Memorandum

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File:	

Sound Exposure levels to Musicians in the School of Music – Preliminary Study

Musicians generate interesting and varied sound levels and frequencies according to the instrument they play. Two instruments (saxophone and trumpet) were measured during typical practice sessions to quantify the sound levels produced and the risk to a musicians hearing.

This is a preliminary report on the potential for staff and students to be exposured to loud sounds that are a potential risk to their hearing.

The background information (appendix A) in this report was first communicated to the School of Music in 1993 and again in 2002.

Hazard Potential -

Musicians require an intact sense of hearing to follow their profession, and to reach excellence. Hence damage to a Musician's hearing has the potential to affect their professional life. The review report (appendix A) considers some of the literature studies that have looked into the sound level exposure suffered by musicians in orchestras.

The majority of papers reviewed; found that the musicians were exposed to sound levels, which in industry are associated with Noise Induced Hearing Loss (NIHL) [1, 2, 3]. The reported effects for musicians range from, no significant difference, to musicians suffering a significant hearing impairment of 20 dB or more. The greater number of papers indicated that in an orchestra, up to 50% and more of the musicians suffered from hearing impairment [2, 4, 7, 8, 9]. The audiometric studies were consistent with noise induced hearing loss [4, 7, 10]. Other noise induced conditions included: hearing fatigue, headache, nervous tension, and subjective disturbances [9].

It was found that percussion instruments (drums, gongs, cymbals etc.) had the highest relative proportion of musicians suffering hearing impairment [1, 2], but the greatest discomfort was reported by those musicians in the near vicinity of the percussion and brass instruments [12]. The brass instruments recorded the highest loudness level in the orchestra [12].

Violinists, violists and cellists recorded the highest absolute number of hearing abnormalities [1] (mainly due to sample size), and a significant difference in hearing, at the higher frequencies (3 - 6 kHz), between the left and right ears, with hearing poorer in the left ear [1, 4, 7].

Exposure Benchmarks –

The Australian National University's policy on hearing conservation [13] requires that, where reasonably possible, the 8-hour average noise exposure of University employees (and students) be less than 80 dB(A). Further more, compliance with the Comcare legislation and regulation [14] requires assessment of occupational areas where noise levels exceed $L_{Aeq, 8hr}$ 85 dB(A) or a peak level of L_{pk} 140 dB(C).

Exposure measurements -

Sound measurements were obtained with a noise dosimeter (*Larson Davis* 705 Noise Badge) and a Sound Level Meter (*SVAN* 925 Sound Level Meter with 1/3 octave analysis (S/N 3691)).

Some of the results recorded by the noise dosimeter are attached and summarised below.

Saxophone –

Sound Level Meter (3 March 2006)

Average sound level (L_{eq})	82 dBA
Maximum sound level	88 dBA

Noise Dosimeter (8 March 2006) (Appendix B)

Average sound level (L_{eq})	96 dBA
Daily personal noise exposure (L_{epd})	95 dBA
90% of noise was recorded above	68 dBA

Trumpet –

Sound Level Meter (10 March 2006)

Average sound level (L_{eq})	93 dBA
Maximum sound level	105 dBA

Noise Dosimeter (8 March 2006) (Appendix C)

Average sound level (L_{eq})	93 dBA
Daily personal noise exposure (L_{epd})	92 dBA
90% of noise was recorded around	70 dBA

The dominant noise source is the musical instrument, resulting in a broad frequency sound with characteristic low frequency components.

Environmental considerations -

The office/practice room is constructed with walls of plasterboard, glass panels, and acoustic panel frames. The suspended ceiling is of sound absorbing panels. The floors of are industrial carpet. This type of construction reduces the sound transmission between offices.

Within the limitations of the office requirements (eg whiteboards, furniture etc), the sound absorbing panels provide some reduction in volume and reverberation.

The major sound transmission route is directly from the instrument to the human ear.

Conclusions and Recommendations -

The preliminary sound measurements indicate that the saxophone and trumpet played regularly and at typical levels exceeds the occupational noise exposure standards. Therefore there is a risk of musicians developing noise induced hearing loss while practicing and playing.

Although further sound measurements could be undertaken on additional instruments, it is recommended that a consistent approach be implemented across all instruments/ music teaching.

It is recommended that the following hearing conservation program for musicians be implemented. Its aim is to prevent occupational hearing impairment, through a strategy of awareness, motivation, control and monitoring. The components are -

a) Motivation, education and awareness of the risk associated with noise.
   It is recommended that the School of Music annually run information seminars on the -
   - Hazards of noise,
   - Effects of noise on hearing,
   - Role of audiometric testing,
   - Methods of reducing noise exposure, including the availability of personal protective equipment.

