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Features

Regulars

Cover Image: [1]Leo Beranek and [2]Cliff Stevenson

Source: [1]http://bit.ly/2ezr2OC, [2]Keith Ballagh and John Pearse

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From the President and the Editor's

President's Column

Dear ASNZ Members, Associates and Fellows, what a year 2016 has been. Some of the major events of the year have some links to the work we do, some directly and some not so direct...

The Institute of Acoustics (UK) are getting to grips with the impact of the Brexit vote on noise management in the UK, with several pieces of relevant legislation being driven by EU requirements. Some commentators are also suggesting that the political and economic "noise" created by the Brexit vote are masking a number of greater risks and uncertainties to the future of the UK economy.

America's new President wants to build a wall. The Acoustical Society of New Zealand has a new President who has already built a wall. I'll be organising an Auckland branch meeting in the new year to explain it all (trust me there is a link to acoustics there).

We had a couple of big earthquakes in New Zealand this year, one close to Dynasty's dads' crop (East Cape) and of course the incredible events we have seen in Kaikoura. I know of at least four seismographs set up in Auckland which registered these events some 300 km and 600 km away (respectively) when set up to monitor construction vibration. The magnitude of energy involved is incomprehensible to me, and it certainly makes one feel very insignificant on this extraordinary planet.

And of course, Kanye has gone quiet for a while.

Sadly, 2016 also is the year that Leo Beranek passed away after an amazing 102 years. Amongst his well known achievements in the field of acoustics, he was also a pioneer of the internet, helping build the first computer-based network for the US Defence Force. His company sent the first email using the @ symbol in 1972. An incredible man indeed.

Amongst all of this was the joint Australia / New Zealand Acoustical Societies Conference held in Brisbane in November. What a fantastic event to be involved in. The atmosphere was great, with much knowledge shared and friendships created and renewed. Hats off to the organisers, contributors, attendees and supporters – it is something I think our Society should commit to every few conferences with the greater depth of knowledge and fostering of our cross-Tasman ties at the joint conference being hugely valuable to a small Society such as ours.

We achieved a quorum at our AGM in Brisbane which was great, and we have welcomed in a few new Council members and had a change around in the President and Secretarial departments as well, with bio's and pictures in this issue of the journal for those of you not familiar.

This year I take over the Presidential helm from the venerable Mr Whitlock who has achieved a great deal for the Society in the past few years. I will be working with the great bunch of people on the Council to continue the professional and economic growth of the Society and to work hard on promotion in the next two years. Not only promotion outside the current membership to increase our profile with central and local government, associated industries and potential new members, but also within our membership to increase our activity, branch meetings, interaction and vitality.

Enjoy the last issue of this fantastic journal for 2016 and have a great holiday break.

Best wishes,

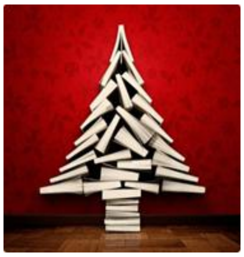
Jon Styles

Editor's Column

Welcome to the last Journal of 2016 (Vol 29 #3). A lot has occurred since the last Journal including this year's Joint Australian and New Zealand Acoustical Societies 2nd Australasian Conference which was held in Brisbane last month, election of New Officers to the Society and a New President, Jon Styles, who has his first Presidents Column in this edition. We have in this edition a mix of three top quality papers including a paper on classroom acoustics, occupational noise and 'seeing' ultra sound in real time. We also have our regular events, news and reviews. We pay tribute to Leo Beranke and New Zealand own Cliff Stevenson, both two well respected men and experts in the field of acoustics. We also introduce a new piece in this journal where we bring you a Member Profile. We want to wish you all a happy holiday, safe New Year and again take the time to again thank all our advertisers for their support and contributors to the journal, especially those who take the time to prepare papers and work. Take care and we will see you all in 2017.

Lindsay & Wyatt journal@acoustics.org

Happy Holidays and a safe New Year



The New Zealand Acoustics Journal team would like to wish all our readers and members of the Society a happy holiday and safe New Year. Wyatt and I would especially like to thank all those who support and help us produce the Journal each year with a special thanks to the Sub-Editors, Adverting Manager and all those special people behind the scenes which work tirelessly to help produce the journal. We would like to make special thanks to RMANet Editor Dr Sarah Brand who prepares the RMA Net articles.

Leo Beranek a Massachusetts renaissance man...

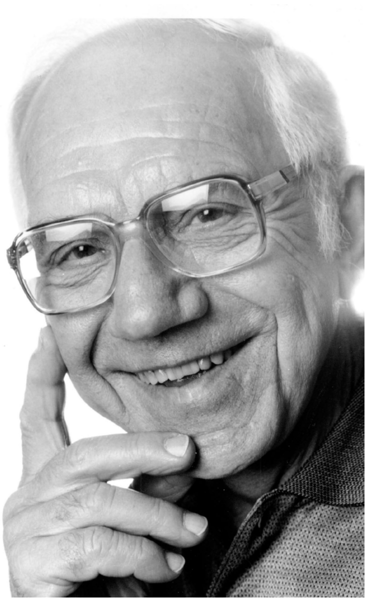
Scientist, teacher, entrepreneur, television executive, philanthropist, author, Leo Beranek died in Westwood, Massachusetts, on October 10, 2016 at age 102 after a long and extraordinarily productive life. He leaves his wife Gabriella, sons James K. Beranek of Cedar Rapids, Iowa and Thomas B. Haynes of Chicago, Illinois and granddaughter, Antonia Hsu Haynes. He was predeceased by Phyllis Knight Beranek, his wife of 42 years.

A 1936 graduate of Cornell College (Iowa) with a B.A. degree in Physics and Mathematics Beranek went on to graduate school in the Applied Physics Department of Harvard University where he received his D. Sc. Degree in 1940 in the field of acoustics.

Beranek stayed at Harvard during World War II as Director of two laboratories; first the Electro-Acoustic Laboratory, which dealt with voice communication in combat vehicles, and then the Systems Research Laboratory, whose mission was to improve the U. S. Navy's ability to combat Japanese Kamikaze aircraft attacks. At the war's end President Harry S. Truman issued Beranek a "Certificate of Merit" for his contributions to the war effort.

After WWII Beranek became Associate Professor of Communication Engineering at the Massachusetts Institute of Technology where he taught courses in electrical engineering and acoustics. His seminal textbook, ACOUSTICS, was published in 1956, forever changing the teaching of acoustics to engineers.

In 1948, the acoustical consulting firm Bolt Beranek and Newman was formed with Beranek as President. Its first projects were the acoustics and sound systems in the United Nations buildings in New York, followed by



NASA's jet engine test facility in Cleveland. NASA's first test of a new supersonic jet engine created such a loud noise for miles around that the City of Cleveland shut it down. Successfully solving the problem, Beranek designed and saw built the world's largest acoustic muffler, which was featured in LIFE magazine (6/11/51).

In the Fall of 1958 BBN began work for the (then called) Port of New York Authority (PNYA) which operated the JFK (then called Idlewild) airport serving New York City. Pan American Airlines had requested permission to fly the Boeing 707 (the first jet-passenger airplane) from JFK, but the PNYA said that the plane must not produce more noise in the neighborhoods around the airport than that produced by existing propeller aircraft. Beranek and his team determined that the Boeing 707 was so noisy its engines had to be equipped with heavy mufflers and follow a prescribed takeoff procedure in order to meet the PNYA's dictum.

In 1965, under Beranek's leadership, BBN became the vanguard of the digital age by putting together one of the best computer software groups in the East. In 1968 the Advanced Research Project Agency (ARPA) awarded BBN a contract to build a network to hook together 19 large-scale computers of different makes, different program languages, and in different locations. To do this BBN invented the ARPANET which consisted of 19 "Interface Message Processors (IMP's)", each of which was associated with one of the 19 main-frame computers. In the network, signals traveled from one IMP to another, and each IMP acted as the interpreter of messages that went to and from its associated main-frame computer. The first message between two IMP's and their associated computers was sent in September 1969. In 1971 BBN invented e-mail with "@" as we know it today. The ARPANET grew and when it reached about 500 users it was split in two and rejoined by the TCP/IP protocol. This occurred on January 1, 1983 and that is the official birthdate of the INTERNET.

...Continued on Page 11

Classroom acoustic conditions: Understanding what is suitable through a review of national and international standards, recommendations, and live classroom measurements

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Abstract

Children spend 45-75 % of their time in the classroom listening to their teacher and classmates. As current teaching methods have a strong focus on group work activities, contemporary classrooms are prone to high noise levels. Therefore, the classroom acoustic environment needs to be designed appropriately. The AS/NZS2107:2000 standard currently has recommendations for unoccupied classroom ambient noise levels and reverberation times, however, these are not enforced. Furthermore, there are no recommendations for occupied classroom acoustic conditions. Therefore, the aim of this paper was to review current classroom acoustic standards and recommendations around the world, summarise typical noise levels found in classrooms, and provide recommendations on the unoccupied and occupied classroom acoustic conditions needed for children at different ages and children with special educational needs.

Originally published in the Proceedings of ACOUSTICS 2016, 9-11 November, Brisbane, Australia

1. Introduction

The primary modes of communication in the educational setting are speaking and listening, with it being estimated that children spend 45-75 % of their time in the classroom comprehending their teacher's and classmates' speech (American Speech-Language-Hearing Association, 2005; Rosenberg et al., 1999). Recent shifts in teaching methods have seen a move away from traditional didactic teaching to a stronger focus on group work activities (Rowe, 2006; Mealings, Demuth, et al., 2015a). As a result, contemporary classrooms are prone to high noise levels (Shield et al., 2010; Mealings, Buchholz, et al., 2015). Studies show that children from classrooms with poor acoustics have lower literacy and numeracy skills, are less productive in the workforce, and tend to be in lower paid jobs than those from classrooms with good acoustics (James et al., 2012; Anderson, 2001). Therefore, it is vital that the classroom acoustic environment is designed to allow children to accurately discriminate what their teacher and the children in their group are saying amongst the other dynamic classroom noise (Mealings, Demuth, et al., 2015b; Mealings, Demuth, et al., 2015c; Mealings, Dillon, et al., 2015). The AS/NZS2107:2000 standard currently has recommendations for unoccupied classroom ambient noise levels (< 35-45 dBA) and reverberation times (< 0.4-0.5 s), however these are not enforced so are rarely achieved. Furthermore, there are no recommendations for occupied classroom acoustic conditions. Therefore, the aims of this paper were to:

- Review and summarise the current classroom acoustic standards (e.g. noise levels, reverberation times, signal-to-noise ratios, and speech transmission index scores) from countries around the world, as well as the recommended levels published in research papers.
- Identify and summarise the typical classroom acoustic conditions found in primary schools from research conducted in Australia, New Zealand, and other countries.
- Provide recommendations on what are considered as "Good", "OK", and "Poor" unoccupied and occupied classroom acoustic conditions for typically developing children, children at different ages, and children with special educational needs, based on the findings of aims 1 and 2.

2. Method

This paper provides a review of national and international classroom acoustic standards, and a review of academic literature and experimental studies that assess how noise and reverberation affect children's speech perception. Initially, databases such as Web of Science were used to identify key peer-reviewed articles using relevant search terms, for example "primary school classroom acoustics". The bibliographies of these key articles were then used to identify additional research papers and classroom acoustic standards for different countries. Effort was made to include recommendations and results for both enclosed and open plan classrooms, as well as recommendations for both typically developing children and those with hearing or language impairments. Forty-three papers in total were included in the final review. The findings from these papers are shown below and a summary of the findings for each category are provided at the bottom of each table. The paper concludes with acoustic recommendations for classrooms drawn from these studies.

Table 1: Recommended classroom acoustic guidelines for typically developing children

Reference Type	Reference	Classroom Type	Unoccupied ANL (dBA)	SNR (dB)	RT (s)	STI
National Standards/ Recommendations	Australia/New Zealand Standard (2000)	Enclosed	< 35 (satisfactory) < 45 (max)		< 0.4-0.5	
	South Australia (1993)	Enclosed Open	< 40 < 45		< 0.4-0.5 < 0.4-0.5	
	American National Standards Institute (2010)	Enclosed	< 35		< 0.6	
	USA (American Speech-Language-Hearing Association, 1995)	Enclosed	< 30		< 0.4	
	UK (1981)	Enclosed	< 40		< 0.5-0.8	
	World Health Organization (1999)	Enclosed	< 35		< 0.6	
	Finland (1991)	Enclosed	< 35		0.6-0.9	
	Japan (Fukuchi & Ueno, 2004)		< 40		< 0.6	
	England/Wales (2003)	Open	< 40		< 0.8	> 0.6
	Denmark (Boligstyrelsen, 2004)	Open	< 30		< 0.3-0.4	> 0.6
	Sweden (2007)	Open	< 30		< 0.4	
	Norway (2008)	Open			< 0.4	
	Iceland (2011)	Open			< 0.4	> 0.6
Other Country Standards Reported in Losso et al. (2004)	Belgium		< 30-45			
	Brazil		< 40-50			
	France		< 38		< 0.4-0.8	
	Germany		< 30			
	Italy		< 36			
	Portugal		< 35		< 0.6-0.8	
	Turkey		< 45			
	UK		< 40			
Research Papers	Australia (AAAC, 2010)	Enclosed Open	< 35		< 0.4-0.5	 > 0.6
	Australia (Mealings, Dillon, et al., 2015; Mealings, Demuth, et al., 2015d)	Enclosed and Open	< 45.9 (occupied)	> +14.5		> 0.75
	USA (Siebein et al., 2000)	Enclosed	< 30-35			
	USA (Bradley & Sato, 2008)	Enclosed	< 35	6 y/o: > +20 8 y/o: > +18 11 y/o: > +15		
	USA (Anderson, 2001)	Enclosed	< 25	> +15	< 0.4-0.6	
	NZ (Wilson, 2002)	Enclosed	< 35		< 0.4	
	Canada (Picard & Bradley, 2001)	Enclosed	6-7 y/o: < 28.5 8-9 y/o: < 34.5 10-11 y/o: < 39 12+ y/o: < 40		< 0.5	
	Sweden, Denmark, Norway (Borrild, 1978)		< 35		< 0.9	
	England (Greenland & Shield, 2011)	Open		6 y/o: > +15.5 8 y/o: > +12.5 11 y/o: > +8.5	< 0.4	> 0.75 > 0.69 > 0.61
	Compilation (Picard & Bradley, 2001)		< 30-40		< 0.4-0.9	
Overall Summary:			**Noise Level: < 25-50 dB**	**SNR: > +8.5 +20 dB**	**RT: < 0.3-0.9 s**	**STI: > 0.6-0.75**

3. Results

3.1 Recommended Classroom Acoustic Guidelines Around the World

Table 1 shows the recommended values for primary school classrooms based on National Standards or research paper recommendations by country. Values are shown for unoccupied ambient noise levels (ANLs), signal-to-noise ratios (SNRs), unoccupied reverberation times (RTs), and speech transmission index scores (STIs). Breakdowns of the recommended values by age group are shown where applicable. Classrooms are also sorted by type (i.e. traditional enclosed classrooms versus open

Table 2: Recommended classroom acoustic guidelines for children with hearing impairments or language delays

Reference Type	Reference	Classroom Type	Unoccupied ANL (dBA)	RT (s)
National Standards/ Recommendations	South Australia (1993)	Enclosed	< 40	< 0.4
	UK (1981)	Enclosed	< 30	< 0.3-0.6
	USA (American Speech-Language-Hearing Association, 1995)	Enclosed	< 30	< 0.4
Research Papers	Australia (AAAC, 2010)	Enclosed	< 30	< 0.4
	Scotland (Airey, 1998)	Enclosed	< 20-30	< 0.3-0.6
	Canada (Picard & Bradley, 2001)	Enclosed	6-7 y/o: < 21.5 8-9 y/o: < 27.5 10-11 y/o: < 32 12+ y/o: < 33	< 0.5
	Sweden, Denmark, Norway (Borrild, 1978)		< 23	< 0.5
	Compilation (Picard & Bradley, 2001)		< 20-35	< 0.3-0.7
Overall Summary			**< 20-35**	**< 0.3-0.7**

plan classrooms). An overall summary is shown at the bottom of the table. The values found in Table 1 are for typically developing children with normal hearing, whereas Table 2 shows the revised levels for children with hearing impairments or language delays who need more favourable listening conditions.

