, whilst knowing that an operation would likely provide them with many benefits: the mean time on the waiting list is around four years.

Position on the waiting list is subject to change because if new people are admitted to the list, they may be placed higher than existing applicants: position is based primarily on need as assessed by hearing disability. Waiting for medical intervention has been shown to increase stress[2] and reduce quality of life.[2]

Thus, people on the cochlear implant waiting list are in a position that may be considered stressful. In addition to the stress of waiting, the effects of acquired profound hearing loss are also likely to be stressful.

Social isolation,[3] tinnitus,[4] grief,[5] and embarrassment[6] can all be consequences of hearing loss and may all result in stress. Further to this, a reduction in social support due to deterioration of interpersonal relationships may also diminish one's capacity to cope with stress.[7]

Stress will lead to negative emotions and physiological arousal (Figure 1). This arousal, mediated by individual factors such as stress reactivity and recovery, and the effects of stress-related health behaviours, will lead to increased risk of physical and mental illness.

The development of a particular illness is affected by genetic predispositions, vulnerabilities, and previous illnesses or injury. Stress increases the risk of developing illnesses and can aggravate current illnesses:[8] it has been linked to diabetes, asthma, arthritis, and depression, among others.[9]

That stress affects people with hearing loss is supported by findings of reduced health-related quality of life,[10] increased depression,[11] increased anxiety,[11] and poorer physical health[10] in this group.

After cochlear implantation, an alleviation of stress may be expected. Cochlear implants (CIs) have been associated with better health-related quality of life [12] and reduced symptoms of mental illness.[13] However, no published findings indicate whether the improvement seen with mental health extends to physical health.

The aim of this study was to investigate the health (physical and mental) of CI recipients and compare it to that of those on the CI waiting list.

2. METHOD

Participants

Two groups were compared: those on the Northern Cochlear Implant Trust (NCIT) waiting list for cochlear implantation and those who have received CIs through the NCIT or who are receiving follow-up care through the NCIT. A questionnaire was sent to all these individuals with approval from the Ethics committee of the University of Auckland (Ref no. 2010/199).

Candidacy for a CI depends upon having a bilateral severe to profound sensorineural hearing loss for their better ear and where hearing aids provide limited or no useful benefit. There is no maximum age for referral, and patients with additional needs are not excluded. Adults have normally acquired hearing

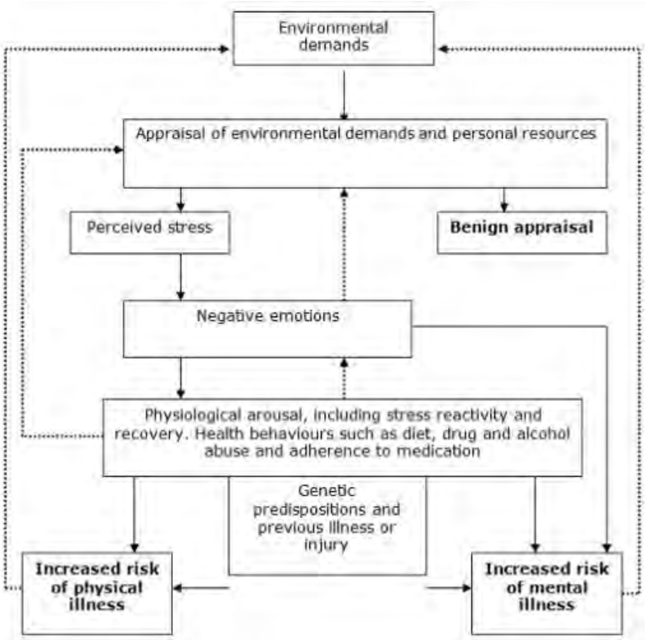

Figure 1. The development of psychophysiological illnesses. Solid lines indicate the processes through which illnesses develop due to stress and the dotted lines show how outcomes may feed back into this process and contribute to the burden of stress. Adapted from Cohen, Kessler and Gordon.[8]

loss post-lingually. In addition, the adults must be fit and well enough to undergo an operation. Of the 64 people on the waiting list, 44 (69%) responded.

The cochlear implant group consisted of adults who had received their implants at least 12-months ago, and were currently using, a cochlear implant through the NCIT, as well as those who had been implanted and funded by another provider (Accident Compensation Corporation (ACC) or private). Questionnaires were sent to 199 people for this group, and 119 (60%) responded.

Instruments

A questionnaire was created to investigate the presence and frequency of potentially stress-related, physical illnesses (Table 2): participants were asked to indicate how many days they suffered from symptoms of each condition in the previous year, thus creating variables that ranged from zero to 365; whether medication was used for each condition in the past year was also indicated. The 21-item Depression, Anxiety, and Stress Scale (DASS-21)[14] was used to assess mental health.

This questionnaire which has three scales: Anxiety, Depression, and Stress, and can also be used, as we have, to provide a total mental-health score.

Questions about demographics, general health perception (Question 1 from the Short Form health questionnaire (SF-36) [15]), frequency of physician visits and sick days, and self-rated dissatisfaction with hearing (10-point scale; Figure 5) were also included. Furthermore, the following factors which may be associated with the relationship between stress and health were investigated: smoking,[16] binge alcohol consumption,[17] cohabitation,[18] employment,[19] and body mass index (BMI).[20]

The two groups were compared in terms of overall health measures. In principle, overall measures should better reflect the impact of stress than specific conditions because the latter would be more influenced by individual predispositions and vulnerabilities: by considering overall effects, the impact of stress should be revealed.

Overall health measures were: percentage of each group experiencing any potentially stress-related health condition (Prevalence), the number of days affected during the previous year (Persistence: N.B. to prevent an artefactual inflation due to Prevalence, Persistence was calculated as the mean days affected for those with any health condition—i.e. the total days affected divided by the number of conditions), and the percentage of those affected who took prescription medication (Medication).

Prevalence gives a measure of the overall health of each group, while Persistence and Medication Use provide evidence of the impact of the conditions.

Data analysis

Questionnaire data were analysed using Analysis of Covariance (ANCOVA) to allow comparison of the waiting list and CI groups while controlling for potentially confounding variables.

To explore the data further, where significant overall effects were observed, analyses were conducted at the level of the specific health conditions assessed. These were conducted using either t-tests (continuous outcomes) or Chi-squared tests (discrete outcomes). Since these analyses were exploratory and there was low statistical power due to the relatively low numbers experiencing each of the individual conditions, no attempt to correct type-I error rates for multiple testing was made.

Least-squares linear regression models for the two stressors (time on the waiting list and dissatisfaction with hearing) were established overall and for the waiting list and cochlear implant groups separately.

Four outcome measures were used: Prevalence (sum of conditions experienced), Persistence (average days affected), Medications, and DASS-total score. Stressors were included as predictors in separate models; all of these controlled for age, sex, living situation, and employment status.

3. RESULTS

No significant differences in age (t[158]=.511, p=0.610), sex (Chi-squared [1, N=162]=1.207, p=0.179), living situation (Chi-squared [1, N=158]=.775, p=0.252), or employment status (Chi-squared [1, N=155]=1.444, p=0.154) were found between the two groups (Table 1).

Those with cochlear implants had had their implant, on average, for 5.73 years (SD=4.93, Range: 375–6653 days) and they had, on average, spent approximately 9 months (mean=0.68 years, SD=0.67, Range: 8-1218 days) on the waiting list prior to their cochlear implant surgery. Those on the waiting list had been on the list, on average, for 18 months (mean=1.47 years, SD=1.18, Range: 45-1960 days).