   Information sheets have been prepared and distributed previously (Appendix D).

b) Assessment of the noise level.
   Further noise monitoring can be undertaken by the OHSIM branch to provide evidence and justification of process, if necessary.

c) Reduction of the noise dose.
   Noise dose can be reduced though a variety of means, including; reducing intensity of noise, distance to source (other instruments), and exposure duration (distributing practice times over the week) etc.

d) Personal hearing protection.
   Flat attenuation earplugs are available that reduce the noise level while keeping the natural sound with no frequency distortion. These would be particularly useful during practice sessions.

e) Regular hearing tests.
   Audiometric testing is part of the University's health surveillance for staff. From the investigations into hearing impairment of musicians in orchestras, several authors recommended that musicians undertake regular audiograms every 3 to 5 years, to assess the effect and diagnose hearing loss more precisely [1, 9], while the Australian Standard suggests every year [15] for employees in an occupationally noisy environment.

It is recommended that the School of Music take a proactive part in protecting musicians' (Staff and Students) hearing for their duration at ANU and provide life long guidance. The proposed plan should assist in reducing the risk of long-term hearing loss.

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References:

[13] The Australian National University, *Hearing Conservation in the University*, http://info.anu.edu.au/policies/Procedures/Human_Resources/ohs/Hearing_Conservation.asp to be reviewed shortly.

[14] Comcare, OCCUPATIONAL HEALTH AND SAFETY (COMMONWEALTH EMPLOYMENT) (NATIONAL STANDARDS) REGULATIONS 1994, Regulation 3 – Occupational Noise. *Note* The regulation should be read in conjunction with the *National Standard for Occupational Noise* [NOHSC:1007 (2000)] and the *National Code of Practice for Noise Management and Protection of Hearing at Work* [NOHSC:2009 (2000)]. See http://www.comcare.gov.au/ohs/section2.html.

[15] Standards Australia, Australian Standard 1269, *Acoustics - Hearing Conservation*.

The background information (appendix A) of this report was initially sent out on 3/8/1993 and again on 29/5/2002.

Appendix A

Review of Sound Exposure Levels to Orchestral Musicians

Musicians require an intact sense of hearing to follow their profession, and to reach excellence. The orchestra consists of a multitude of musical instruments, each with its individual sounds and characteristics. This review considers some of the literature studies that have looked into the sound level exposure suffered by musicians in orchestras.

The majority of papers reviewed, found that the musicians were exposed to sound levels, which in industry, are associated with Noise Induced Hearing Loss (NIHL) [1, 2, 3]. The equivalent continuous sound level exposure (L_{eq}) was reported for an orchestra to be in the range of 79-99 dB(A), with a mean of 90 dB(A) [4]. Based on 15 hours exposure per week (not including practice or off-the-job playing) this equated to an 8-hour $L_{Aeq, 8hr}$ of 75-95 dB(A) with a mean of 86 dB(A) [4]. In industry around the world, an $L_{Aeq,}$ level above 80 – 85 dB(A) requires hearing conservation measures.

The reported effects for the range of a musicians sound exposures range from, no significant difference, to musicians suffering a significant hearing impairment of 20 dB or more. The conclusion of no major difference in hearing [3, 5, 6] resulted from comparing the audiometric (hearing tests) results of musicians with non-industrially noise-exposed persons. But when compared to the normal base for hearing, the musicians did show hearing impairment [5]. It was commented that some musicians had better hearing than unscreened, non-industrially noise exposed persons [4]. However, the greater number of papers indicated that in an orchestra, up to 50% and more of the musicians suffered from hearing impairment [2, 4, 7, 8, 9]. The audiometric studies were consistent with noise induced hearing loss [4, 7, 10]. Other noise induced conditions included: hearing fatigue, headache, nervous tension, and subjective disturbances [9].

Many of the studies also included in-depth sound exposures and audiometry for various sections of the orchestra [1, 2, 4, 7, 11, 12]. It was found that percussion instruments (drums, gongs, cymbals etc.) had the highest relative proportion of musicians suffering hearing impairment [1, 2], but the greatest discomfort was reported by those musicians in the near vicinity of the percussion and brass instruments [12]. The brass instruments recorded the highest loudness level in the orchestra [12].

Violinists, violists and cellists recorded the highest absolute number of hearing abnormalities [1] (mainly due to sample size), and a significant difference in hearing, at the higher frequencies (3 - 6 kHz), between the left and right ears, with hearing poorer in the left ear [1, 4, 7].

One paper, commented that the type of instrument played and their position on the orchestral stage had no significant correlation with hearing loss [11]. A comparison between 18 woodwind and 18 brass players, matched for sex and age showed no significant difference in hearing [3].