3.2 Acoustic Levels Found in Classrooms Around the World

Table 3 shows the typical acoustic levels found in primary school classrooms from research papers by country. Values are shown for unoccupied ambient noise levels (ANLs), occupied background noise levels (BNLs; broken down by class activity where applicable), signal-to-noise ratios (SNRs), unoccupied reverberation times (RTs; or occupied RTs as noted), and speech transmission index scores (STIs). A description of the number and type of classrooms involved in the studies are also provided. An overall summary is shown at the bottom of the table.

Table 3: Typical acoustic levels found in classrooms

Country	Reference	Classroom Type	Unoccupied ANL (dBA)	Occupied BNL (dBA)	SNR (dB)	RT (s)	STI
Australia	Rural Queensland (Massie et al., 2004)	4 primary school classrooms		362-75	-9 to -3	1.3-1.8	
	Australia (Massie & Dillon, 2006)	12 Year 2 classrooms		64-72		1.0-1.9	
	Sydney (Mealings, Buchholz, et al., 2015)	4 enclosed / open-plan primary school classrooms (5-6-year-olds)	36-46	68-72	-6 to +16[b] -16 to -5[c,d]	0.5-0.7	0.30-0.88
New Zealand	Auckland (Wilson, 2002)	12 primary school classrooms		50-70 0.35-0.63a	M = -8	0.35-0.63[a]	
	Auckland (Harper, 1995)	5 primary / intermediate classrooms	28-55 M = 37		-5 to +11 M = +6	0.37-0.56 M = 0.43	0.72-0.82 M = 0.76
	Wellington (Blake & Busby, 1994)	106 primary school classrooms (5-7-year-olds)			0 to +23 Median = +6 (+10[b] ; +1[c,d])		
	Auckland (See Wilson, 2002)	4 enclosed classrooms	47		+1 to +8	M = 0.73	
	Auckland (See Wilson, 2002)	4 open plan classrooms	60 (main class empty, other classes occupied)		+4.5 to +7.5	M = 0.76	
United Kingdom	Edinburgh (MacKenzie & Airey, 1999)	60 primary school classrooms	44.1-44.7	49-85		M = 0.7 (many 0.9-1.0)	0.5-0.7
	Edinburgh (Airey, 1998)	Enclosed untreated primary schools	55.5	69.6[b] 77.3[c,d]		M = 0.7 M = 0.6[a]	0.5
	Edinburgh (Airey, 1998)	Enclosed treated primary schools	46.6	70.0[b] 70.1[c,d]		M = 0.4 M = 0.4[a]	0.7
	Edinburgh (Airey, 1998)	Open plan primary schools	56.6	63.6[b] 72.1[c,d]		M = 0.6 M = 0.4[a]	0.5
	England (Greenland & Shield, 2011)	42 semi-open plan primary school classrooms	33-40 M = 35		+11.7[b] +6.7[c] +3.9[d]	0.26-0.64	0.65[b] 0.55[c] 0.49[d]
	London (Shield & Dockrell, 2004)	140 primary school classrooms	47	66.3-74.3 M = 72			

Table 3 continued

Country	Reference	Classroom Type	Unoccupied ANL (dBA)	Occupied BNL (dBA)	SNR (dB)	RT (s)	STI
Canada	Ottawa (Bradley & Sato, 2008)	41 primary school classrooms			M = +4.5	M = 0.42	
	Ottawa (Sato & Bradley, 2008)	41 primary school classrooms	42.2	49.1	M = +11.1	M = 0.45 M = 0.41[a]	
	Ottawa (Bradley, 1986)	10 primary school rooms (12-13-year-olds)	38-45			M = 0.7	
United States	Compilation (Berg et al., 1996)		30-50	55-85 M = 60		0.3-1.5	
	Ohio (Knecht et al., 2002)	32 elementary schools	34.4-65.9				
	Hawaii (Pugh et al., 2006)	79 primary school classrooms	51.2			0.2-1.27	
Europe	Sweden (Norlander et al., 2005)	Combined primary/high school		63.24			
Asia	Hong Kong (Choi & McPherson, 2005)	47 primary school classrooms		54.1-67.6 M = 60.74	M = +13.53		
	Japan (See (Sato & Bradley, 2008))		22-59			0.2–1.0	
	Japan (Tsuchiya et al., 2004)	Open plan				0.7	0.65-0.75
South America	Brazil (Losso et al., 2004)		51.5-70.5			1.15-1.68	
Compil-ations	Crandell & Smaldino, 2000		41-51	48-65	-7 to +5	0.35-1.2	
	American Speech-Language-Hearing Association, 2005		32-67		-7 to +5	0.4-1.2	
	(Picard & Bradley, 2001	Primary school rooms		51.7-75	-4.5 to +23	0.7-1.2 0.2-0.9[a]	
Overall Summary			**22-70.5**	**48-85**	**-16 to +23**	**0.2-1.9**	**0.30-0.88**

Key for table 3

[a] Occupied reverberation time

[b] Noise levels during whole class teaching

[c] Noise levels while children are working at tables

[d] Noise levels while children are working with movement

4. Conclusions

The This paper has reviewed current classroom acoustic standards and recommendations around the world and summarised typical noise levels found in classrooms. The final aim of this paper was to bring these findings together and conclude with recommendations on the unoccupied and occupied classroom acoustic conditions needed for typically developing children at different ages as well as children with special educational needs. Table 4 provides recommendations on what are "Good", "OK", and "Bad" overall acoustic levels for primary school classrooms with typically developing children based on the findings of this paper. Subsequently, Table 5 provides a breakdown of these levels by age group.

Finally, Table 6 provides recommendations on the classroom acoustic variables for children with hearing or language impairments. It is generally recommended that noise levels should be 10 dB lower and RTs should be 0.2 s lower for these children as they are more adversely affected by poor classroom acoustic conditions (MacKenzie & Airey, 1999). Meeting the relevant recommendations in primary school classrooms will help ensure all children are able.

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Table 4: Overall acoustic recommendations for primary school classrooms

Rating	Unoccupied ANL (dBA)	Occupied ANL (dBA)	RT (s) (unoccupied)	STI
Good	< 30	< 50	< 0.4	< 0.75
OK	30 - 40	50 - 55	0.4 - 0.6	0.6 - 0.75
Bad	> 40	> 55	> 0.6	< 0.6

Table 5: Acoustic recommendations for primary school classrooms for children at different ages

Age Group	Rating	Unoccupied ANL (dBA)	Occupied ANL (dBA)	SNR (dB)	RT (s) (unoccupied)	STI
6 - 7 years	Good	< 28	< 45	> +20	< 0.4	< 0.75
	OK	28 – 35	45 – 50	+15 to +20	0.4 - 0.6	0.7 - 0.75
	Bad	> 35	> 50	< +15	> 0.6	< 0.7
8 - 9 years	Good	< 35	< 47	> +18	< 0.4	< 0.7
	OK	35 – 40	47 – 53	+12 to +18	0.4 - 0.6	0.6 - 0.7
	Bad	> 40	> 53	< +12	> 0.6	< 0.6
10 - 11 years	Good	< 39	< 50	> +18	< 0.4	< 0.61
	OK	39 – 40	50 – 56	+9 to +15	0.4 - 0.6	0.6 - 0.61
	Bad	> 40	> 56	< +9	> 0.6	< 0.6
12+ years	Good	< 40	< 50	> +18	< 0.4	< 0.61
	OK	40 – 45	50 – 56	+9 to +15	0.4 - 0.6	0.6 - 0.61
	Bad	> 45	> 56	< +9	> 0.6	< 0.6

Table 6: Acoustic recommendations for primary school classrooms with hearing/language impaired children

Rating	Unoccupied ANL (dBA)	Occupied ANL (dBA)	SNR (dB)	RT (s) (unoccupied)	STI
Good	< 20	< 40	> +20	< 0.3	< 0.75
OK	20 - 30	40 - 45	+15 to +20	0.3 - 0.5	0.6 - 0.75
Bad	> 30	> 45	< +15	> 0.5	< 0.6

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Other networks soon joined and today people around the world enjoy the fruits of this invention.

Beranek left BBN in 1969 to become President of Boston Broadcasters Inc., which, after a long court battle, took over operation of Channel 5-TV in 1972 using the call letters WCVB. The programming at WCVB was so improved that the New York Times in 1981 carried a full page article headed “Some say this is America’s best TV station”. The station was later sold to Metromedia.

After his foray into broadcasting, Beranek returned to acoustics. Among others, he consulted on five concert halls and an opera house in Japan. Among them was the Tokyo Opera City Concert Hall, which was hailed as an “acoustical ‘miracle’” on the front page of the New York Times (4/18/2000). The Hall, which opened in September 1997, is now considered one of the five best concert halls acoustically in the world.

Publications: Beranek published 185 technical papers and thirteen books, the last four of which are: Concert Halls and Opera Houses (Springer 2004); Noise and Vibration Control Engineering (with co-author) (Wiley 2006), Riding the Waves (autobiography) (MIT Press 2010), and Acoustics: Sound Fields and Transduxers (with co-author) (Elsevier 2014).

Public Service: Beranek served the Boston Symphony Orchestra as a member and chairman of the Board of Overseers and later as member and Chairman of the Board of Trustees (1968-1988). He was fulltime president of the American Academy of Arts and Sciences for five years. The alumni of Harvard University voted him a member of their senior governing body, the Board of Overseers, for six years, He also served as President of the Acoustical Society of America and the Audio Engineering Society.

Both the Museum of Fine Arts Boston and the Boston Symphony Orchestra list Beranek and his wife as major financial benefactors.

Honours: Member, National Academy of Engineering; Fellow, American Academy of Arts and Sciences; Fellow, American Physical Society; Honorary Member, American Institute of Architects; Fellow, Institute of IEEE.

Awards: 2003 National Medal of Science (Presented by President George W. Bush); IEEE Founders Medal; Gold Medals from the Acoustical Society of America, Audio Engineering Society, and American Society of Mechanical Engineers; Lifetime Achievement Award from the International Commission on Acoustics; and the Abe Lincoln TV Award (Top USA Award for TV Management). from the Radio and TV Commission.

Honorary Doctorates: Worcester Polytechnic Institute; Northeastern University; Suffolk University; Cornell College (Iowa); Emerson College.

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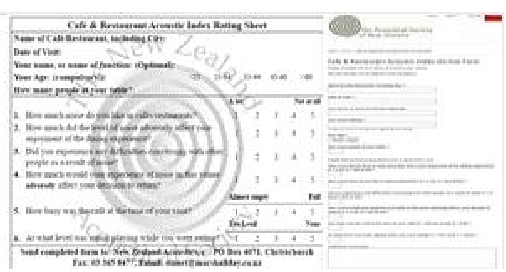

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Seeing (ultra)sound in real-time through the Acousto-PiezoLuminescent lens

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Abstract

In this contribution, we focus on a recently developed piezoluminescent phosphor $BaSi_2O_2N_2$:Eu (BaSiON), and report on Acoustically induced PiezoLuminescence (APL). Insonification of the BaSiON phosphor with (ultra)sound waves leads to intense light emission patterns which are clearly visible by the bare eye. The emitted light intensity has been measured with a calibrated photometer revealing it is directly proportional to the applied acoustic power. As such, APL can be used to devise a simple but effective acoustic power sensor. Further, the emitted APL light pattern has a specific geometrical shape which we successfully linked to the pressure field of the incident (ultra)sonic wave. This is explicitly demonstrated for an ultrasonic (f = 3.3 MHz) transducer. By varying the insonification distance (from near- to far-field), multiple 2D slices of the transducer's radiation field light up on the BaSiON phosphor plate. By simply photographing these light patterns, and stacking them one after another, the 3D spatial radiation field of the ultrasonic transducer was reconstructed. Good agreement was found with both classical scanning hydrophone experiments and simulations. Recently we found that APL can also be activated by acoustic waves in the kHz range, thus covering a wide frequency range. Some first preliminary results are shown.

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1. Introduction

Humans have the natural ability to sense an internal or external pressure applied to the skin. As such, people can react whenever touched, and are alerted in case of danger. Few materials have a similar ability, though in a slightly different way: they emit cold-body radiation (i.e. radiation not resulting from heat according to black body physics) when stimulated by mechanical stress and are therefore termed mechanoluminescent (ML) materials. The phenomenon of ML was discovered by Sir Francis Bacon who first observed it in 1605 when scraping sugar (Bacon, 1605). Depending on the stimulating mechanical action and the degree of deformation, different names are used, including fractoluminescence, triboluminescence, and piezoluminescence. Last decades, humans have designed several novel ML materials, called phosphors, with an increased sensitivity to different mechanical stimulations (Chandra et al., 2013). As such, these phosphors have already been successfully employed for a range of interesting applications:

- sensing a dynamic (elastic) pressure by dispersing the active non-stoichiometric $Sr_{0.975}Al_2O_{3.985}$:$Eu_{0.01}$ in an epoxy matrix (Xu et al., 2000), or by covering structural components with an active CaZnOS:Mn film (Zhang et al., 2013),
- assessing quasi-dynamic crack propagation (up to 15 m/s) using the fractoluminescent $SrAL_2O_4$:Eu,Dy phosphor (Kim et al., 2007, Timilsina et al., 2013),
- mapping personalized handwriting (Wang et al., 2015),
- determination of stress intensity factors in mode I setup (Timilsina et al., 2013) and
- detection of ultrasonic waves (Terasaki et al., 2013, Zhan et al., 2011, Zhang et al., 2013).