Health

11% (n=4) of those on the waiting list and 6% (n=7) of those with cochlear implants were smokers (Chi-squared [6, n=158]=4.552,

Table 1. Demographic characteristics of participants by group

Variables		Waiting list	Cochlear implant
Age	Mean	60.2 (SD=17.9)	58.6 (SD=17.3)
Sex	Male	17 (39%)	57 (48%)
	Female	27 (61%)	61 (52%)
Living situation	Alone	9 (21%)	32 (28%)
	With others	34 (79%)	83 (72%)
Employment (full or part-time)	Employed	17 (40%)	58 (51%)
	Other	25 (60%)	55 (49%)

p=0.602). In regards to binge alcohol consumption, 27% of those on the waiting list and 28% of those with cochlear implants reported consuming five units of alcohol or more, on at least one day a week (Chi-squared [8, n=157]=8.307, p=0.404).

Of those on the waiting list, 55% were considered overweight or obese according to their BMI compared to 62% with cochlear implants (Chi-squared [2, N=146]=1.295, p=0.523).

Those on the waiting list visited their doctor an average of 6.2 (SD=4.8) times a year, whereas those using cochlear implants did so 4.3 (SD=3.7) times a year (t(151)=2.616, p=0.010). However, no significant differences between the two groups were found in days off work because of illness or bedridden days (both p>0.4).

General health

People on the waiting list were less likely to rate their health as very good or excellent and more likely to rate their health as poor, fair or good than people with cochlear implants (Chi-squared [4, N=157]=9.609, p= 0.048; Figure 2).

Prevalence of potentially stress-related health conditions

People on the waiting list reported experiencing an average of 5.8 (SD=3.01) different health conditions in the past 365 days whereas those with cochlear implants reported an average of 4.5 (SD=2.70) conditions, (F[1,161]=7.153, p=0.008).

This difference remained after correcting for age, sex, living situation and employment, (F[5,152]=5.525, p=0.020). The distribution of the number of conditions experienced in the past year is shown in Figure 3.

Within this, tinnitus (Chi-squared [1, N=160]=5.758, p=0.016); diabetes (Chi-squared [1, N=163]=7.705, p=0.006); CVD (Chi-squared [1, N=162]=4.324, p=0.038) and hypertension (Chi-squared [1, N=163]=5.272, p=0.022) were all significantly more common in those on the waiting list than in those with CIs (Table 2).

No conditions were significantly more common in the cochlear implant user group than in the waiting list group (all p>0.1).

Persistence

When people on the waiting list were affected by a condition, they were affected for longer than those with cochlear implants (F(1, 152)=11.604, p=0.001).

The average number of days affected for those in the WL group was 164 days (SD=121 days) compared to 97 days (SD=103 days) for the cochlear implant group. This difference remained after correcting for age, sex, employment status and living situation, (F(1, 142)=11.970, p=0.001).

Additionally, digestive problems (t(69)=2.154, p=0.035), migraines (marginally) (t(24)=1.913,p=0.068); and tinnitus (t(65)=2.830, p=0.006) when experienced, occurred more frequently in the waiting list group than the cochlear implant group (Table 2). There was no difference between the two groups for any of the other individual conditions (all p>0.1).

Medication

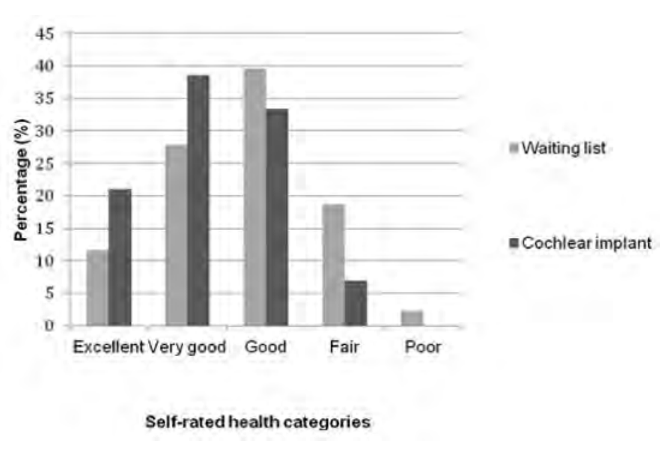

Figure 2. Self-rated general health perceptions of those on the waiting list for cochlear implantation compared to those with cochlear implants.

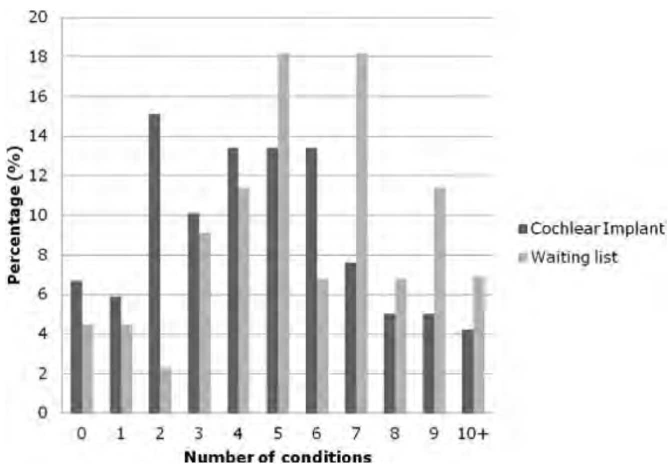

Figure 3. Distribution of number of potentially stress-mediated conditions experienced by CI-users and people on the waiting list for a CI.

People on the waiting list, on average, took prescription medication for 3.1 (SD=2.4) conditions whereas those with cochlear implants took prescription medication for 1.8 (SD=1.9) conditions (F(1, 161)=12.602, p=0.001). This difference remained after correcting for age, sex, living situation and employment, (F(1, 146)=11.597, p=0.001).

People on the waiting list were more likely to take prescription medication for migraines (F(1,26)=4.984, p=0.034), ear infections (F(1, 19)=8.44, p=0.009), and sleep disturbances (F(1, 42)=9.990, p=0.003) than those in the cochlear implant group (Table 2).

Mental health

The proportion of each group meeting the DASS-21 diagnostic criterion for anxiety (Chi-squared [1, 158]=5.699, p=0.016), depression (Chi-squared [1, 158]=3.874, p=0.042), and stress (Chi-squared [1, 158]=5.347, p=0.023) was higher in those on the waiting list than in those using cochlear implants (Figure 4).

Total psychological distress, indicated by the total score on the DASS-21, was also increased in the waiting list group (Mean=22.9, SD =18.6) when compared to those with cochlear implants (Mean=15.4, SD=15.5), F (1, 156)=6.560, p=0.011. This difference remained after correcting for age, sex, living situation and employment, (F [1, 144]=5.678, p=0.018).

Dissatisfaction with hearing

As would be expected, people on the waiting list had greater dissatisfaction with their hearing (Mann-Whitney U = 142.5, p<.001) than those on the waiting list (Figure 5).