A study of 417 musicians found no difference in median threshold hearing values, although the actual sound exposure exceeded the permitted sound level values applied to industrial noise, and therefore concluded that the industrial noise criteria were not a valid option when discussing sound produced by acoustical instruments [6]. To clarify this point, the definition of excessive noise is: ‘sound which may cause hearing loss because of its intensity, duration and/or frequency distribution, or that which disturbs cognitive or physiological functions’ [13]. Orchestral music may or may not come under this definition, according to personal interpretation.

The Australian National University’s policy on hearing conservation [13] requires that, where reasonably possible, the 8-hour average noise exposure of University employees (and students) be less than 80 dB(A). Further more, compliance with the Comcare legislation and regulation [14] requires assessment of occupational areas where noise levels exceed $L_{Aeq, 8hr}$ 85 dB(A) or a peak level of L_{pk} 140 dB(C).

Where noise levels exceed the allowable levels, the following hearing conservation program for musicians can be implemented [15]. Its aim is to prevent occupational hearing impairment, through a strategy of evaluation, control and monitoring. The components are -

a) Motivation, education and awareness of the potential noise levels.
b) Assessment of the noise level.
c) Reduction of the noise dose.

d) Personal hearing protection and regular hearing tests.

From the investigations into hearing impairment of musicians in orchestras, several authors recommended that musicians undertake regular audiograms every 3 to 5 years, to assess the effect and diagnose hearing loss more precisely [1, 9], while the Australian Standard suggests every year [15] for employees in an occupationally noisy environment.

It is clear that attempts to control the sound level through earmuffs would be unacceptable to the musicians, and rearrangement of the instruments with the percussive members one metre lower than the other musicians [as recommended in 2] may effect the audience's perception of the music, but may be worth consideration. Flat attenuation earplugs are available that reduce the noise level while keeping the sound natural with no distortion.

References:

[1] Audiometric Tests in Musicians, G. Schacke, A. Kwiatkowski, & A. Fuchs, *Zentralblatt fur Arbeitsmedizin, Arbeitsschutz, Prophylaxe und Ergonomie*, 37(7): 221-26, 1987.

[2] Prevention of Noise Induced Hearing Loss in Musicians of Chinese Opera, G. Bu, *Chung-Hua-Erh-Pi-Yen -Hou-Ko-Tsa-Chih.*, 27(2): 73-5, 124, 1992.

[3] Noise and the Classical Musician, D. McBride, F. Gill, M. Harrington, K. Gardiner, & C. Attwell, *BMJ*, 305: 1561-3, 1992.

[4] Sound Exposures and Hearing Thresholds of Symphony Orchestra Musicians, J.D. Royster, L.H. Royster, & M.C. Killion, *J. Acoust-Soc-Am.*, 89(6): 2793-803, 1991.

[5] Extended High Frequency Hearing Sensitivity. A Normative Threshold Study in Musicians, D.W. Johnson, R.E. Sherman, J. Aldridge, & A. Lorraine, *Ann-Otol-Rhinol-Laryngol.*, 95(2 pt 1): 196-202, 1986.

[6] The Hearing of Symphony Orchestra Musicians, K. Karisson, P.G. Lundquist, & T. Olaussen, *Scand-Audiol.*, 12(4): 257-64, 1983.

[7] Hearing Impairment in Orchestral Musicians, B. Ostri, N. Eller, E. Dahlin, & G. Skylv, *Scand-Audiol.*, 18(4): 243-9, 1989.

[8] Pop Music and Hearing, A. Axelsson, & F. Lindgren, *Ear-Hear.*, 2(2): 64-9, 1981.

[9] Study on the effects of very loud Music on Musicians in the Orchestre de la Suisse Romande, J. Rabinowitz, R. Hausler, G. Bristow, & P. Rey, *Mediecine et hygiene*, 40: 1-9, 1982.

[10] Noise Induced Hearing Loss and Orchestral Musicians, G.A. Westmore, & I.D. Eversden, *Arch-Otolaryngol.*, 107(12): 761-4, 1981.

[11] Effects of Instrument Type and Orchestral Position on Hearing Sensitivity for 0.25 to 20 kHz in the Orchestral Musician, D.W. Johnson, R.E. Sherman, J. Aldridge, & A. Lorraine, *Scand-Audiol.*, 14(4): 215-21, 1985.

[12] Symphony Orchestra Musicians: How much auditory load are they exposed to?, J.C. Landry, J. Jaccard, & M. Levantal, *Revue suisse pour l'industrie chimique*, 8(4a): 5057, 1986.

Note: Information from hard to get references was taken from the abstract.

Appendix B, C
Noise Dosimeter Results

Appendix D
Noise Management Information Sheet