The phenomenon of ML is closely related to persistent luminescence or afterglow (Van den Eeckhout et al., 2010, Matsuzawa et al., 1996, Brito et al., 2012). Persistent luminescence is a specific type of luminescence where the emission is delayed for seconds up to days after the excitation, due to the presence of trap states. After excitation, charge carriers are captured in traps, often related to lattice defects or intentionally added impurities. The trapped charges are then thermally released, after which recombination at the luminescence center occurs. The thermal barrier for detrapping determines the afterglow duration, depending on the ambient temperature and the trap depth, which can be a distribution rather than a single, discrete trap depth (Van den Eeckhout et al., 2013). The detrapping can also occur following mechanical action, although not all persistent luminescent materials show ML, which is presumably related to their crystal structure (Botterman et al., 2012). Here we use the bluish-green emitting $BaSi_2O_2N_2$:Eu (BaSiON) phosphor which shows both persistent luminescence and ML. The emitted light has an emission peak at 498 nm (full-width-half-maximum of 32 nm), resulting from a $4f^65d$-$4f^7$ transition within divalent europium. BaSiON is characterized by a broad trap depth distribution and applying pressure was reported to lead to a preferential release from deep traps. Direct recombination at the ionized europium center can then occur (leading to immediate light emission), or retrapping into shallower traps, causing a short afterglow when the pressure is released (Botterman et al., 2012). In this paper, we demonstrate that luminescence can also be triggered by acoustic waves. For the BaSiON phosphor, we actually observe intense luminescence upon insonification which is even visible with the bare eye. In the remainder of the text, we use the term Acoustically induced PiezoLuminescence or Acousto-PiezoLuminescence (APL). First, the relation between APL light intensity and applied acoustic power is investigated. Secondly, the APL phenomenon is used to reconstruct the 3D spatial radiation field of an ultrasonic transducer (frequency f = 3.3 MHz) in both near- and far-field (Kersemans et al., 2015). The obtained results are confronted with both scanning hydrophone experiments and 3D acoustic holography simulations, showing good comparison. Finally, preliminary results are shown, indicating that the APL phenomenon is not only useful for ultrasonic waves with MHz frequency, but can also be activated in the acoustic kHz range.

2. Experimental Procedure

BaSiON powder (Botterman et al., 2012) is embedded as an active ML component in a momentive Epikote RIM 135 epoxy matrix. The choice for the $BaSi_2O_2N_2$:Eu material is mainly motivated by its strong light emission when stimulated in the elastic regime. The experiments for this study have all been obtained on thin BaSiON samples which have been optically charged by UV radiation sources. After charging, we respected a time period in order to reduce the strong, initial persistent luminescence. The BaSiON sample is then placed in water, after which it is insonified, leading to increased light emission (see Figure 1).

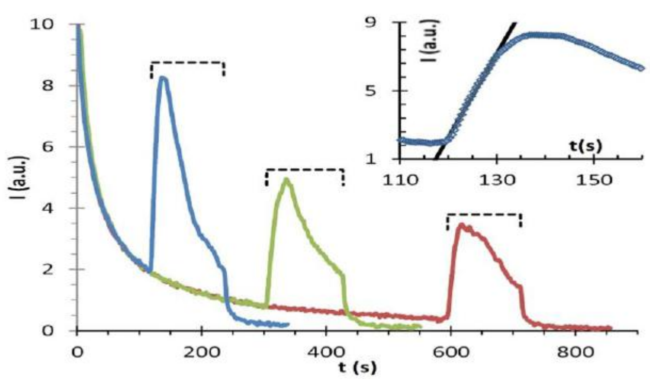


Figure 1: Measurement of the integrated emission intensity I when applying ultrasound (indicated by the dashed lines) at different times t. The inset shows an enlargement, along with a linear fit (dotted line) for the first 10 s.

The integrated light I, emitted by the BaSiON sample upon insonification, can be captured with a fiber coupled spectrometer (Ocean Optics QE6500) and a calibrated photometer (International Light Technologies ILT1700). To increase the contrast, the experiments take place in a darkened room. Figure 1 illustrates three cases in which ultrasound has been applied for different time periods after charging the BaSiON sample with UV light. During application of the ultrasound (indicated by the dashed lines), one can easily verify that the integrated light emission increases significantly.

The employed ultrasonic transducer (GYMNA 200 apparatus) has a circular active area of 470 mm^2, is immersed in water to enhance the transfer of ultrasound and is operated at a frequency of 3.3 MHz. The insonification distance z can be varied in order to obtain results in both near- and far-field of the transducer. The experimental setup is shown in Figure 2a. Figure 2b shows an example of a typically observed APL light pattern (captured with a standard digital camera) upon insonification of the BaSiON sample.

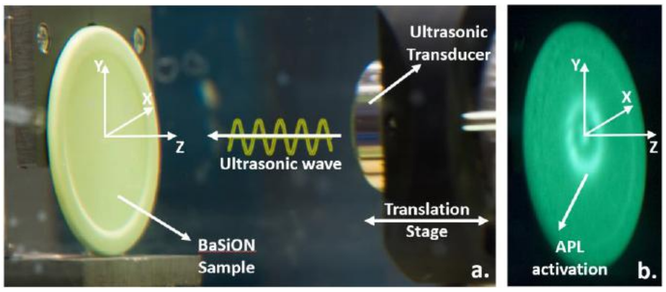


Figure 2: (a) Experimental setup and (b) example of APL activation

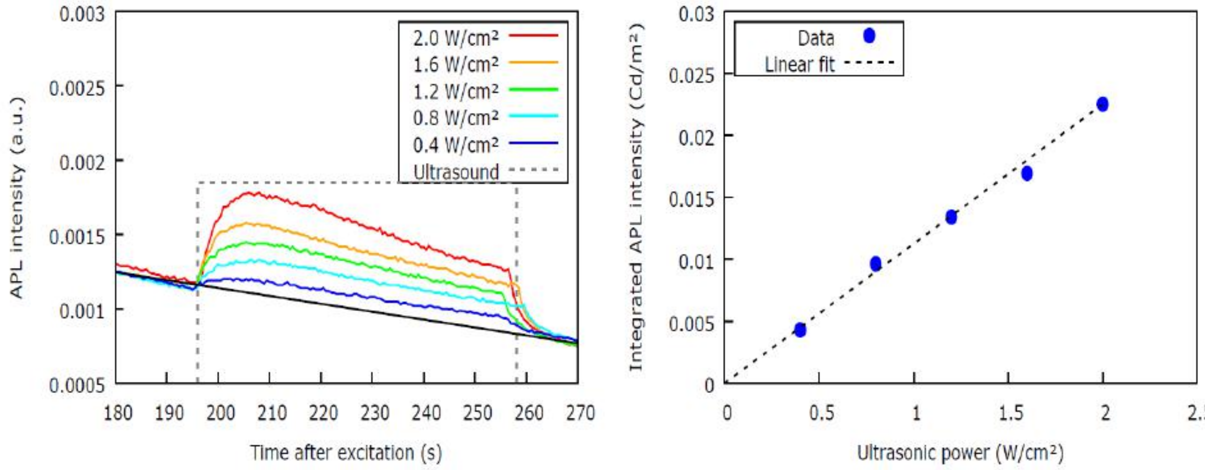
3. Results

3.1 Acoustic Power Sensor

First, it was investigated how the light emission varies with applied acoustic power. For this, the insonification distance z was fixed, while the applied acoustic power density was varied between 0 – 2 W/cm^2. Typically, this results in acoustic pressures up to 40 kPa in water. Figure 3a shows the recorded APL signal, with the dotted line indicating the time window during which ultrasound was applied. After integrating the light emission (between wavelengths of 450 and 550 nm, and between 210 and 250 seconds), one can easily verify the linear relationship between light emission intensity and applied acoustic power (Figure 3b). Hence, this indicates that the APL phenomenon can be used to devise a simple but effective acoustic power sensor.

3.1 Imaging Ultrasound

In Figure 2b one can easily verify that not only increased light emission is observed upon insonification, but that the APL signal has a specific geometrical shape. Moreover, when varying the insonification distance z we noted that the geometrical pattern of the APL signal changes. This strongly suggests that the observed light pattern provides some insight on the local cross-sectional pressure distribution of the applied ultrasonic beam.



(a) (b)

Figure 3: APL signal for different acoustic power (a) and linear relationship between integrated APL intensity and acoustic power (b).

Figure 4 shows the photographed APL light patterns for a range of insonification distances *z* at 2 W/cm^2. Since the BaSiON samples were sufficiently thin, the photographs could be obtained in transmission (i.e. at the opposite side of insonifcation). A red-green-blue color scheme has been applied to the recorded images in order to enhance the visibility of features.

At short insonification distance *z*, one expects a representation of the vibrating surface of the transducer. The photograph obtained at *z* ≈ 17.5 mm reveals an activated zone with global dimensions corresponding to the dimension of the employed transducer. However, instead of a uniform amplitude field, the activated zone has an annular shape with a disc inside. Clearly, the surface of the employed transducer vibrates with an inhomogeneous amplitude distribution, rather than a uniform amplitude profile. Comparison of the results obtained at different insonification distances *z* yields a change in geometry of the activated zone. For *z* ≤ 100 mm, the activated zone remains more or less similar, although the inner disc becomes less intense while the annular ring expands. At *z* ≈ 107.5 mm, the inner disc disappears leaving only a broad annular ring. At *z* ≈ 197.5 mm, the beam transforms back to the original distribution, i.e. a disc inside an annular ring. Finally, the pressure field evolves to a more or less Gaussian distribution at *z* ≈ 297.5 mm. It has been verified that the Gaussian shape remains for distances up to *z* ≈ 600 mm, while gradually spreading out. It is clear that the evolution of the cross-sectional pressure distribution as function of insonification distance *z* may be understood in terms of near- and far-field characteristics of a harmonically driven circular radiator.

One can also observe angular variations in the APL images, which cannot be linked to the diffractive nature of a bounded beam, nor to the geometry of the circular transducer. We have performed further experiments with different BaSiON samples, yielding the same results. Hence, the angular features are not induced by an inhomogeneous distribution of the dispersed luminescent powder. Consequently, small deviations in the radiation field of the transducer are most likely the cause of the angular variation in the APL signal. One possible origin for this may be the inappropriate fixation of the piezoelectric crystal in its housing, thus causing a spatially distorted and non-uniform vibration amplitude.

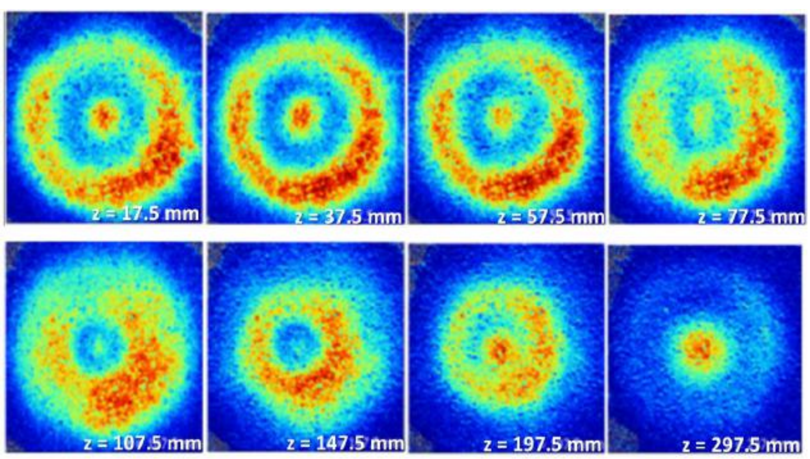


Figure 4: Photographed and digitized APL light emission intensity at various insonification distances *z*

In order to confirm the APL results, we numerically reconstructed the radiation field according to the holographic principle on the basis of a fast Fourier transform beam propagation model (FFT-BPM) (Goodman, 1996). The transducer is modelled as a circular radiator having an amplitude distribution according to (with *x*, *y* in mm):

$$A(x, y, x = 0) = \begin{cases} 0 & 12.2 < \sqrt{x^2 + y^2} \\ 1 & 5.5 \leq \sqrt{x^2 + y^2} \leq 12.2 \\ 0 & 3.5 \leq \sqrt{x^2 + y^2} \leq 5.5 \\ 1 & \sqrt{x^2 + y^2} \leq 3.5 \end{cases}$$

This amplitude distribution can be considered as a simplified model for the true amplitude profile at the transducer's surface. The phase is assumed to be uniform over the transducer's surface. The numerical source is discretized in steps of $\Delta x = \Delta y = 0.02$ mm, oscillating at a frequency $f = 3.3$ MHz. The surrounding medium is modelled as water with density $p = 1000\ kg/m^3$ and wave speed $c = 1480$ m/s . After transforming (2D fast Fourier scheme) the pressure field to spatial frequency domain (k_x, k_y), the result is multiplied with the free-space propagator $exp(ik_z z)$, with $k_z=\sqrt{(k^2-k_x^2-k_y^2)}$ the wave number in z-direction and z the propagation distance. Application of the inverse Fourier transform then results into a representation of the acoustic beam in real space, which is propagated over a distance z. The periodic nature of the fast Fourier transform however results in reflections at the boundary of the numerical domain, which becomes especially cumbersome for large propagation distances. To avoid these interfering reflections without enlarging the size of the numerical domain, the acoustic beam is incrementally propagated in steps of $\Delta z = 1$ mm while applying a damping function D, in real space, to absorb the energy at the boundaries of the numerical domain:

$$D(x,y) = exp\left(-\left(\sqrt{2\sqrt{x^2+y^2}/_{0.97\,W}}\right)^{50}\right)$$

with W the size of the numerical domain.

The computed beam pattern in the YZ-plane is shown in Figure 5a. One can readily identify near-field features, until the far-field ($z \approx 250$ mm) emerges as a Gaussian-like amplitude distribution. Cross-sectional views at various distances z are shown in Figure 5b. In Figure 5c, the corresponding APL images are listed for the respective z-values. It may be clear that good agreement is found.