Table 2. Specific health conditions

Health Condition	Number Responding		Prevalence (%)		Persistence (Days)		Medication (%)	
	Waiting List	CI Users	Waiting List	CI Users	Waiting List	CI Users	Waiting List	CI Users
Tinnitus	42	118	60*	38	308*	199	12	2
Hypertension	44	119	48*	29	280	237	94	90
Digestive symptoms	44	118	48	48	135*	62	71	63
Cold	44	119	48	49	6	9	30	23
Back Pain	43	119	42	42	140	108	65	43
Joint Pain	44	119	39	35	214	158	50	40
Neck Pain	44	119	34	28	142	72	54	31
Arthritis	44	119	25	17	349	309	50	53
Sleep problems	44	119	25	29	236	174	55*	12
Migraine	44	119	25	14	72**	19	64*	24
Ear infection	44	119	23	13	45	11	100*	46
Diabetes	44	119	21*	6	320	243	89	50
Influenza	44	119	21	19	5	10	50	39
Asthma	44	118	18	9	105	40	100	91
Chest infection	44	119	18	9	74	23	71	82
Cardiovascular Disease	43	119	16*	6	365	268	100	100
Heart palpitations	44	119	14	8	105	32	50	33
Skin problems	44	119	9	6	219	218	100	86
Thyroid disorder	44	119	7	2	365	365	100	100
Irritable Bowel Syndrome	44	119	7	9	365	139	50	55
Cancer	44	119	7	2	¾	¾	¾	¾
Stroke	44	119	2	1	¾	¾	¾	¾
Ulcer	44	119	0	3	¾	365	¾	100
Colitis	44	119	0	1	¾	0	¾	100
Other	44	119	25	21	¾	¾	¾	¾

Note: Prevalence (Percentage of group with any potentially stress-related health condition), Persistence (mean number of days experiencing potentially stress-related health conditions), and Medication (Percentage of group using medication to treat potentially stress-related health conditions). Asterisks indicate where the waiting list group had poorer health markers than the CI group. *p<0.05; **p<0.01

Stressors prediction of health measures

Linear regression models controlling for age, sex, living situation and employment were run to examine the association between the potential stressors (Dissatisfaction with hearing and Time spent on the waiting list) and the four measures of health (Prevalence, Persistence, Medication, and DASS).

Dissatisfaction with hearing was associated with poorer health according to all four measures overall, but only with Persistence and Mental Illness in the CI group, and only (marginally) with Mental Illness in the Waiting List group (Table 3).

Time on the waiting list predicted greater Persistence and use of Medication overall, but was not related to Prevalence or Mental Illness, and was not associated with any of the health measures within the two groups separately (Table 3).

4. DISCUSSION

We showed that potentially stress-related health conditions had greater prevalence, illness persistence, and use of medications for in people on the waiting list. These findings are consistent with previous findings of an association between stress and illness.[9]

There was no a priori reason why waiting list candidates should have poorer health than CI users, and nor did controlling for potential confounding factors influence the effects; this implies that poorer health was attributable to the experience of living with acquired hearing loss and/or the experience of being on a waiting list for life-changing surgery.

Associations were stronger between dissatisfaction with hearing and the health measures, but time spent on the waiting list was also associated with health. This may imply that both are influential.

Prevalence, persistence, and medication

People on the waiting list had higher prevalence of stress-related conditions than those with a cochlear implant. The effects of stress on health vary between individuals, and may be mediated by predispositions such as genetics or previous illnesses.[21]

Thus, individuals who are undergoing similar stressors may develop different illnesses, and an overall indication of the total conditions experienced provides a stronger indication of psychophysiologically-mediated illness than any individual condition alone. Basing analyses on the total conditions also avoids potential statistical power issues associated with the rarer conditions.

Health conditions were more persistent in those on the waiting list. On average, individuals on the waiting list, when affected by any condition, were affected for 164 days compared to 97 days for those with cochlear implants. The findings are consistent with earlier research showing stress to aggravate current conditions and delay recovery from illness.[22].

The greater use of prescription medication in the waiting list group also indicates reduced health for this group. The differences in Persistence described above may have been greater had it not been for the medication used.

Smoking and binge alcohol consumption

The poorer health of those on the waiting list could be directly due to stress, or could be indirectly influenced by health-related behaviours common in people under stress, such as consumption of too much alcohol or smoking[23] However, no differences were seen between the two groups in relation to smoking and binge alcohol consumption.

There were few smokers and binge alcohol drinkers in both groups, which is consistent with previous findings of low levels of alcohol consumption and smoking in the hearing-impaired population[24], and this gave only limited statistical power to detect any differences which may have been present.

Tinnitus

The rate of tinnitus was 60% in the waiting list group and 38% in the cochlear implant group. This difference of about one third is comparable to previous reports of decreases in tinnitus rates after cochlear implantation [25].

Tinnitus holds a particular place in the relationship between stress, hearing loss and illness. Firstly, as for many of the conditions, tinnitus can be caused by stress [26], and can also lead to stress,[27] resulting in a cycle of increasing illness and stress. Secondly, tinnitus can be caused by hearing loss [4] or by stress.[26] Furthermore, cochlear implantation could reduce tinnitus via activation of the auditory pathways[4] or by reducing stress[26].

Thus, unlike other conditions, there were two mechanisms that

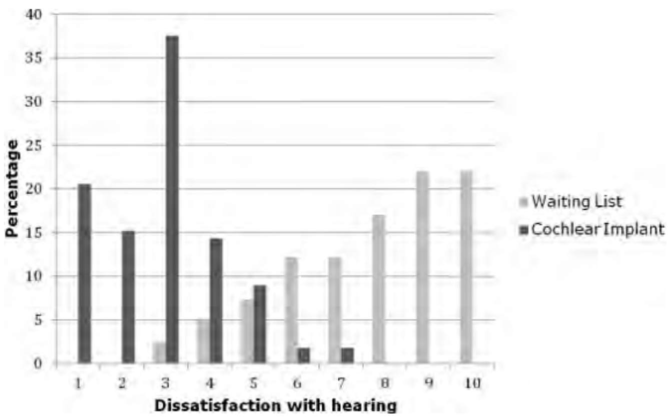

Figure 3. Distribution of number of potentially stress-mediated conditions experienced by CI-users and people on the waiting list for a CI.

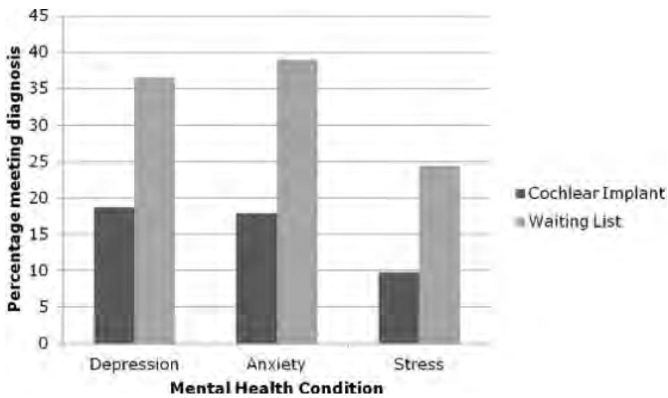

Figure 4. Percentage of each group meeting DASS-21 criteria for depression, anxiety, and stress.

may cause and reduce tinnitus. This may explain why tinnitus was the most commonly experienced condition in the waiting list group (stress plus hearing loss) and was also the condition with the greatest reduction following cochlear implantation (reduced stress plus auditory pathway activation).

Mental health

Symptoms of depression and anxiety[28] have previously been shown to improve following cochlear implantation. The current study adds further support for the mental health benefits of cochlear implantation as symptoms of all three facets (stress, depression, and anxiety) of the DASS were lower in those with cochlear implants than in those on the waiting list.

Dissatisfaction with hearing

Overall, dissatisfaction with hearing predicted poorer physical and mental health. This is consistent with the idea that impaired hearing would have an impact on health via isolation and frustration leading to chronic stress and thus impaired immune function.

The effects were less clear within the groups, but this would be explained by the reduced statistical power and the relative homogeneity of hearing within groups: the people on the CI waiting list all hear very poorly, so it is difficult to detect gradual effects amongst them.