Finally, we also recorded several cross-section of the radiation field by means of scanning hydrophone experiments. The XY-plane is scanned (spatial resolution of 0.25 mm) with a calibrated ONDA HGL-0400 needle hydrophone at various distances z. The ultrasonic amplitude is acquired with the USIP40 (General Electric) apparatus at sampling frequency of 400 MHz. Typically, one such experiment takes 30 minutes, which is in sharp contrast with the fast APL imaging (order of seconds for the actual measurement). The results are shown in Figure 5d for the selected insonification distances z. One can readily identify the presence of the radial and angular distribution, which we earlier linked to diffractive properties of the bounded beam on the one hand and to imperfections in the transducer design on the other hand. The transition of the cross-sectional geometry at the different distances z is in excellent agreement with both simulation and APL results.

3.3 Towards Acoustic Frequencies

APL experiments have also been performed at acoustic

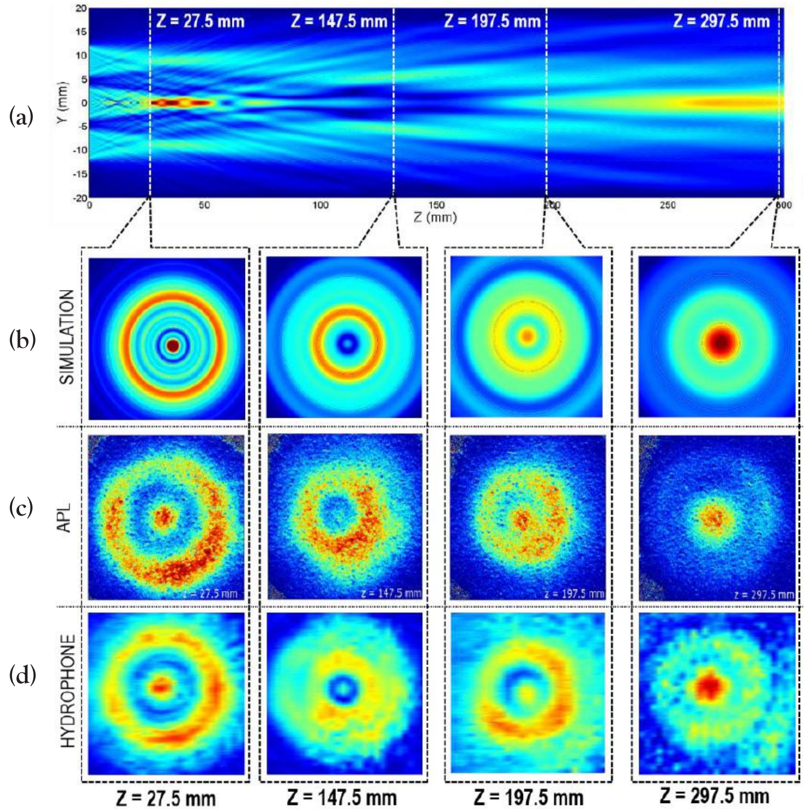


Figure 5: Simulated radiation field in YZ-plane (a), and XY cross-sectional views at various distances z: Simulation (b), APL experiment (c) and scanning hydrophone experiment (d)

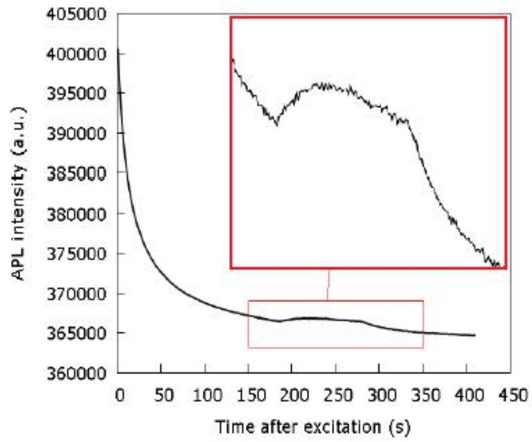


Figure 6: APL signal obtained for PZT patch at 20 kHz and input voltage of 50 V_{pp}

frequencies using lead zirconium titanate (PZT) patches which are directly bonded to BaSiON (as well as other piezoluminescent phosphors) samples using phenyl salicylate. The PZT patches are driven in the kHz range by a wave generator (Tektronix AFG 3021B) coupled to a voltage multiplier (Falco WMA300). Electrical input voltage between 1-300 V_{pp} is considered. Our preliminary results indicate that also kHz waves trigger the APL phenomenon. At low voltage input (1-50 V_{pp}) however the PZT patches do not lead to strong APL signal, which is in clear contrast to the excellent results obtained with the MHz transducer. These first results indicate that the acoustic power generated by the PZT patches is simply not sufficient to trigger the APL phenomenon efficiently (see Figure 6). The observed increase in light intensity barely exceeds the afterglow curve, indicating that only a limited amount of APL is involved, and that the process is dominated by thermal detrapping.

The logic step would be to increase the applied voltage on the PZT in order to induce higher acoustic power, and as a consequence to increase the APL signal with respect to the signal associated with thermal detrapping. By increasing the input voltage to 50 - 300 V_{pp}, a clear increase in light emission was observed. However, by doing so we noted that also secondary effects are induced in the employed PZT patches, which compromise the APL measurements. First of all, we found that the used PZT patches behave nonlinear at high voltage input.

This is illustrated in Figure 7 showing the vibrational response in frequency domain (measured with a laser Doppler vibrometer) of a PZT driven at a frequency of 5 kHz and voltage input of 200 V_{pp}. Besides the clear spike at the input frequency of f = 5 kHz, one can clearly discern several super- and subharmonics revealing the nonlinear behavior of the PZT patch when driven at high voltage. This nonlinear response of the PZT's became pronounced for voltages higher than 50 V_{pp}.

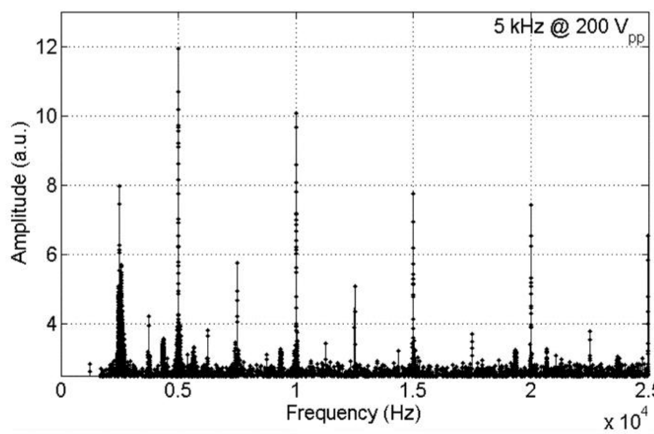


Figure 7: Vibrational response of a PZT patch driven at 5kHz and 200 V_{pp}

Apart from nonlinearity in the response of the PZT patch, we also noted some heating when applying voltages higher than 50 V_{pp}. The temperature evolution of the PZT patch has been monitored by a thermographic camera for different applied voltages. The results are shown in Figure 8, revealing that considerable heat is produced when driving the PZT at voltages higher than 50 V_{pp}. Obviously, the generation of heat compromises our APL measurements as thermoluminescent processes come into play. Hence, these preliminary results indicate that APL can be triggered in the acoustic regime, but with the current low power PZT patches the efficiency is not satisfactory.

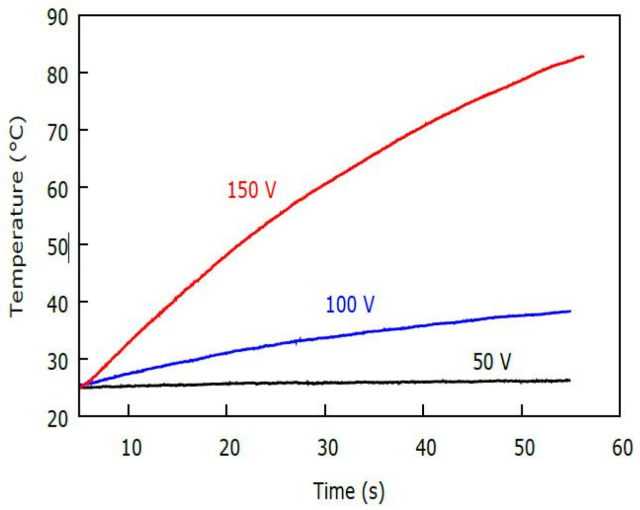


Figure 8: Temperature evaluation of PZT patch when driven at 20 kHz and different voltages

In addition, the employed PZT patches show secondary effects which compromise the APL measurements. Currently we are investigating different excitation methods in the kHz range in order to overcome the aforementioned problems of the PZT patches regarding nonlinearity and heating. As such, we hope to apply the APL phenomenon for various applications in the acoustic frequency region.

4. Conclusions

This paper introduced the phenomenon of acoustically induced piezoluminescence (APL). It was shown that the APL effect provides opportunities for the development of a simple but effective acoustic power sensor. Further, the APL phenomenon has been employed to obtain cross-sectional images of the pressure field of an ultrasonic beam (f = 3.3 MHz) in real-time. Combining many of such cross-sections then yields a 3D spatial representation of the pressure distribution of an ultrasonic field in both near- and far-field. Good agreement was found between the reconstructed pressure distributions through APL on the one hand, and both simulation and conventional scanning hydrophone experiments on the other hand. Compared to conventional methods, APL imaging of ultrasonic beams has the clear advantage that it is simple, cheap and fast. Finally, preliminary experiments have been presented which indicate that the APL phenomenon is equally valid for acoustic frequencies. Unfortunately, secondary effects in the employed PZT actuators compromised the APL signals, making a clear interpretation difficult. Current research focuses on implementing alternative excitation methods in the kHz range in order to isolate the APL signals from secondary phenomena, and to identify the underlying physical processes of APL.

10. Acknowledgments

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Remembering Cliff Stevenson

Professor D.C. (Cliff) Stevenson who was a Fellow of the Acoustical Society passed away in December, 2013 and I was concerned that this should not go unmarked by the Society. Cliff was an active member of the Society from its inception, and was one of the pioneers in acoustics in New Zealand.

Cliff was born in Auckland in 1924 and was a very bright student. It was very much of the times that his father wanted him to leave school after Primary School and join the carpentry business, but his mother insisted he should go to high school, and later encouraged him to go to University. His education was interrupted by World War II, during which he joined the air force and saw active service in the Pacific Theatre.

After the War he completed an engineering degree and then I suppose with flying very much in his mind he went to the UK where he did a Master of Science at Cranfield Institute of Technology. He later worked at the Aeronautical Research Laboratory in Melbourne where he became interested in the effect of jet noise on aircraft structures. He joined the academic staff at the Department of Mechanical Engineering at Canterbury in 1954 and in 1963 took up a position as Associate Professor at Monash University in Melbourne teaching Fluid Mechanics and Acoustics.

In 1969 he returned to Canterbury University as Head of the Mechanical Engineering Department and remained in this position until he retired in 1989. He built up an active acoustics group at Canterbury with a reverberation room,

...Continued on Page 25

Methods of validation of occupational noise exposure measurement with multi-aspect personal sound exposure meter

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Abstract

Occupational noise measurement over the full working day is usually performed using personal sound exposure meters (noise dosimeters). As workers carrying a dosimeter inevitably disturb the measurements, (whether willingly or unwillingly), it can be a challenge to validate results and ensure they are representative of the actual occupational noise exposure. This paper reports on a case study of mechanical workshop noise measurement. Evaluation of daily occupational noise exposure is impeded by non-occupational sound source events, for example "faked" increases in noise level achieved by putting the dosimeter immediately adjacent to the working tool and accidental bumps and scrapes of the microphone against solid surfaces. As shown in this paper, with newer generation, "smart" dosimeters, it is largely possible to eradicate such distortions and thereby achieve a better estimate of the actual occupational noise exposure.

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1. Introduction

With mobile workers, undertaking many noise-related tasks or subject to unpredictable work patterns, standards like ISO 9612:2009 advise the use personal sound exposure meters (PSEM) and a full-day measurement strategy for evaluation of daily occupational noise exposure. Inevitably in this approach, some workers wearing PSEM will disrupt the measurements (willingly or unwillingly), thus it is recommended that the specialist responsible for the evaluation, constantly observe the workers. However, as such measurements can take two or more workdays to complete and may need to be performed in harsh conditions; this recommendation is often not followed, with a resulting increased uncertainty as to the actual occupational noise exposure.

With the new "smart" PSEM devices, which log not only short L_{Aeq} time history, but also the frequency spectrum, record audio and track of mechanical shocks to the meter and permit detection of time periods where the worker removed the meter – it is possible to exclude many cases of distortion and therefore achieve better estimates of daily noise exposure. The current study presents an analysis of the potential impact of the following on the estimation of daily occupational noise exposure:

- noise of non-occupational origin,
- apparent amplification of the occupational exposure due to the PSEM being removed by the worker and "parked" adjacent noisy machinery,
- accidental bumps of meter's microphone against hard surfaces.

2. Methods

The study was performed using a SVANTEK SV 104, personal sound exposure meter (see figure 1). The SV 104 meets Class 2 IEC 61672:2002 and was designed to perform measurements in accordance with ISO 9612, ACGIH, NIOSH, OSHA and numerous other occupational noise standards. In addition to L_{Aeq}, L_{Ceq}, L_{Cpeak}, L_{AVG}, TWA etc., the meter is capable of logging short period time histories of 1/1 octave band spectra, record audio events or record audio continuously. The output of a built-in tri-axis accelerometer is logged during measurement thus allowing mechanical shocks which the meter (and its microphone) may receive to be recorded for later identification. This facility also permits those periods when the device was motionless to be detected (such as might occur, if the PSEM was removed by the worker and "parked" somewhere).

Figure 1: SV 104 8 personal sound exposure meter

The logging results were analysed using SVANTEK Supervisor software. This provides various tools to evaluate occupational noise exposure and allow detection and separation of measurement distortions, using data recorded on the PSEM.