Amongst the CI-users, there was rather more variability in functional hearing, and those who were still dissatisfied with their hearing also tended to have more persistent health problems and poorer mental health.

Time on waiting list

Overall, time spent on the waiting list was associated with more persistent health problems and greater use of medication, consistent with the idea that the waiting is stressful in itself. When psychophysiological changes persist through time, their effects add up and the risk of illness increases.[29] Increased waiting times for elective surgery have previously been associated with increased mental distress.[30]

Implications of findings

The implications of this research are important: cochlear implantation is reliant on available funding (e.g. government, donations) because the cost of implantation and support is very high and is thus rarely covered by an individual recipient. In New Zealand, public support of adult cochlear implantation is limited due to funding restrictions (for the Northern Cochlear Implant Programme, this has increased to 30 in the last 2 years). However, the increased presence and prolongation of illness in those on the waiting list will also burden the public health system. Thus, the true cost of cochlear implantation should take into account the consequent reduction of health system use and improved productivity.

Strengths and limitations

The main strengths of this research were that there were good and similar response rates for the two groups, and that the conditions assessed were all potentially mediated by stress. As far as we know, this is the first time that such differences have been observed in a CI/waiting list population, and the information may be valuable to policy-makers

It must be acknowledged that it is possible that some other factor(s) could lead to the observed differences in health. The research relied on self-report of health conditions, and those on the waiting list may have reported illness more readily than those with CIs for some unknown reason.

On the other hand, there was no obvious incentive for such behaviour, in that physical health state does not influence ranking on the waiting list, and the research was conducted independently and with anonymous questionnaires.

The research was cross-sectional and it cannot be ascertained that the health of the people on the waiting list was not already poor when they joined it. However, entry to the waiting list is permitted only if applicants are considered healthy enough to sustain an operation, and since entry to the waiting list is based primarily on hearing disability, there is no reason to suppose that the health, on entry to the waiting list, of current list members would have been poorer than those who have already received CIs.

Where present, associations between health measures and dissatisfaction with hearing and time on the waiting list were of the order of 0.2. These are small, but it must be borne in mind that our regression models controlled for potential confounding variables, and that many extraneous factors would be involved in influencing health. The effects are thus worthy of consideration, and the presence, rather than the magnitude of associations is of interest.

Table 3. Standardised linear regression coefficients (Beta) for the relationship between Stressors (Dissatisfaction with hearing and Time on waiting list) and Stress-related health measures. Models were run overall and for the CI and waiting-list groups separately. All models controlled for age, sex, living situation, and employment.

Variables	Dissatisfaction with Hearing			Time on Waiting List		
Stress-related Health Measures	Overall	Cochlear Implant Group	Waiting List Group	Overall	Cochlear Implant Group	Waiting List Group
Prevalence	0.189*	0.047	0.071	0.075	0.050	-0.066
Persistence	0.288**	0.209*	-0.039	0.200*	0.125	0.052
Medication	0.217**	0.040	0.044	0.198*	0.063	0.122
Mental Illness	0.291**	0.296**	0.380~	0.063	0.019	-0.196

Finally, while the conditions we considered were potentially stress mediated, we had no physiological markers of stress in the waiting list group other than their physical illnesses, and future research measuring physiological stress markers in both groups would be useful.

5. CONCLUSION

The findings of this research are important for two main reasons: they demonstrate the impact of long-term stress on both physical and mental health, and they imply that living with significant acquired hearing loss while waiting for a cochlear implant is detrimental to health.

Funding for adult cochlear implantation in New Zealand is limited, leading to lengthy waiting lists. Reduction of the waiting list time for cochlear implantation may contribute to the reduction of stress-associated medical conditions in those who have lost their hearing and thereby reduce the burden on the health system.

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Reviews of ISO Standards

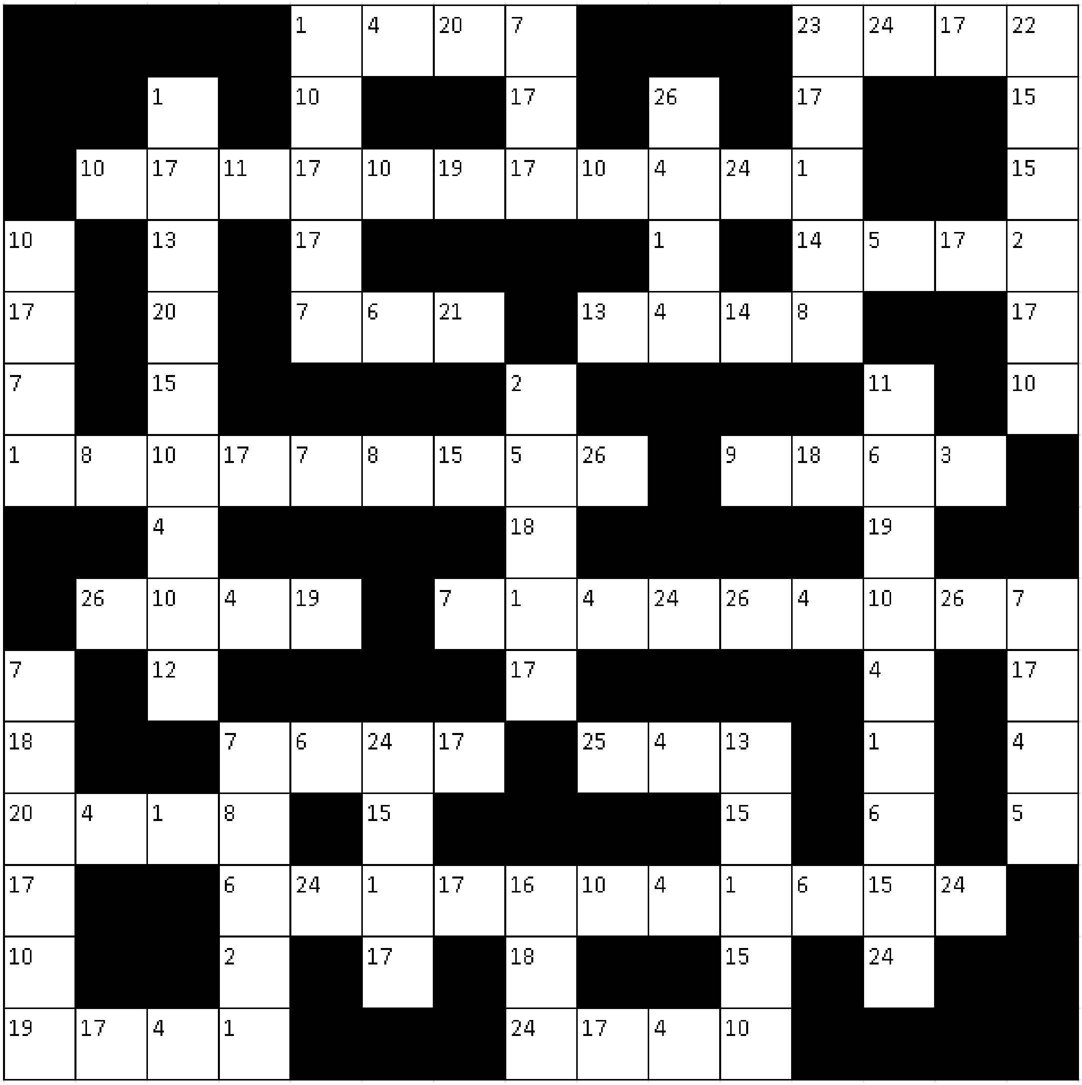
The following 21 ISO standards are due for systematic review in mid-September and New Zealand is required to vote. The questions we have to answer for each standard are shown at the end of the list. If there are members who regularly use, or are sufficiently familiar with, any of the standards and have a view on how we should vote please would you be kind enough to email that view to George Dodd (g.dodd@auckland.ac.nz).

ISO 226:2003 (Ed 2, vers 2)	Acoustics -- Normal equal-loudness-level contours
ISO 389-1:1998	Acoustics -- Reference zero for the calibration of audiometric equipment -- Part 1: Reference equivalent threshold sound pressure levels for pure tones and supra-aural earphones
ISO 389-7:2005 (Ed 2, vers 2)	Acoustics -- Reference zero for the calibration of audiometric equipment -- Part 7: Reference threshold of hearing under free-field and diffuse-field listening conditions
ISO 7029:2000 (Ed 2, vers 2)	Acoustics -- Statistical distribution of hearing thresholds as a function of age
ISO/TS 13475-2:2000 (vers 2)	Acoustics -- Stationary audible warning devices used outdoors -- Part 2: Precision methods for determination of sound emission quantities
ISO/TS 15666:2003 (vers 2)	Acoustics -- Assessment of noise annoyance by means of social and socio-acoustic surveys
ISO/TS 4869-5:2006 (vers 2)	Acoustics -- Hearing protectors -- Part 5: Method for estimation of noise reduction using fitting by inexperienced test subjects
ISO/TS 7849-1:2009	Acoustics -- Determination of airborne sound power levels emitted by machinery using vibration measurement -- Part 1: Survey method using a fixed radiation factor
ISO/TS 7849-2:2009	Acoustics -- Determination of airborne sound power levels emitted by machinery using vibration measurement -- Part 2: Engineering method including determination of the adequate radiation factor
ISO 11819-1:1997 (vers 2)	Acoustics -- Measurement of the influence of road surfaces on traffic noise -- Part 1: Statistical Pass-By method
ISO 13472-2:2010	Acoustics -- Measurement of sound absorption properties of road surfaces in situ -- Part 2: Spot method for reflective surfaces
ISO 13473-1:1997 (vers 2)	Characterization of pavement texture by use of surface profiles -- Part 1: Determination of Mean Profile Depth
ISO 13473-2:2002 (vers 2)	Characterization of pavement texture by use of surface profiles -- Part 2: Terminology and basic requirements related to pavement texture profile analysis
ISO 13473-3:2002 (vers 2)	Characterization of pavement texture by use of surface profiles -- Part 3: Specification and classification of profilometers
ISO 17201-2:2006 (vers 2)	Acoustics -- Noise from shooting ranges -- Part 2: Estimation of muzzle blast and projectile sound by calculation
ISO 3740:2000 (Ed 2, vers 2)	Acoustics -- Determination of sound power levels of noise sources -- Guidelines for the use of basic standards
ISO 4869-1:1990 (vers 3)	Acoustics -- Hearing protectors -- Part 1: Subjective method for the measurement of sound attenuation
ISO 4869-2:1994 (vers 3)	Acoustics -- Hearing protectors -- Part 2: Estimation of effective A-weighted sound pressure levels when hearing protectors are worn
ISO 4871:1996 (Ed 2, vers 2)	Acoustics -- Declaration and verification of noise emission values of machinery and equipment
ISO 9614-1:1993 (vers 3)	Acoustics -- Determination of sound power levels of noise sources using sound intensity -- Part 1: Measurement at discrete points
ISO 9614-2:1996 (vers 3)	Acoustics -- Determination of sound power levels of noise sources using sound intensity -- Part 2: Measurement by scanning
ISO 9614-3:2002	Acoustics -- Determination of sound power levels of noise sources using sound intensity -- Part 3: Precision method for measurement by scanning

ISO Systematic Review Questions

Question	Possible Answer (* A Comment is required for this answer value)
1 Recommended action	Withdraw Revise/Amend Confirm Confirm, with correction of errors * Abstain Abstain with survey replies
2 Has this International Standard been adopted or is it intended to be adopted in the future as a national standard or other publication?	Yes* No
3 (Reply only if the answer to Question 2 is “Yes”) Is the national publication identical to the International Standard or was it modified?	Identical Modified *
4 Is this International Standard used in your country without national adoption or are products used in your country based on this standard?	Yes No *
5 Is this International Standard, or its national adoption, referenced in regulations in your country?	Yes * No

Acoustics Crossword Cracker



1	2 F	3	4	5	6	7	8	9	10	11	12	13
14	15	16	17	18	19	20	21	22 W	23	24	25	26

Solutions to Acoustics Crossword #9

Across:

5. Verses
6. Debase
8. Rehears
9. Urged
11. Stiffener
12. Exquisite
16. Shelf
17. Compact
19. Silent
20. Adagio

Down:

1. Brahe
2. Beta
3. Bemuffle
4. Jargon
5. Verifiers
7. Aski
10. Derivation
11. Stiffens
13. Quells
14. Inch
15. Gauge
18. Mode

Lecture Review: Neuroimaging and Tinnitus

Neuroimaging and Neuromodulation: Complementary Approaches for Identifying the Neural Correlated of Tinnitus

Lecture by: Prof. Sven Vanneste

19th June 2013, The University of Auckland

Professor Sven Vanneste is a Neuroscientist and his work involves investigating the neural correlates of tinnitus and neuromodulation of tinnitus using non-invasive neuromodulation techniques such as repetitive transcranial magnetic stimulation (rTMS), transcranial direct current stimulation (tDCS), and invasive neuromodulation techniques - cortical and deep brain stimulation. He visited the Section of Audiology, University of Auckland on 19th June 2013 and gave a talk about significance of neuroimaging and neuromodulation for identifying neural correlates and tinnitus management at one of our quarterly Oticon Foundation Hearing Education Centre seminars.

Tinnitus is a phantom perception of sound in the absence of its external sound source. Approximately 10-15% of adult population suffers from continuous tinnitus world-wide and its prevalence increases up to 33% in elderly. Tinnitus can significantly affect the quality of life of sufferers. It is usually associated with some form of auditory damage and does not have a cure yet.

Recent neuroimaging studies have shown that tinnitus perception involves simultaneous activation of several brain networks/areas and auditory cortex is only one of them. Non-invasive brain stimulation using rTMS and tDCS has been successful in transient tinnitus suppression. Rare case studies on people with catastrophic tinnitus using invasive cortical and deep brain stimulation have also revealed good results. However no single neuromodulation technique appears to be offering benefit to all the participants or total tinnitus absence, a likely explanation to this could be the possibility of having different sub-types of tinnitus and responsiveness towards a treatment depending upon several factors such as amount of distress associated with tinnitus, its quality, duration, gender, age etc.

In future we need to consider an intervention model which simultaneously target several networks involved in tinnitus perception such as attention, distress, memory, auditory and salience networks. Neuroimaging has certainly broadened our knowledge and provided insights about better understanding of the neural correlates of tinnitus. However we still need further research about neuromodulation to modulate the wide variety of networks involved in tinnitus perception to be able to come a step closer to offer better management and to put that annoying noise to silence.

The Tinnitus clinic at the University of Auckland is also actively involved in conducting several tinnitus research projects; some of them involve using a combination of neuromodulation along with various other forms of therapies and training to evolve better intervention strategies for tinnitus management.

We are also hosting next year's Tinnitus Research Initiative conference, from 10th- 13th March 2014, which is an annual event showcasing the latest advancements in tinnitus research globally.