A full working day (approximately 7 hours) measurement was conducted in a mechanical workshop. Activities included CNC machine operation, metal sawing and grinding operations (see figure 2). The worker had two SV 104 installed on both shoulders. The PSEM was set to log at 500 ms intervals. An audio event recording trigger level

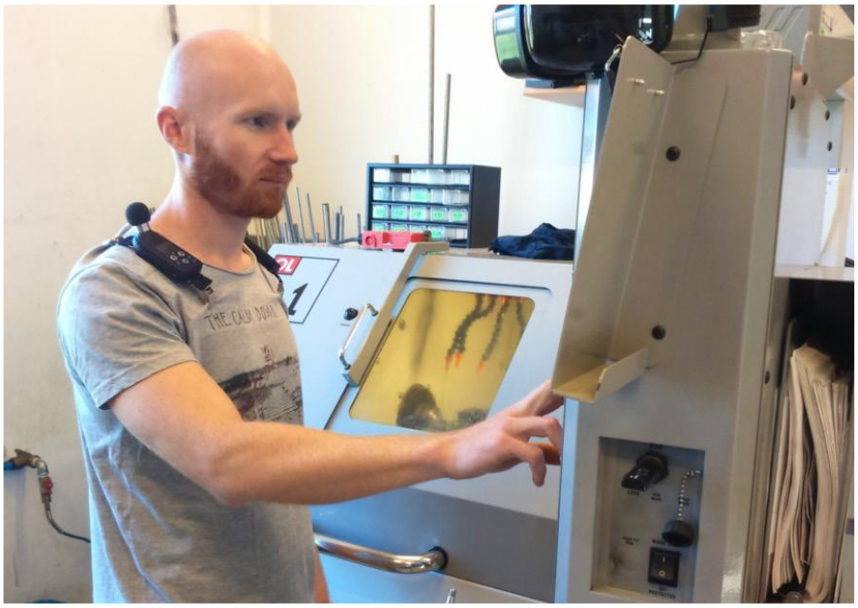

Figure 2: Workshop worker operating CNC machine (left) and saw (right)

of 85 dB short L_{Aeq} was used.

Figure 3: Worker operating CNC machine, left shoulder PSEM detached and positioned on CNC chamber

The operator listened to loud music occasionally to simulate noise exposure increase due to nonoccupational sources. During the measurement period, the PSEM on the left shoulder was bumped against hard surfaces in the workshop multiple times, to check the impact of such shocks on measurement results.

The left hand device was also removed from the workers shoulder twice, for an overall period of approximately 1 hour 12 minutes. During these periods the PSEM was "parked" on top of the CNC machine (see figure 3) to simulate worker manipulation of the apparent daily occupational noise exposure.

3. Results

The measurement "shift" was 7 hours 13 minutes. The "raw" results obtained (without further analysis to remove periods where the measurements were subject to distortion) are summarised in Table 1. As may be noted, the left shoulder PSEM recorded a Noise Dose which was 106 % of the allowable dose.

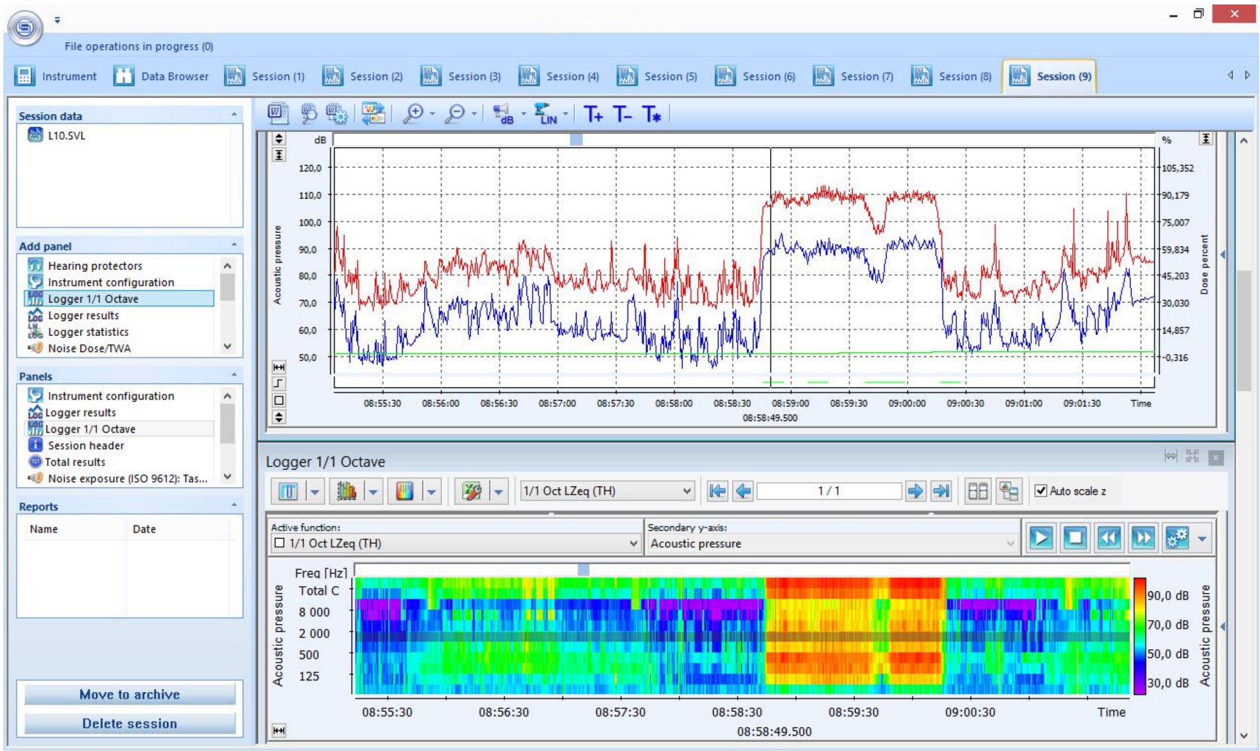

Figure 4: Time history of L_{Aeq} and L_{Cpeak} together with a spectrogram of a loud music event, left shoulder instrument

Table 1: Summary results of the measurement, without eliminating disturbances

Instrument placement	L_{Aeq} (dB)	Dose (%)	L_{Cpeak} (dB)
Right shoulder	74.1	7.3	121
Left shoulder (+ distortions)	85.7	106	> 140

3.1 Introduced Music Noise

As noted above, the measurement results from both instruments were influenced by loud music. Figure 4 shows a typical view of the analysis software output screen.

Two short period loud music events (2 minutes 26 seconds in total) from the left shoulder instrument time history stand out due to their different frequency characteristics relative to those typical for workshop tools. The loud music resulted in an increase in the daily dose of 1.3 % (L_{Aeq} 90 dB for 2 minutes 30 seconds). Apart from the spectral differences, music events can be identified by playback of the audio events logged by the PSEM.

3.2 PSEM parked adjacent operating machinery

Two periods of no movement were noted in the left shoulder PSEM record, these are highlighted with an orange marker in the time history shown in Figure 5. The periods sum to a total of 1 hour 12 minutes and are responsible for 13.7 % of the daily dose. The events shown can be matched to the period of time when the instrument was removed by the worker and placed on top of the CNC chamber.

Figure 5 allows comparison of the time history from the left and right shoulder PSEM. Left shoulder – blue trace, including those periods where the meter was removed and placed on top of the CNC machine (L_{Aeq}, average over the 1 hour 12 minutes period was 84.6 dB) and right shoulder – red trace (remaining on the worker's shoulder, average L_{Aeq}, over the same period, 69 dB). During the period, the worker remained within 0.5 –2.5 m of the CNC machine.

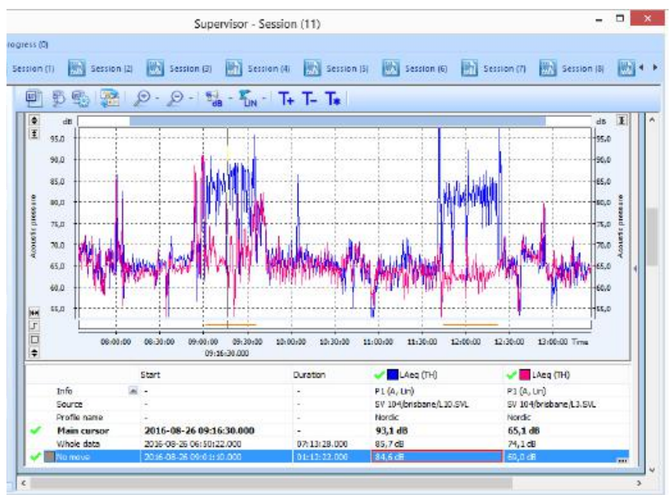

Figure 5: Full day measurement L_{Aeq} overview from both instruments

3.3 Bumps against hard surfaces

Three example bumps to the instrument, labelled in blue as "High vibration level" are pictured with Figure 6. The bumps together add 6 % of the daily allowable dose. During the approximate 7 hour period a total of 17 "High vibration level" events were automatically marked by the PSEM. These events were responsible for 88 % (of 106 % of the allowable dose) in the exposure


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measurement. However, in a real situation, where the software tool indicates a “High vibration level”, suggesting that a particular recorded peak sound pressure level event is more than likely an artefact, that impacted only the microphone, (not the workers ear), it is still advisable to discuss the situation with the worker and confirm the finding, as a true impulsive noise (rather than an artefact from the microphone being bumped) may be especially harmful.

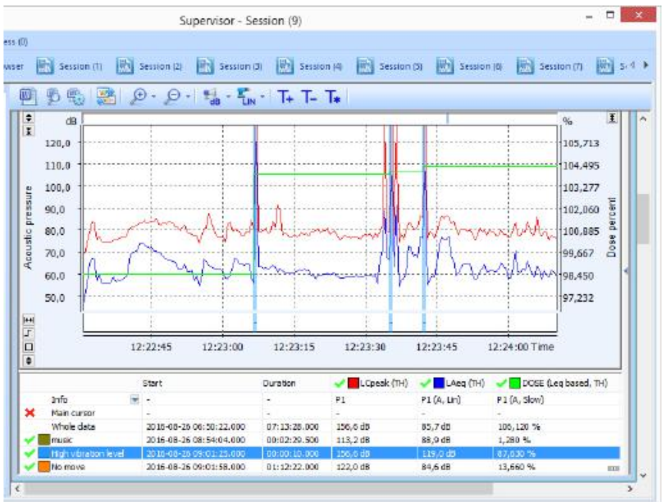

Figure 6: Left shoulder PSEM: three mechanical shocks, L_{Aeq} and L_{Cpeak} time history

In the current experiment, some of the stronger bumps the instrument received, would likely damage a classic condenser/ceramic microphone. However, the SV 104 is equipped with an extremely robust MEMS technology microphone and no sensitivity shift occurred during this experiment. This was verified by comparing pre and post-measurement calibration factors. Calibration was performed with a SVANTEK SV 35 Class 1 calibrator at 114 dB sound pressure level. The observed calibration drift was 0.02 dB.

Table 2: Impacts of distortions, left shoulder instrument

Factor	L_{Aeq} (dB)	Duration	Dose (%)
Music	89	2 min 30 sec	1.3
No movement	84.6	1 hour 12 min	13.7
Bumps	119	10 sec	87.6
Whole measurement	85.7	7 hours 13 min	106

3.4 Summary and final estimation of daily occupational noise exposure

The effect of the three kinds of distortions considered in this experiment can be seen in Figure 6. This table is derived from the Supervisor analysis software outputs (which are presented in a table below the time history plot). The measurements were started at the beginning of the worker’s shift and stopped at its end, 7 hours and 13 minutes later, thus this period can be treated as the exposure time. The duration of observed distortions in this particular case should not be removed from the exposure time, as it is known that the worker remained at his post throughout the entire period. After eradicating the various “distortions”, the final daily occupational noise exposure $L_{EX,8h}$ was calculated (as an output of the Supervisor software) as 71.3 dB (L_{Aeq} 71.8 dB for 7 hours 13 minutes), which is 4.3 % of allowable dose (criterion level: 85 dB for 8 hours working day).

4. Conclusions

As discussed in this paper, sound which is non-occupational in origin can affect occupational noise exposure measurements quite noticeably. There is thus a need to be able to identify it. The instrument studied allows this to be done visually via a spectrogram and also by audio playback of the recorded events.

Manipulated noise level increase from occupational tools achieved by positioning the instrument closer to machine is difficult to identify, as it has the same frequency characteristics as more usual exposures and also sounds similar in playback to recordings made where the PSEM (and the worker’s ear) are in close proximity to an occupational noise source such as during tool usage. This is where the logged output from a motion sensor can be very helpful in identifying, suspect periods of measurement.

The effect of bumps to the PSEM and microphone for the assessed exposure can be very large. It is thus important to be able to distinguish between high sound pressure level events actually heard by the worker and those apparent events which affect only the microphone and which should be removed from the time history when evaluation of the true daily occupational noise exposure is to be made.

5. References

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a low noise wind tunnel and a tyre noise measurement rig. At various times Walt Eversman, Jeremy Astley and Alan Cummings were there with Cliff doing significant research work in acoustics.

Cliff had a long and distinguished career, publishing over 50 scientific papers, and being awarded three patents. In 1990 he became the first person to be awarded a Doctorate in Engineering from Canterbury University. He served on many public committees, and of particular note was vice-chair of the Board of Health committee, appointed in 1971 to undertake a survey of noise and its control, leading to the influential Report No. 21 "NOISE". Recommendations were made on the control of noise from aircraft, traffic, rail and noise in the community. Cliff carried out some of the earliest research in New Zealand into aircraft noise, and traffic noise and the community response, and I believe some of this work was published in our journals.

A paper of particular interest was "Traffic Noise: A Social Survey and Measurement of Traffic noise in Christchurch, New Zealand", which was published in the Transactions of the Professional Engineers of New Zealand 1979. This showed that the community response was very similar to the studies carried out internationally and which were so well summarised in the Schultz dose-response relationship.

I first met Cliff as a nervous first year student in 1971, and recall his first lecture in which he advised the class not to become acoustic consultants as great reductions in noise energy yielded disappointing results in both the decibel scale and human perception and consequently disappointed clients. Somehow I forgot to take his advice.

Cliff was a gentle, patient teacher, who had an ability to make complex matters simple, and stimulated and encouraged generations of students. As part of his legacy acoustics and noise control is still a strong component at Canterbury University.

Cliff was a fine example of the New Zealanders of his generation, good hearted, modest, with a strong public service ethos and comfortable with all types of people.

New Zealand and acoustics in New Zealand have been enriched by his contributions.

Keith Ballagh and John Pearse

Officers of the Society

The AGM of the New Zealand Acoustical Society Inc was held at the Brisbane Convention and Exhibition Centre, Brisbane on 10th November 2016. The Acoustical Society of New Zealand is pleased to announce the following elected Officers of the Society:

President:	Jon Styles
South Island Vice President:	Robbie Blakelock
North Island Vice President:	Mark Poletti
Secretary:	James Whitlock
Treasurer:	Siiri Wilkening
Councilors:	Jamie Exeter, Grant Emms, Stuart Bradley, Neil Jepsen, Fadia Sami, Tim Beresford, Nick Henrys, Wyatt Page and Lindsay Hannah.

The Society welcomes all new Officers and in specific our new President Jon Styles. Jons first Column can be read at the front of this journal.

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A review of sound levels in the ICU at Christchurch Hospital

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Abstract

Hospitals are intended to be quiet spaces that promote tranquillity and patient recovery. However, studies carried out internationally indicate that hospitals are quite noisy and the noise levels far exceed the recommendations of the World Health Organization (WHO). The incidence of high noise levels affects patients and staff, increasing recovery times and affecting communication and performance respectively. This present study was carried out to assess how the noise levels in the ICU of Christchurch Hospital compared with similar hospitals overseas. The study monitored ambient noise in the ICU for both day and night-time periods over a continuous seven day period. Noise levels had an L_{Aeq} of 55-60 dB during the day and 45-50 dB at night, with frequently occurring peaks above 75 dB L_{Cpeak}, which reflect international trends. The major surprise was the very high number of peak noise events that occurred each and every hour throughout each day.

An original peer-reviewed paper

1. Introduction

Whilst we anticipate that hospitals would be quiet spaces where tranquillity prevails, international studies show that, in general, hospital noise levels exceed the recommendations of the World Health Organization (WHO). These recommendations are for a daytime level L_{Aeq} of 35 dB and L_{Aeq} of 30 dB overnight (Berglund, et al, 1999). Previous studies have shown a rising trend in hospital noise levels over the last 50 years (Busch-Vishniac, 2005; Shahid et al, 2014), of around 0.5 dB per annum. This trend has been partly attributed to population growth, urbanisation, and the development of more mobile and automated medical technology (Goines & Hagler, 2007). Elevated levels of noise can have negative effects on patients and staff alike. Hospital patients in typical intensive care units (ICUs) need a healthy, restorative environment in which to recover as they are particularly vulnerable to the effects of noise pollution (Goines & Hagler, 2007). Patient recovery is affected by many factors, one of which is noise exposure (Hsu, et al, 2010). This current study was initiated by hospital staff in response to an increasing awareness of increasing noise levels.

Noise pollution has been and is still an ongoing issue throughout modern society and is no less so in hospital environments. Earlier research reiterates Florence Nightingale's 1859 quote: "Unnecessary noise, then, is the most cruel absence of care, which can be inflicted on either sick or well," (Busch-Vishniac, et al, 2005), and point out that WHO regard noise as the leading stressor that affects patients' wellbeing (Shahid, et al, 2014).

One of the main disturbances reported by patients in hospital is the noise level (Hume, 2010; Stansfeld & Matheson, 2003). The ability to sleep well is imperative for a patient's physical and psychological homeostasis during a critical recovery period. The lack of a full sleep results in tiredness in the following days, fatigue, and the need for compensatory rest periods (Muzet, 1981). Horne (1988) reports that the main purpose of sleep is to allow tissue restoration through protein synthesis and cell division. McCarthy, Ouimet & Daun (1991) report that 70 % of growth hormones are secreted during sleep. These are important components in wound healing and therefore post-surgery patients in the ICU, who do not get adequate sleep, may not heal as efficiently and thereby their hospital stays are prolonged. Unfortunately, unlike being able to shut our eyes to reduce visual input, we cannot close our ears naturally to attenuate sound during sleep (Goines & Hagler, 2007).

Noise can induce subjective and/or physiological stress on patients in hospital (Hsu, et al, 2010; Topf, 2000). Noise can evoke adverse physiological responses such as tachycardia, hypertension, dyspnoea, insomnia, thyroxin, adrenalin increases, delayed wound healing, heightened blood pressure and heart rate, increasing complications and longer hospital stays; while psychological symptoms include annoyance, fatigue, impatience, rage, frustration, discontent, excitement and uneasiness (Hsu, et al, 2010; Hsu, Ryherd, Persson & Ackerman, 2012; Stansfeld & Matheson, 2003; Shahid et al, 2014; Topf, 2000). Community surveys have shown that those who were exposed to higher noise levels were more likely to report the presence of headaches, restless nights, and being tense and edgy (Stansfeld & Matheson, 2003). These effects are more prominent in vulnerable populations, such as for patients in hospital (Hume, et al (2010).

Topf (2000) found that most medical equipment in critical care units (CCU) produces sound levels close to 70 dB L_{Aeq}, which they compare to heavy traffic or a noisy restaurant. Hospital ICUs have a very individual acoustic environment; medical alarms, heating and air conditioning systems, occupant sounds, and machine noise, all contribute to the overall noise field (Ryherd, et al, 2011). Much of this noise is generated by activity and equipment that is for the benefit of the patient, but paradoxically can also be one of their major concerns. The purpose of medical alarms is to communicate a deviation from normal patient status, for improving safety, and for eliciting staff attention (ACCE, 2006). However, a pilot study by Atzema, Shull, Morgundvaag, Slaughter and Lee (2006) showed that 99 % of alarms were false with only 1 % indicating the need for a change in patient management!

Deng, Xiao and Kang (2013) found that staff in the ICU claimed that alarms and monitors were the loudest cause of noise. Marqués, Calvo, Mompart, Arias and Quiroga (2012) found that 68 % of patients reported that noise stopped them from sleeping, 38 % thought noise was most disturbing when they wanted to rest, and 31 % said noise made them feel worse when they were in pain. Further, 35 % of participants reported that noise was most annoying when it was repetitive, while another 28 % reported annoyance when the noise was very loud. A majority 65 % of respondents reported that noise was the most unbearable when the source was loud speech. Liu and Tan (2000) found that approximately one third of patients found sound levels noisy, one out of six patients felt these levels caused them distress and half the patients would have preferred a quieter environment.

Noise from outside the hospital environs may also have an effect on patients. Fife and Rappaport (1976) compared responses from cataract surgery patients who had no pre-existing health conditions who were undergoing treatment in a hospital when there was construction activity. Studies at one year prior to construction, one year during construction, and one year after completion of construction, showed that noise from directly outside the patients' windows affected how long patients needed to recover, with an associated increased chance of rehospitalisation within three months of discharge. Christchurch Hospital is not only being redeveloped but is also undergoing repairs caused by the 2010/2011 earthquakes and the many large aftershocks.

2. Methodology

2.1 Participants

Participants in this study were all patients over the age of 18 years admitted to the ICU at Christchurch Hospital, New Zealand, who were willing to participate in a noise study. The study was approved by the University's Human Ethics Committee.

2.2 Procedure

The Christchurch Hospital ICU consists of nine main beds laid out in the shape of an L as shown in Figure 1. There are three isolation rooms adjacent to the hallway and the nurses' station and store rooms are positioned centrally in the ward.

Noise monitoring was carried out using a Brüel & Kjær multi-channel Pulse system with two microphones and complied with New Zealand Standard NZS6802:2008

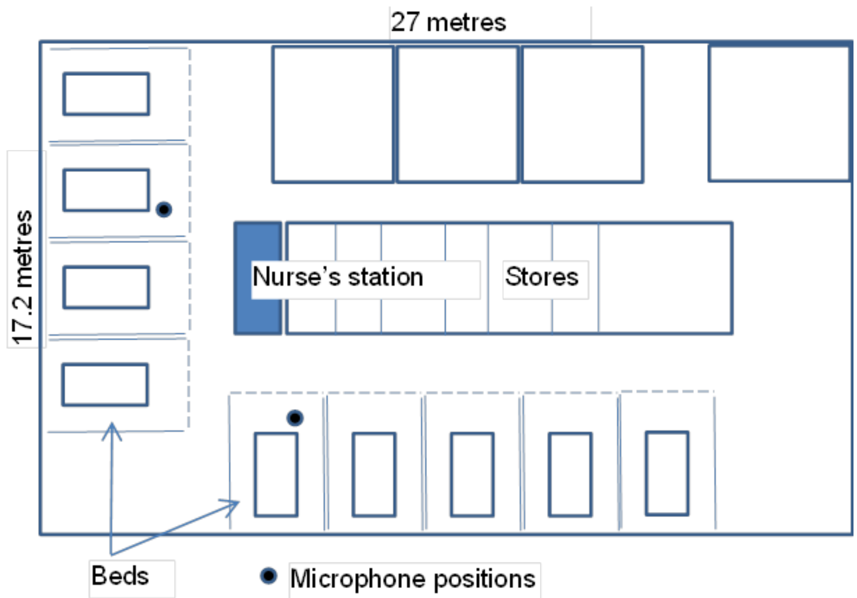

Figure 1: Layout of the ICU ward

and followed the WHO guidelines (Berglund, et al, 1999). The two microphones were placed in areas that had earlier been subjectively identified as being noisy. Ideally the microphones would be placed just above the head of the patient and at an appropriate distance from the wall, but this was not feasible due to the presence of medical equipment and the safety protocols of the ICU. Therefore the microphones were mounted on curtain railings at the ends of beds 5 (mic-2) and 8 (mic-2).

Data was collected continuously at one second intervals over a period of one week, beginning at 9am on Wednesday 16th September and finishing at 9am on Wednesday 23rd September 2015. A sampling rate of 45 kHz was used in order to capture frequencies up to 10 kHz. Microphone placement and equipment security was checked daily during this period.

The dependent variables in the ICU study were the objective noise levels measured. The independent variables were the day of the week, time of the day and levels from each microphone. The extraneous variables include change in staff behaviour due to the presence of the instrumentation and any exterior construction noise. For each daily measurement period the sound level data was binned at two-hour intervals and exported to Brüel & Kjær Pulse Reflex v17.1.1 data analysis software. Each 24-hour period (12 bins) was separated into six different times of day, each including two two-hour periods: early morning (3am-7am), morning (7am-11am), midday (11am-3pm), afternoon (3pm-7pm), evening (7pm-11pm) and night (11pm-3am). Pulse Reflex was used to determine the number of peaks that exceeded 75 dB for each time of day, and the numbers of peaks and times of day were then exported to Microsoft Excel and pivot charts were subsequently created.

Data from the Microsoft Excel files were exported to IBM SSPS Statistics 23 software, where statistical analysis was carried out, using a linear mixed model analysis with pair-wise comparisons, to determine correlations between day of the week, time of day, and microphones 1 and 2 for statistical parameters of L_{Aeq} and L_{Cpeak}. Day and time of day were entered as fixed effects and difference in microphones was entered as a "random" effect. A Bonferroni interval adjustment was used due to multiple variables. For analysis of the number of peaks in each period, independent-samples t-tests were used.

3. Results

In all areas of the ICU surveyed, the surfaces of walls and ceilings were hard plaster, while flooring was linoleum. There were medical machines/alarms for all nine patients on the main floor, ceiling air conditioning, a number of blood transfusion machines in the area, metal rubbish bins and carts and different medical teams/cleaning staff coming in and out. There was a notice at the entrance into the ICU from the staff room asking everyone to please keep the noise level down at night.

Observation identified the main sources of 'noise peaks' as being due to medical alarms, trolleys, metal bins being closed, doors slamming, chairs scraping, drawers shutting, and loud speech. During the period of noise monitoring, the current ICU building was being extended in the adjacent room (through the hallway to the top right of Figure 1). This caused additional building noise and disruption for staff during this period.

L_{Aeq} values in the ICU for each two-hour period over the days of a weeklong survey are shown in Figures 2 to 8 below. The levels were all in excess of the 35 dB for day and 30 dB for night WHO guidelines, (Berglund, et al, 1999).