Lecture Reviewed by:

Giriraj Singh Shekhawat

Research Assistant

The University of Auckland ¶

A few blunders in acoustic reports. These are quotes taken directly from published documents within the acoustic fraternity. Contributions to this page, and comments, are encouraged.

Here are some more pearls from a recent article that relates to a new product on the market:

"...It is very dense, and has a gravity of two..."

Now that is a very stern product.

"...is engineered not to stop or even absorb sound, but, through a unique thermodynamic process, transforms the sound energy into trace amounts of inaudible friction energy (heat), in a process called 'isothermal/adiabatic'. As the [product] material flexes, internal friction occurs and the acoustical energy is dissipated into a 'very small' trace amount of heat..."

Wow, a new process! We don't need to stop or absorb sound any longer, just convert it into heat. And better still, the heat is inaudible. I wonder why I didn't think of that?

Continued on Page 34...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• Novahush Bafflestack
• Novahush Panel Absorber
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• Renhurst Ceiling Systems
• I.C.E. Metal Acoustic Tiles
• Linear Coruline Perforated Metal Ceiling System
• ACS Linear Look Metal Ceiling Systems
• Lindner Metal Systems Acoustic Tiles
• Armstrong Metalworks Acoustic Tiles
Mineral Fibre Ceiling Systems
• Armstrong range of acoustic ceiling tiles
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...Continued from Page 32

Another new product with some amazing properties:

"[this product] is a reinforced aluminium faced acoustic foam with low flammability and smoke emissions. The aluminium foil provides a flame resistant, light and heat resistant face that also prevents the ingress of dust and contaminants. The acoustic layer provides high sound abortion (particularly mid frequency) and thermal insulation. Its low smoke emissions making suited for use in air conditioning and public buildings. Its resistance to moisture make it well suited for use in marine and industrial applications and also for use in tropical, high humidity environments"

This sounds like a great way to reduce noise, by making suitable everywhere!

A nice little line from a domestic heat pump brochure;

"...Operation has been made very silent by improvements to the design of the fan blades and the new grille shape. The power inverter is even more silent when outside temperature drops as it automatically switches to low-noise mode to reduce operating noise by 3dB..."

So, now we have "very silent" and "more silent", and what's more, 3dB is all it takes to get from one to the other! ¶

2013

15 - 18 September, Innsbruck, Austria Internoise 2013
http://www.internoise2013.com

9-11 October, Hangzhou, China 4th Pacific Rim Underwater Acoustics Conference (PURAC 2013)
http://pruac.zju.edu.cn/index.htm

9 - 11 October, Hangzhou, China 4th Pacific Rim Underwater Acoustics Conference (PURAC 2013)
http://pruac.zju.edu.cn/index.htm

17 - 20 October, New York, USA 135th AES Convention
http://www.aes.org/events/135/

23 - 25 October, Kerala, India 12th biennial Symposium on Ocean Electronics (SYMPOL 2013
http://sympol.cusat.ac.in

10 - 15 November, New Delhi, India Acoustics 2013 New Delhi
http://www.acoustics2013newdelhi.org

2 - 6 December, 166th Meeting of the Acoustical Society of America, San Francisco, USA
http://www.acousticalsociety.org

2014

10-13 March, 8th International TRI Tinnitus Conference, Auckland, NZ
http://www.conference.co.nz/tri14

5 - 9 May, 167th Meeting of the Acoustical Society of America, Providence, USA
http://www.acousticalsociety.org

6 - 10 July, 21st International Congress on Sound and Vibration (ICSV21), Beijing, China
http://www.icsv21.org/

07 -12 September, Krakow, Poland Forum Acusticum 2014
http://www.fa2014.pl/

06 - 10 October, Prague, Czech Republic 11th European Conference on Non Destructive Testing
http://www.ecndt2014.com/

27 - 31 October, 168th Meeting of the Acoustical Society of America, Indianapolis, USA
http://www.acousticalsociety.org

Auckland

215, Dominion Rd	(1)	★★★★½
Andrea (form. Positano), Mission Bay	(1)	★★★
Aubergine's, Albany	(1)	★★★★½
Backyard, Northcote	(1)	★★
Bask, Browns Bay	(1)	★★★
Bay (The), Waiake, North Shore	(1)	★★★★★
Bolero, Albany	(1)	★★★★
Bosco Verde, Epsom	(1)	★★★★½
Bouchon, Kingsland	(1)	★★
Bowman, Mt Eden	(1)	★★★★½
Bracs, Albany	(1)	★★★★
Brazil, Karangahape Rd	(1)	★★★
Buoy, Mission Bay	(2)	★★★★½
Byzantium, Ponsonby	(1)	★★★
Café Jazz, Remuera	(1)	★★★★½
Carriages Café, Kumeu	(1)	★★★★
Charlees, Howick	(1)	★★★★★
Cibo	(1)	★★★★★
Circus Circus, Mt Eden	(1)	★★
Cube, Devenport	(1)	★★
Del Fontaine, Mission Bay	(1)	★★★★★
Deli (The), Remuera	(1)	★★★★
Delicious, Grey Lynn	(1)	★★★★★
De Post, Mt Eden	(1)	★★
Dizengoff, Ponsonby Rd	(1)	★★
Drake, Freemans Bay (Function Room)	(1)	★★
Eiffel on Eden, Mt Eden	(1)	★★
Eve's Cafe, Westfield Albany	(1)	★★★½
Formosa Country Club Restaurant	(1)	★★★★★
Garrison Public House, Sylvia Park	(1)	★★★★½
Gee Gee's	(1)	★★★
Gero's, Mt Eden	(9)	★★★
Gina's Pizza & Pasta Bar	(1)	★★★½
Gouemon, Half Moon Bay	(1)	★★
Hardware Café, Titirangi	(1)	★★★★★
Hollywood Café, Westfield St Lukes	(1)	★★½
IL Piccolo	(1)	★★★★
Ima, Fort Street	(1)	★★★★
Jervois Steak House	(1)	★★★
Kashmir	(1)	★★★★
Khun Pun, Albany	(2)	★★★★★
Kings Garden Ctre Café, Western Springs	(1)	★★
La Tropezienne, Browns Bay	(1)	★★
Malaysia Satay Restaurant, Nth Shore	(1)	★★★★★
Mecca, Newmarket	(1)	★★★★★
Mexicali Fresh, Quay St	(1)	★★
Mezze Bar, Little High Street	(16)	★★★★
Monsoon Poon	(1)	★★★★★
Mozaike Café, Albany	(1)	★★
Narrow Table (The), Mairangi Bay	(1)	★★★★½
One Red Dog, Ponsonby	(1)	★★★
One Tree Grill	(1)	★★★
Orbit, Skytower	(2)	★★★★
Patriot, Devonport	(1)	★★★½
Pavia, Pakuranga	(1)	★★★★★
Prego, Ponsonby Rd	(2)	★★
Remuera Rm, Ellerslie Racecourse	(1)	★★★★★
Rhythm, Mairangi Bay	(1)	★★
Rice Queen, Newmarket	(12)	★★★★
Sails, Westhaven Marina	(2)	★★★★★
Scirocco, Browns Bay	(1)	★★★
Seagers, Oxford	(1)	★★★★
Shahi, Remuera	(1)	★★★½
Shamrock Cottage, Howick	(1)	★★
Sidart, Ponsonby	(1)	★★★★½
Sitting Duck, Westhaven	(1)	★★★½
Sorrento	(1)	★★½
Stephan's, Manukau	(1)	★★★★★
Tempters Café, Papakura	(1)	★★★★★
Thai Chef, Albany	(1)	★★★★★
Thai Chilli	(1)	★★★★★
Thai Corner, Rothesay Bay	(1)	★★★★★
Tony's, High St	(1)	★★★
Traffic Bar & Kitchen	(1)	★★
Umbria Café, Newmarket	(1)	★★★★½
Valentines, Wairau Rd	(1)	★★★★★
Vivace, High Street	(2)	★★½
Wagamama, Newmarket	(1)	★★★★½
Watermark, Devonport	(1)	★★
Woolshed, Clevedon	(1)	★★½
Zarbos, Newmarket	(1)	★★
Zavito, Mairangi Bay	(1)	★★ ★

Arthur's Pass

Arthur's Pass Cafe & Store	(1)	★★★½
Ned's Cafe, Springfield	(1)	★★★★

Ashburton

Ashburton Club & MSA	(1)	★★★★½
Robbies	(1)	★★★
RSA	(1)	★★★★

Readers are encouraged to rate eating establishments which they visit by completing a simple form available on-line from www.acoustics.ac.nz, or contact the Editor.
Repeat ratings on listed venues are encouraged.