The linear mixed-effect model test showed a significant

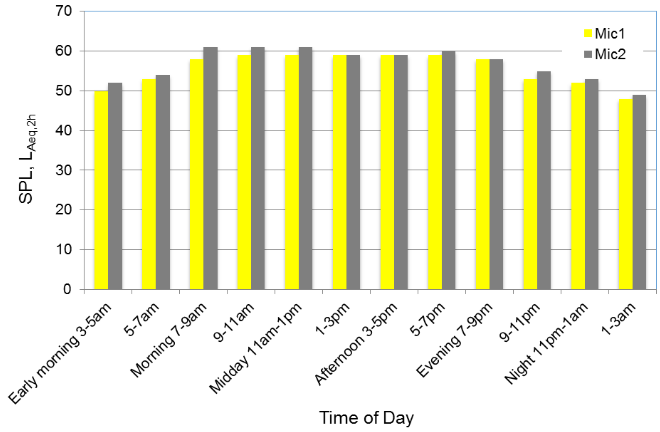

Figure 2: L_{Aeq} as a function of time for Monday 21/10/2015

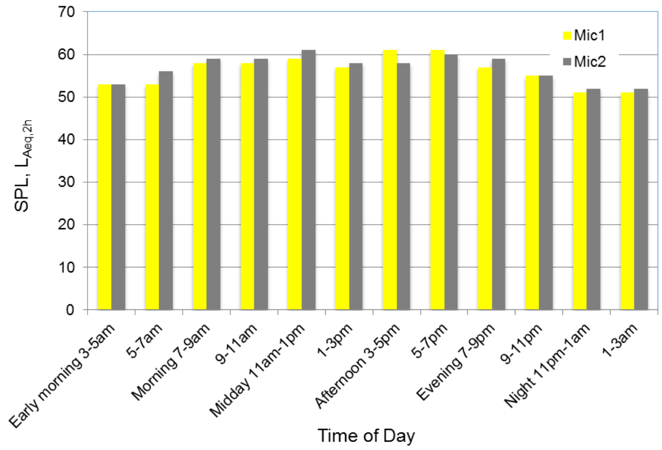

Figure 3: L_{Aeq} as a function of time of Tuesday 22/10/2015

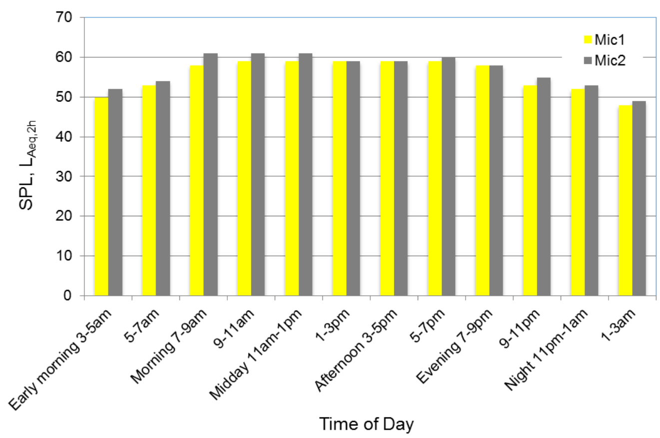

Figure 4: L_{Aeq} as a function of time for Wednesday 23/10/2015

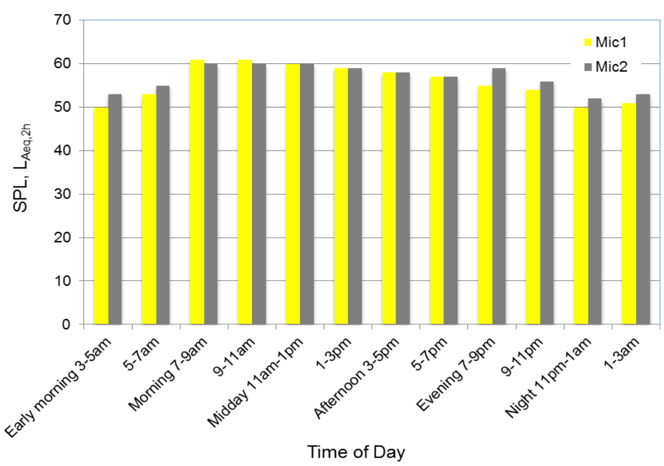

Figure 5: L_{Aeq} as a function of time for Thursday 24/10/2015

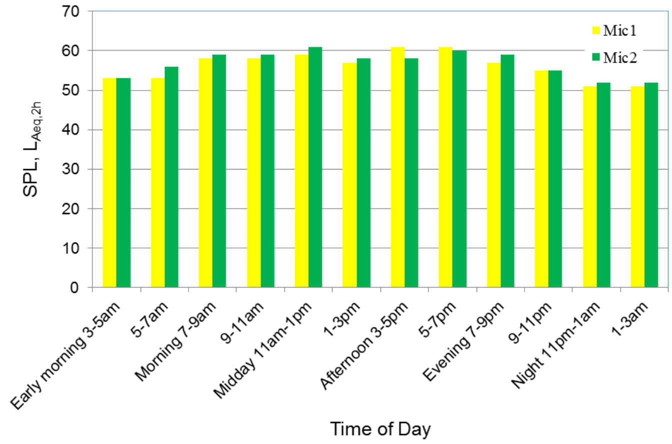

Figure 6: L_{Aeq} as a function of time for Friday 25/10/2015

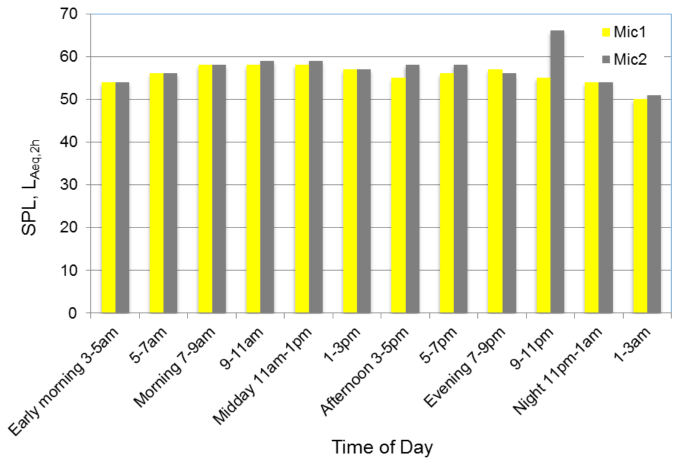

Figure 7: L_{Aeq} as a function of time of Saturday 26/10/2015

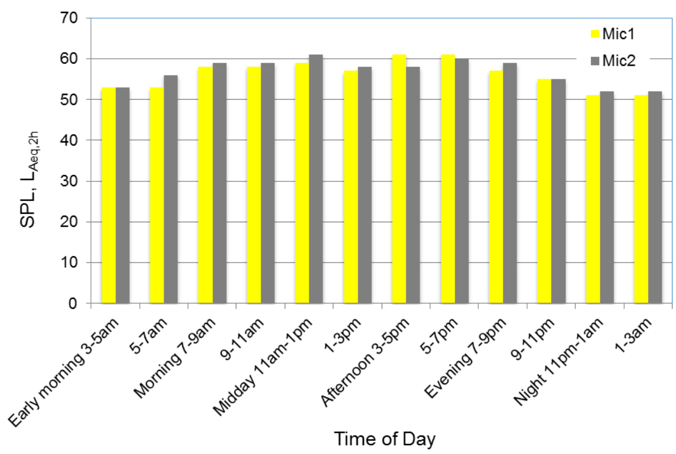

Figure 8: L_{Aeq} as a function of time for Sunday 27/10/2015

correlation between the time of day and L_{Aeq} measured ($F(5, 155) = 122$, $p = <.001$). With the exception of two outliers, Monday 9:00am and Saturday 10:00pm, this correlation is visible in Figures 2-8. The pair-wise comparisons showed the early morning and night have a significant mean difference between all times of day ($p = < 001$), however, morning, midday and afternoon were not significantly different to each other ($p = 1.00$). There were no significant correlations between the day of the week and L_{Aeq} measurements ($F(6, 155) = .51$, $p = .838$), nor any significant differences between the measurements at the two microphone positions (p = .087). The microphone differences accounted for an estimated 33.8 % of random effect L_{Aeq} variance.

L_{Cpeak} was the highest peak level recorded in each two-hour period. The highest peak recorded (135 dB) occurred on Saturday evening about 10:00pm, and was followed by one on Monday morning about11:00am. The lowest level for the noise peaks, for any two-hour period, was 94 dB. Day of the week was not significant (F(6, 155) = 1.04, p = 399). Time of day was (F(5, 155) = 3.95, p = .002), however only morning and midday had significant effects. The microphone number was not a significant factor (p = .62) but accounted for an estimated 5.9% of random variance.

The number of 'noise peaks' (local maxima) that exceeded 75 dB L_{Aeq} were counted per four-hour time of day period for each microphone. The lowest number of 75 dB exceedances was four, measured in the early morning period of Wednesday, and the highest number was 221, measured in the morning period of Thursday. The day of the week was again not significant (F(6, 156) = 1.54, p = .168), while time of the day was (F(5, 156) = 27.0, p = <.001). Independent-samples t-tests were performed to compare the results from the different microphones on the number of peaks. There were significant differences

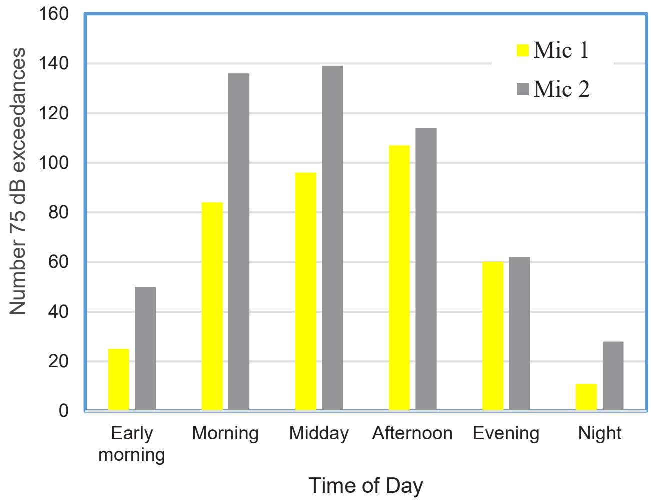

Figure 9: Number of 75 dB L_{Aeq} exceedances, for each time of day on Monday 21/10/2015

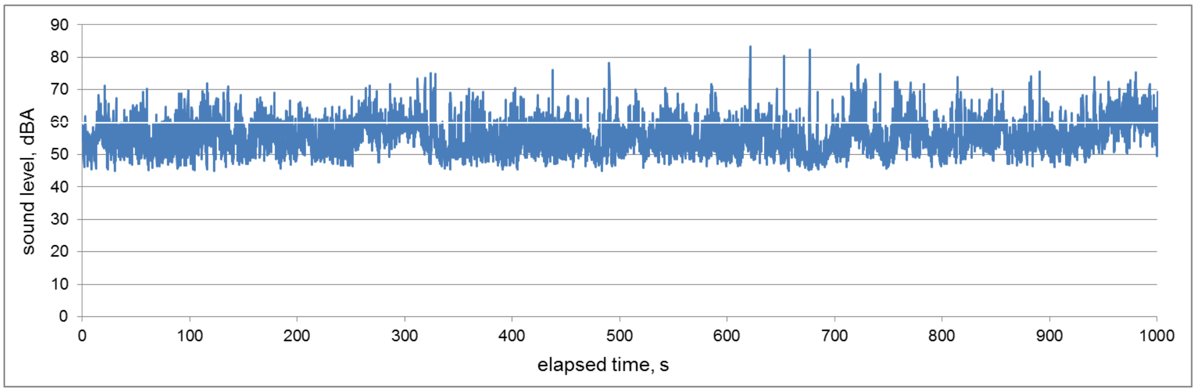

Figure 10: Sample 16-minute time history from a daytime survey

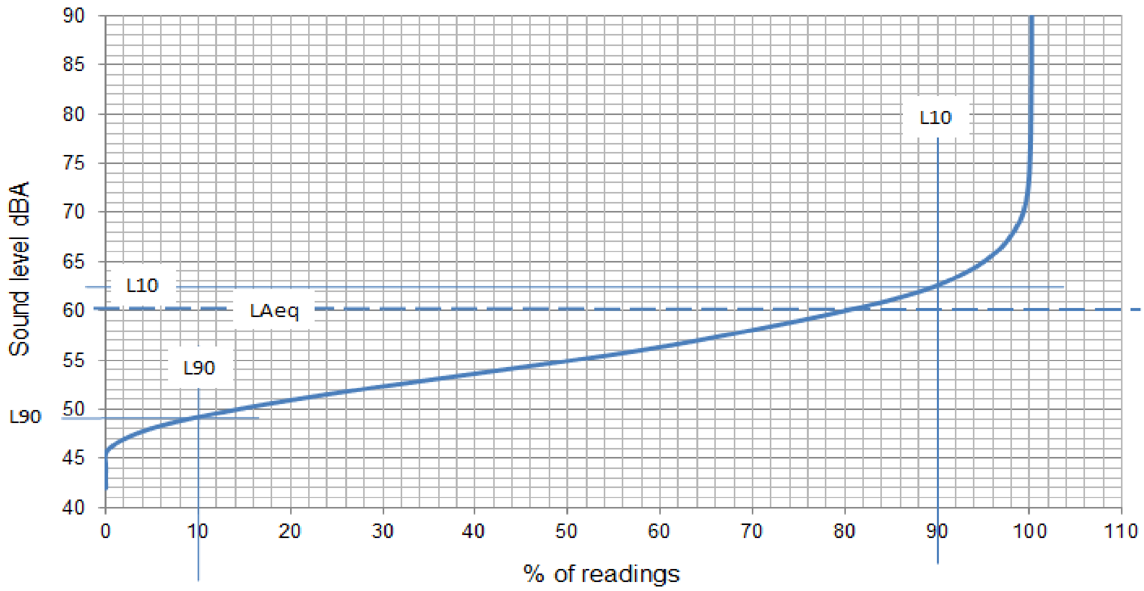

Figure 11: Distribution of sound pressure level readings in Figure 10

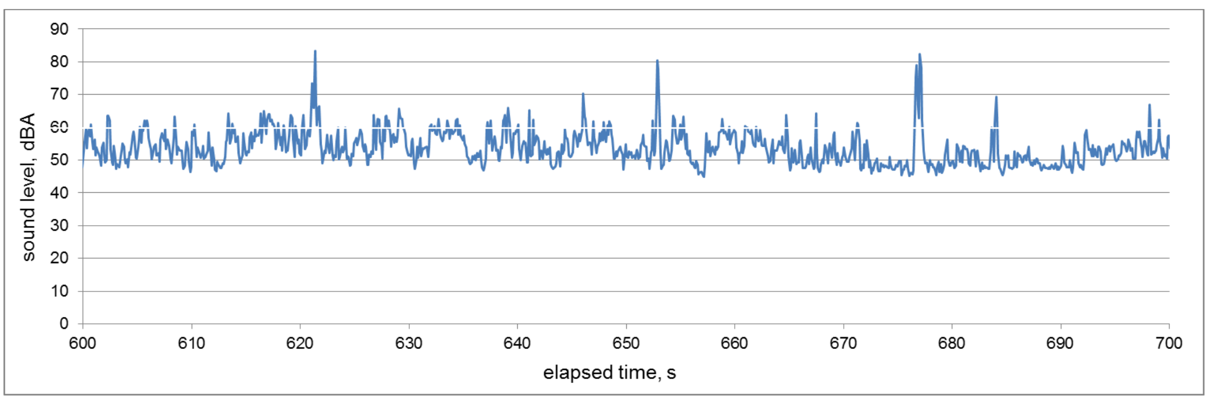

Figure 12: Expansion of part of Figure 10

between the two microphones, one (M = 29.9, SD = 22.7) and two (M = 42.5, SD = 21.9) in this variable ($t(166) = -3.65$, $p = < 001$). Distribution of the occurrence of 75 dB exceedances for 21st September is shown in Figure 9.

Figure 10 shows a short time history from one of the records of sound pressure level and the distribution is shown in Figure 11. The computed L_{Aeq} is 59.7 dB, approximately 5 dB above the median (L_{A50}) and 12 dB above L_{A90}. Figure 10 gives an example of the 'peakiness' of the noise in ICU and also shows three exceedances that are greater than 20 dB above the background at the time – expanded record in Figure 12.

4. Discussion

According to the WHO, patients in the ICU should be given special attention due to their immediate health concerns (Berglund, et al., 1999). The noise levels measured in the Christchurch Hospital ICU exceeded the levels recommended by the WHO and were in the range of levels reported in the literature for other hospitals.

The L_{Aeq} recorded during the day was between 55 and 63 dB compared to the recommended 35 dB, while overnight was between 48 and 55 dB compared with the recommended level of 30 dB. These elevated noise levels may cause adverse psychological and physiological effects on patients, such as stress, annoyance, fatigue, insomnia, adrenaline increases, heightened blood pressure and heart rate and increased hospital stays (Hsu, et al., 2010; Stansfeld & Matheson, 2003), however these effects were not assessed in the present work. It is notable however that the measured levels are well below the regulatory levels for health and safety in the workplace.

Impulse noise peaks contribute significantly to the noise levels as measured in Christchurch Hospital. From the L_{Cpeak} readings, it was observed that there was at least one exceedance above 94 dB every two hours, and usually many more than one. This sound level is subjectively as loud as a belt sander or lawn mower but only of very short duration. Two peaks in particular, both measured by microphone two, reached 120 dB and 135 dB on Monday morning and Saturday night respectively. These levels are analogous to a sudden thunder clap or tsunami siren and peaks of this magnitude are sufficient to disturb all patients and staff, causing stress and concern (Berglund, et al, 2004; Ryherd, et al., 2011).