★ Lip-reading would be an advantage. ★★ Take earplugs at the very least. ★★★ Not too bad, particularly mid-week.
★★★★A nice quiet evening. ★★★★★The place to be and be heard. (n) indicates the number of ratings.

Tuscany Café & Bar	(1)	★★★

Bay of Plenty

Alimento, Tauranga	(1)	★½
Imbibe, Mt Maunganui	(1)	★½
Versailles Café, Tauranga	(2)	★★

Blenheim

Raupo Cafe	(1)	★★

Bulls

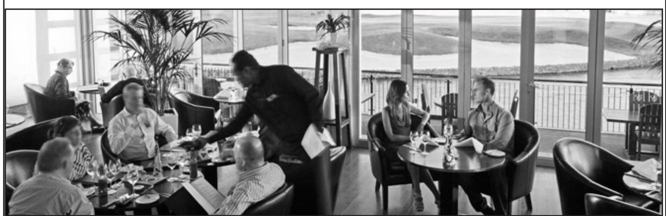
Mothered Goose Cafe, Deli, Vino	(1)	★★

Cambridge

GPO	(1)	★★★★★

Christchurch

3 Cows, Kaiapoi	(1)	★★★★
Abes Bagel Shop, Mandeville St	(1)	★★★★
Alchemy Café, Art Gallery	(1)	★★★★★
Anna's Café, Tower Junction	(1)	★★★★
Arashi	(1)	★★
Azure	(2)	★★★
Becks Southern Ale House	(11)	★★★★½
Bridge (The), Prebbleton	(1)	★★★★★
Buddha Stix, Riccarton	(1)	★★★★
Bully Haye's, Akaroa	(1)	★★
Café Valentino (St Asaph St)	(1)	★★★
Cashmere Club	(1)	★★★★★
Chinwag Eathai, High St	(8)	★★
Christchurch Casino	(1)	★★
Christchurch Museum Café	(1)	★★★★
Cobb & Co, Bush Inn	(1)	★★★
Coffee Shop, Montreal Street	(1)	★★
Cookai	(3)	★★½
Cortado, Colombo Street	(4)	★★★★
Costas Taverna, Victoria Street	(1)	★½
Coyote's	(6)	★★★
Curator's House	(25)	★★★½
Decadence Café, Victoria St	(1)	★★★★★
Drexels Breakfast Restaurant, Riccarton	(1)	★★★★
Elevate, Cashmere	(6)	★★★
Fava, St Martins	(1)	★★
Foo San, Upper Riccarton	(1)	★★★½
Fox & Ferrett, Riccarton	(1)	★★★★★
Freemans, Lyttleton	(9)	★★★½
Gloria Jean's, Rotheram St	(1)	★★★★
Golden Chimes	(1)	★★★★★
Governors Bay Hotel	(1)	★★★★
Green Turtle	(1)	★★★★
Harpers Café, Bealey Ave	(1)	★★★★★
Hari Krishna Café	(1)	★★★
Holy Smoke, Ferry Rd	(1)	★★
Indian Fendalton	(2)	★★
Joyful Chinese Rest., Colombo St	(1)	★★★★★
Kanniga's Thai	(1)	★★★
La Porchetta, Riccarton	(4)	★★½
Lone Star, Riccarton Road	(6)	★★★
Lyttleton Coffee Co, Lyttleton	(1)	★★★★
Manee Thai	(6)	★★½
Merrin Street (Monteiths)	(2)	★★½
Mexican Café	(6)	★★★
Myhanh, Church Corner	(4)	★★★½
Number 4, Merivale	(2)	★★★★
Oasis	(1)	★★★★½
Old Vicarage	(2)	★★★½
Phu Thai, Manchester Street	(1)	★★★
Portofino	(3)	★★★★★
Pukeko Junction, Leithfield	(1)	★★★★
Red, Beckenham Service Centre	(1)	★★★★
Red Elephant	(1)	★★★★
Retour	(1)	★★★
Riccarton Buffet	(2)	★★★★½
Robbies, Church Corner	(2)	★★★★½
Route 32, Cust	(1)	★★★★
Salt on the Pier, New Brighton	(6)	★★★½
Sand Bar (The), Ferrymead	(2)	★★★½
Speights Ale House, Ferrymead	(3)	★★★★★
Speights Ale House, Tower Junction	(1)	★★★★
Tokyo Samurai	(1)	★★★★★
Tutto Bene, Merivale	(2)	★★
Twisted Hop (The), Woolston	(3)	★★★★½
Untouched World Cafe	(1)	★★★★★
Venuti	(3)	★★★★★
Visions Restaurant, CPIT	(1)	★★
Waitikiri Golf Club	(1)	★★
Waratah Café, Tai Tapu	(1)	★★★



Clyde

Old Post Office Cafe	(1)	★★★★★

Dunedin

A Cow Called Berta	(1)	★★★½
Albatross Centre Cafe	(1)	★★★★★
Bennu	(1)	★★★★
Bx Bistro	(1)	★★★★
Chrome	(1)	★★★★½
Conservatory, Corstophine House	(1)	★★★★★
Fitzroy Pub on the Park	(1)	★★★★★
High Tide	(2)	★★

Nova	(1)	★★★★★
St Clair Saltwater Pool Cafe	(1)	★★★★½
Swell	(1)	★★
University of Otago Staff Club	(1)	★★

Feilding

Essence Cafe & Bar0	(1)	★★★★

Gore

Old Post	(1)	★★★
The Moth, Mandeville	(1)	★★★★★

Greymouth

Cafe 124	(1)	★★★

Hamilton

Embargo	(1)	★★★★★
Gengys	(1)	★★
Victoria Chinese Restaurant	(1)	★★★★★

Hanmer Springs

Coriander's	(2)	★★★★½
Laurels (The)	(2)	★★★★★
Saints	(1)	★★★★½

Hastings

Café Zigliotto	(1)	★★★

Havelock North

Rose & Shamrock	(1)	★★★½

Levin

Traffic Bar & Bistro	(1)	★★

Masterton

Java	(1)	★★

Matamata

Horse & Jockey	(1)	★★★★★

Methven

Ski Time	(2)	★★★

Napier

Boardwalk Beach Bar	(2)	★★★★★
Brecker's	(1)	★★★★★
Café Affair	(1)	★★
Cobb & Co	(1)	★½
Duke of Gloucester	(1)	★★★★½
East Pier	(1)	★★
Estuary Restaurant	(1)	★★★★★
Founder's Cafe	(1)	★★★★★
Napier RSA	(1)	★★★★★
Sappho & Heath	(1)	★★

Nelson/Marlborough

Allan Scott Winery	(1)	★★★★★
Amansi @ Le Brun	(1)	★★★★★
Baby G's, Nelson	(1)	★★★★★
Boatshed Cafe (The)	(1)	★★★★
Boutereys, Richmond	(1)	★★★★
Café Affair, Nelson	(1)	★★
Café on Oxford, Richmond	(1)	★★★
Café Le Cup, Blenheim	(1)	★★★
Crusoe's, Stoke	(1)	★★★
Cruizies, Blenheim	(2)	★★★★½
Grape Escape, Richmond	(1)	★★★★★
Jester House, Tasman	(1)	★★★★★
L'Affaire Cafe, Nelson	(1)	★★
Liquid NZ, Nelson	(1)	★½
Lonestar, Nelson	(1)	★★★★
Marlborough Club, Blenheim	(1)	★★
Morrison St Café, Nelson	(1)	★★½
Oasis, Nelson	(1)	★★★★★
Rutherford Café & Bar, Nelson	(1)	★★★★★
Suter Cafe, Nelson	(1)	★★
Verdict, Nelson	(1)	★★
Waterfront Cafe & Bar, Nelson	(1)	★★★
Wholemeal Trading Co, Takaka	(1)	★★★★★

New Plymouth

Breakers Café & Bar	(1)	★★★
Centre City Food Court	(1)	★★★★
Elixer	(1)	★★★★
Empire Tea Rooms	(1)	★★★★½
Govett Brewster Cafe	(1)	★★
Marbles, Devon Hotel	(1)	★★★
Pankawalla	(1)	★★★★★
Simplicity	(1)	★★★
Stumble Inn, Merrilands	(1)	★★★
Yellow Café, Centre City	(1)	★★★
Zanziba Café & Bar	(1)	★★★

Oamaru

Riverstone Kitchen	(1)	★★★★★
Star & Garter	(1)	★★★
Woolstore Café	(1)	★★★★

Palmerston North

Café Brie	(1)	★★★
Café Esplanade	(2)	★★★★
Chinatown	(1)	★★★★
Coffee on the Terrace	(2)	★★★
Elm	(1)	★★★★½
Fishermans Table	(1)	★★★★★

CRAI Ratings (cont.)

Gallery	(3)	★★★★
Rendezvous	(1)	★★½
Roma Italian Restaurant	(1)	★★★
Rose & Crown	(1)	★★
Tastee	(1)	★★★
Thai House Express	(1)	★★★★★
Victoria Café	(1)	★★★★

Queenstown

Bunker	(1)	★★★★
The Cow	(1)	★★★
Sombreros	(1)	★
Tatler	(1)	★★★★
Winnies	(1)	★★★★★

Rotorua

Cableway Rest. at Skyline Skyrides	(1)	★★★★★
Lewishams	(1)	★★★
Woolly Bugger, Ngongotaha	(1)	★★★
Valentines	(1)	★★★★★
You and Me	(1)	★★★★★
Zanelli's	(1)	★★

Southland

Lumberjack Café, Owaka	(1)	★★★★★
Pavilion, Colac Bay	(1)	★★
Village Green, Invercargill	(1)	★★★★★

Taihape

Brown Sugar Café	(1)	★★★★½

Taupo

Burbury's Café	(1)	★★★
Thames		
Thames Bakery	(1)	★★★
Waiheke Island		
Cortado Espresso Bar	(1)	★★★★
Cats Tango, Onetangi Beach	(1)	★★★★

Timaru

Fusion	(1)	★★★★★

Wanganui

3 Amigos	(1)	★★★½
Bollywood Star	(1)	★★★½
Cosmopolitan Club	(1)	★★★★
Liffiton Castle	(1)	★★½
RSA	(1)	★★★½
Stellar	(1)	★★★★½
Wanganui East Club	(1)	★★★★

Wellington

162 Café, Karori	(1)	★★★★★
180o, Paraparaumu Beach	(1)	★★
88, Tory Street	(35)	★★
Anise, Cuba Street	(1)	★★
Aranya's House	(1)	★★★★★
Arbitrageur	(2)	★★★
Arizona	(1)	★★
Astoria	(2)	★★★
Backbencher, Molesworth Street	(1)	★★★
Bordeaux Bakery, Thorndon Quay	(1)	★★
Brewbar (function room)	(49)	★★★
Brown Sugar, Otaki Railway Station	(1)	★★★
Buzz, Lower Hutt	(1)	★★½
Brewery Bar & Restaurant	(5)	★★★★
Carvery, Upper Hutt	(1)	★★★★★
Chow	(1)	★½
Cookies, Paraparumu Beach	(1)	★★★½
Cosa Nostra Italian Trattoria, Thorndon	(1)	★★★★
Gotham	(6)	★★★½
Great India, Manners Street	(2)	★★★★★
Habebie	(1)	★★
Harrisons Garden Centre, Peka Peka	(1)	★★★★
Hazel	(1)	★★
Katipo	(1)	★★★★★
Kilim, Petone	(4)	★★★★½
Kiss & Bake Up, Waikanae	(1)	★★★
La Casa Pasta	(1)	★★★★½
Lattitude 41	(3)	★★★★
Legato	(1)	★★
Le Metropolitain	(1)	★★★★★
Loaded Hog	(5)	★★★★½
Manhatten, Oriental Bay	(1)	★★★★
Maria Pia's	(1)	★★★
Matterhorn	(1)	★★★
Mungavin Blues, Porirua	(1)	★★★★★
Olive Cafe	(1)	★★★★★
Olive Grove, Waikanae	(1)	★★★½
Original Thai, Island Bay	(1)	★★★★
Palace Café, Petone	(1)	★★½
Parade Café	(1)	★★
Pasha Café	(1)	★★★★
Penthouse Cinema Café	(2)	★★★½
Pod	(1)	★★½
Rose & Crown	(1)	★★★★★
Shed 5	(1)	★★
Siem Reap	(1)	★★
Speak Easy, Petone	(1)	★★
Speights Ale House	(1)	★★
Sports Bar Café	(1)	★★★★
Stanley Road	(1)	★★★
Stephan's Country Rest., Te Horo	(1)	★★★★★
Wakefields (West Plaza Hotel)	(1)	★★★
Windmill Café & Bar, Brooklyn	(1)	★★
Yangtze Chinese	(1)	★★★★½
Zealandia Café, Karori Sanctuary	(1)	★★★½

In a Class *of its Own*

The unmistakable look of Hand-held Analyzer Type 2270 can overshadow a number of discrete yet significant distinctions which make this powerful instrument the complete toolbox for sound and vibration professionals. These include:

- Integrated digital camera
- Two-channel measurement capability
- Integrated LAN and USB interfaces for fast data transfer to PC and remote control and monitoring of Type 2270
- Environmental protection IP44

Versatile in the Extreme

Type 2270 also boasts a wide range of application software modules that can be licensed separately so you get what you need when you need it.

Currently available measurement software includes:

- Sound Level Meter application
- Real-time frequency analysis
- Logging (noise level profiling)
- Sound and vibration recording
- Building acoustics
- Tonal assessment

Type 2270 meets the demands of today's wide-ranging sound and vibration measurement tasks with the accuracy and reliability associated with Brüel & Kjær instrumentation.

To experience the ease-of-use of Type 2270, just go to www.bksv.com and view the on-line video demonstrations.

For more information please contact your local Brüel & Kjær representative

Hand-held Analyzer *Type 2270*

Brüel & Kjær

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