The distributions of the number of exceedances of 75 dB L_{Aeq} and also those more than 20 dB above the preceding background level, were determined in order to get a more thorough idea of the nature of the intrusiveness and disturbance of noise due to normal activity in the ICU. There were many causes of these loud sounds, however, there was a strong correlation with the time of day and the number of 75 dB exceedances. Observation showed that exceedances were caused by metal bins, doors slamming, loud speech, drawers shutting and medical alarms. This is a good indication that staff behaviour modification and equipment renewal/modification may help in reducing noise levels.

Speaking with medical staff while in the ICU allowed some insight to their routine. Nursing staff may alter each patient's alarm settings to the nurse's individual preferences. Observation of alarm management in Christchurch Hospital's ICU showed that most nurses quickly check the patient's status and press a button to stop the alarm. Atzema, et al., (2006) reported that more than 90 % of alarms they studied were false and required no action for the patient, and Topf, 2000 similarly reported most alarms are around 70 dB L_{Aeq} but require no action. It is therefore recommended that each alarm in ICU be measured and if too high they be set to narrower parameters to prevent them becoming background noise rather than an alarm.

During measurement and observation it was noted that most continuous noise was due to conversation, which although directly related to a patient may be a source of disturbance and annoyance to patients in adjacent beds. If the level of staff speech were reduced noise levels would be significantly lower, but this would affect the easy, positive working atmosphere and possibly lead to difficulties in hearing instructions. Staff chatter observed was always friendly towards patients throughout the measurement survey. It would be of benefit to maintain the amount of casual staff chatter but reduce the volume, so that only the patients concerned are able to hear the conversation.

The contribution that the ICU building extension work had on overall noise levels is unknown but was an ongoing factor throughout the sound level monitoring period. However, some staff members complained that construction noise was their primary concern at present. Fife and Rappaport (1976) found that construction noise outside patients' windows increased their length of recovery and chance of being re-hospitalised. Noise from construction activities contributed to the high number of peaks that occurred during the daytime survey, but the fraction was not quantified. Some staff members did say that construction noise occasionally made them jump.

This present study in the ICU indicates that more in-depth analysis is needed in order to identify specific sources of noise so that they can be mitigated by treatment at source or changes in protocols. Additional noise measurement and analysis is recommended to extend the study to include other wards in the hospital. In future studies, more microphones will be used to better be able to create sound maps for each area. This present study also included a postal type subjective questionnaire survey for staff and patients but the response of returns was low and meant that analysis was compromised. There was however a clear indication from respondents that current noise levels were considered as too high. In future studies the questionnaire will be based on an interview type rather than a postal type.

5. Conclusions

During the monitoring period, noise in the ICU exceeded the WHO recommended levels of 35 dB L_{Aeq} during the day and 30 dB overnight, for both periods by approximately 20 dB. There were many peaks in sound level that exceeded 100 dB L_{Cpeak}, and these levels can prevent patients from sleeping, have negative psychological and physiological effects and reduce speech intelligibility. Results from Christchurch Hospital's ICU are comparable with overseas ICUs where, as for this study, the main sources of noise were loud speech, medical alarms, tools and other objects being dropped, rubbish bin lids being closed and doors being shut.

For patient and staff safety it would be desirable to institute a protocol to manage noise levels in the ICU to lower and more acceptable levels. A thorough study of noise levels in different places of the ICU and various wards would give investigators more useful information for improving the environment in Christchurch Hospital. Ongoing research extending the current study into other wards and operating theatres will be reported in a subsequent paper.

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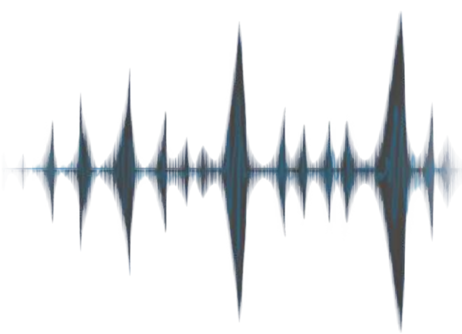
...Continued from Page 25

New ASNZ Fellow – Stuart Camp

The Acoustical Society of New Zealand is pleased to announce that Stuart Camp was inducted as the Societies newest Fellow. Stuart was inducted at the dinner of this year's Joint Australian and New Zealand Acoustical Societies 2nd Australasian Conference held in Brisbane last month. Many people will know Stuart as the past Editor of the Journal, taking the journal from strength to strength over the years. Stuart was a foundation member of the Acoustical Society of New Zealand and has served as both a past President and Committee Member. Stuart is the eighth Fellow, joining Sir Harold Marshall, George Dodd, John Quedley, Mark Johnson, Cliff Robertson, Rod Satory and Ross McBeath in the society's top echelon. We congratulate Stuart on this achievement and wish him well in all his future endeavors. Well done!

rma net

RMANet has launched a new online library [rma.co.nz] of legal decisions which include decisions from the New Zealand Environment Court (formerly the Planning Tribunal) and relevant judgments of the New Zealand District Court, High Court, Court of Appeal and Supreme Court, plus relevant decisions of the Privy Council. The library has over 11000 decisions which date back to the enactment of the New Zealand Resource Management Act in 1991. For further information see rma.net.nz or contact RMA Net Editor Dr Sarah Brand at editor@rma.net for further details.



NZ Acoustical Society Member Profile - Dr Mark Poletti

Location: Callaghan Innovation, Wellington, New Zealand

Position: Principal Scientist at Callaghan Innovation

Expertise: Acoustics, audio, electronics, signal processing.

Qualifications: BSc, MSc, PHD

Work Questions

1. What initially drew you to the field of acoustics? *It was a combination of my interest in audio and electronics, plus the fact that my first job was an acoustics technician at the University of Auckland. My career goal was originally signal processing but I've found myself doing more acoustics than signal processing over the years.*
2. What three skills do you most need to be successful in your day to day work? *First would be knowledge of your area of expertise. The second is creativity, and the third is meeting the needs and requirements of customers and your employer.*
3. What is the most satisfying project you have worked on and why? *Inventing and commercialising the Variable Room Acoustics system, which became the basis of the Meyer Constellation system. In science, a lot of job satisfaction comes from discovering things and publishing the details, but commercial outcomes are also satisfying and important since science should contribute tangibly to society.*
4. What is your favourite and least favourite sounds? *Most favourite sound is probably a loud guitar amplifier. Least favourite would a tossup between fingernails on a blackboard and anything by Katy Perry.*
5. What is one unexpected outcome you can tell us about on a project you're worked on and why? *Some of the work I did on digital filters for the Variable Room Acoustics system got used in an algorithm to weigh cows.*
6. What professional goals do you still wish to attain? *Science is an endless frontier (to quote Vannevar Bush – you can read his 1945 report online) and for me, research is an ongoing goal I'm still interested in pursuing. I'd also like to get involved in starting a company to commercialise audio products.*

Personal Questions

7. What is something we should know about you that is not on your CV? *I play the guitar and do occasional gigs around Wellington*
8. Other than acoustics what are you passionate about? *Music, writing, and a little history and philosophy*
9. If you were a musical instrument what instrument would you be? *A guitar*
10. Are you a hunter or gatherer? *Gatherer*
11. If you had one superpower what would it be and why? *I have one and I'm not going to tell you what it is because then a lot of people would pester me.*

Specific Question

12. You were awarded the Cooper Medal for the development of the Variable Room Acoustics System (VRAS) algorithms, the technology behind the Meyer Constellation System. What effect did this recognition have on your day-to-day research? *I appreciated the recognition but it didn't have much effect on my day-to-day activities.*

Cats seem to grasp the laws of physics

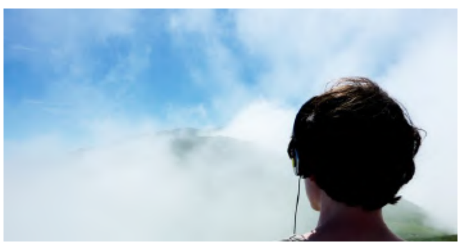
It has been reported in ScienceDaily that cats understand the principle of cause and effect as well as some elements of physics. Combining these abilities with their keen sense of hearing, they can predict where possible prey hides. Previous work conducted by the Japanese team established that cats predict the presence of invisible objects based on what they hear.

To find out more visit www.sciencedaily.com

Reverse Sensitivity Buffer and Effects Areas

The NZTA web site has a host of useful information on transport noise and vibration. As part of this information the New Zealand Transport Agency (NZTA) have prepared a map of the state highway network across New Zealand. This map, among other things, is a useful tool providing information such as vehicle movements per day. Search the NZTA website under Reverse Sensitivity Buffer and Effects Areas.

The SoundCloud



What to layback and hear natural New Zealand sounds? Visit https://soundcloud.com/naturesounds_nz

2017

2 - 5 May, Rotterdam, Netherlands Wind Turbine Noise 2017
www.windturbinenoise.eu

18 - 22 June, Zurich, Switzerland 12th. ICBEN Congress on Noise as a Public Health Problem
www.icben.org/ICBEN2017.html

25 - 29 June, Boston, USA Acoustics 2017 Boston: joint meeting, 173rd meeting of the Acoustical Society of America and 8th Forum Acusticum of the European Acoustics Association
www.acousticalsociety.org

23 - 27 July, London, UK. 24th International Congress on Sound and Vibration (ICSV24)
www.icsv24.org

30 July - 3 August, Vienna University of Technology, Vienna, Austria. 13th International Conference on Theoretical and Computational Acoustics (ICTCA 2017)

27 - 30 August, Hong Kong. 46th International Congress and Exposition on Noise Control Engineering (INTER-NOISE 2017)
www.internoise2017.org

3 - 8 September, Skiathos Island, Western Aegean, Greece. 4th Underwater Acoustics Conference and Exhibition (UACE2017)
www.uaconferences.org

4 - 6 October, A Coruña, Spain. TECNIACÚSTICA 2017 - 48th Spanish Congress on Acoustics - Iberian Encounter on Acoustics
www.sea-acustica.es/index.php?id=570

26 - 29 November, Bali, Indonesia. Regional Conference on Acoustics and Vibration (RECAV 2017)
www.aavi.its.ac.id

4 - 8 December, New Orleans, Louisiana, USA. 174th Meeting of the Acoustical Society of America
www.acousticalsociety.org

8 - 10 December, Honolulu, Hawaii, USA. 2017 International Congress on Ultrasonics
www4.eng.hawaii.edu/~icu2017/

2018

7 - 9 May, Ibiza Spain. NOVEM (Noise and Vibration Emerging Methods) 2018
novem2018.sciencesconf.org

7 - 11 May, Minneapolis, USA. 175th Meeting of the Acoustical Society of America
www.acousticalsociety.org

27 - 31 May, Heraklion, Crete, Greece. EURONOISE 2018
euracoustics.org/events/eaa-conferences

The AAAC is a not for profit peak body representing professionals who are involved in providing comprehensive noise and vibration services to a wide range of clients and the community. www.aaac.org.au

SEEKING APPLICATIONS

Following enquiries from member consultancy practices who had offices in both New Zealand and Australia, in 2016 the members voted to allow expansion of our organisation to welcome likeminded professional firms from New Zealand, with a renaming from Australian to Australasian and associated constitutional changes. The intention is to bring the benefits of the AAAC to NZ; such as peer collaboration, member only discussion forum and networking events.

The AAAC is now seeking NZ based consultancy practices. A membership application form will be provided by contacting info@aaac.org.au.

ROLE OF THE AAAC

While the Australian and New Zealand Acoustical Societies (AAS and ASNZ) provide a platform for any individual involved in acoustics to improve their technical and professional skills through collaboration, comradery and organised events, the AAAC is for Acoustical Consulting firms who nominate a representative from each of their regional offices (if they wish). The AAAC focus is on practice and business matters. It doesn't represent individuals, and works with the Societies for the overall benefit of the Australasian Acoustics community.

NZ MEETING

The AAAC is planning to hold our AGM in Queenstown New Zealand in July 2017. Any firm interested in joining is welcome to attend a special meeting associated with the AGM. The AGM normally involves a meeting on Saturday, a dinner with partners on Saturday evening and a social function on Sunday morning.

HISTORY OF THE AAAC

The AAAC was officially formed in 1978. In 2016, the AAAC comprises some 56 member firms across Australia. They provide a wide range of Consulting, Testing and Research facilities to Community, Industry, Commercial and Government organisations as well as to individual projects and programs.

BENEFITS AND OBJECTIVES OF THE AAAC

The objects for which the Association is established are:
(a) To inform the public of the role and responsibilities of Acoustical Consultants and in particular the services which such consultants provide.
(b) To establish and encourage adherence to standards of professional behaviour and conduct for acoustical consultants.
(c) To provide members with a forum for exchange of information on matters relating to acoustics.
(d) To cooperate and liaise with other Associations and bodies with respect to matters of mutual acoustical interest.
(e) To inform and protect the community by discouraging, clarifying, negating or questioning unclear inaccurate or unproven representations of an acoustical nature.
(f) To cooperate and liaise with authorities and associations having similar or analogous interests and in so doing, to contribute to the establishment, maintenance and application of standards, laws and registrations.
(g) To encourage amongst the members of the association a high professional standard in all matters of practice including the calibration and use of instruments, measuring techniques and data processing employed by acoustical consultants.
(h) To promote the welfare of acoustical consultants and the common interests of the members of the association and to do all such things as may be meaningful and lawful from time to time.

For more information contact: info@aaac.org.au **or AAAC Chairman (Matthew Stead) on +61 408 805 293**

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Publication Dates and Deadlines

New Zealand Acoustics aims to publish three journals per calendar year in April, August & December.

The Deadline for material for inclusion in the journal is the 1st of each month before publication, although ideally articles should be received before this date if possible. Enquires about publications are always welcome, including student papers and those from non-experts. The focus of the journal is first and foremost to promote New Zealand Acoustics. For further information contact journal@acoustics.org.nz

Advertising

Enquiries regarding advertising are welcome. For a list of current prices and any further information please contact: advertising@acoustics.org.nz

Society Membership

Associate Membership of the Acoustical Society of New Zealand is open to anybody interested in acoustics. Members receive benefits including;

- Direct notification of upcoming local events
- Regular mailing of Noise News International
- Reduced charges for local and national Society events
- Priority space allocation for trade stands at society events
- Discounted rates on selected acoustic products

To join the society, visit www.acoustics.ac.nz or contact the Secretary; secretary@acoustics.org.nz