Technical Note

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NOISE EXPOSURE REDUCTION FOR ORCHESTRAL MUSICIANS

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INTRODUCTION

When we think of musicians exposed to loud noise or music, we tend to imagine a heavy metal rock band on stage with special effects from lighting, fog and amplified music. This genre of music tends to be loud with limited dynamic range. Many rock musicians do use a form of personal protective equipment in the form of communication earplugs with the primary intention of receiving foldback to enable them to control and coordinate the sound coming from the stage, not to reduce the effects of noise [1].

At the other end of the musical spectrum are the classical musicians who may be playing Mahler, Wagner or Adams, music with a wide dynamic range and at times very loud depending on the player's location within the orchestra [2]. For example in the horn section during Gustav Mahler's Symphony No 3 the average continuous A-weighted sound pressure level (L_{Aeq}) sits around 94 dB while the C-weighted peaks reach 131 dB [3].

The use of ear plugs has been suggested as a possible solution however, the inherent distortion of the resultant perceived sound spectrum due to the non-linear attenuation characteristics of ear plugs means that plugs are often rejected by musicians. Even 'musicians' ear plugs introduce some non-linearities and this coupled with the occlusion effect makes their use problematic [4].

Hence musicians in large orchestras need some form of occupational noise management if their hearing health is to be maintained. This is why the *National Acoustic Laboratories* in conjunction with the *University of Technology, Sydney* - industrial design department - and the then Symphony Australia (now *Symphony Services International*), the organisation that provides services to Australia's major symphony orchestras, developed the Goodear.

The Goodear is an acoustic shield designed for use in an orchestral setting intended to reduce the noise exposure of the musician sitting in front of the shield from particularly loud playing from instruments to the rear. Unlike the majority of current acoustic shields it is not made of a hard, transparent plastic but rather a more robust material with a sound absorbent surface that prevents sound reflection. One difficulty with sound reflection from hard surfaced plastic or acrylic barriers is that they create spurious sound sources within the orchestra and can increase the sound exposure of adjacent musicians.

When the original version of the Goodear was produced, in 1997, NAL carried out a series of tests gauging the acoustic performance. More recently a second series of tests has been carried out on a slightly modified production model aimed at verifying performance. The results of these tests are presented here.

TEST METHOD

The testing was carried out in the large anechoic test room at the NAL facilities in Chatswood, NSW, as shown in Fig. 1. This room provides excellent sound isolation from external noise and a sufficiently low noise floor that guarantee the acoustic test results. The shield is approximately 280 x 500 mm and 50 mm thick, formed in a shallow 'V' shape and is positioned, when in use, with the offending sound source located to the rear of the apex of the 'V' and the musician's head located in front of the 'V' opening.

The shield was set up with the 'V' opening facing away from and 1.0 m in front of a loud speaker that provided the source test noise of wideband 'pink' noise at a level of around 80 dB. Measurements were taken at microphone positions 0.01 m, 0.10 m and 0.20 m inside the 'V' to account for various head positions. The usual position would be between 0.20 m and 0.10 m with the possibility of moving closer to increase attenuation when particularly loud passages are due to be played. Measurements were taken with and with-out the shield present, the difference in levels being the attenuation in sound level. The parameter used was L_{Aeq}.

A measurement position was set up at approximately 1.0 m to the right of the sound source to explore any change in exposure experienced by an adjacent musician. In this case the change in level measured with the shield present represents the variation in noise exposure for the adjacent musician. Measurements were made with the Goodear and also with a hard surfaced, plastic shield of similar dimensions to the Goodear to represent existing generic clear shields.

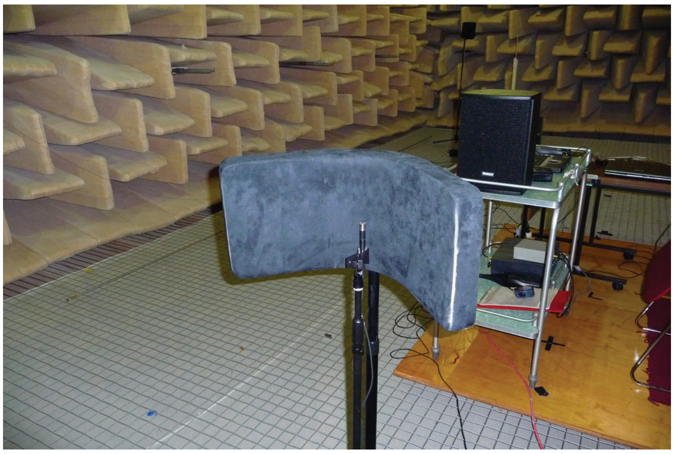

Figure 1. Experimental set-up of the Goodear test.

RESULTS

The attenuation test results using various spectral weightings for the various test positions are presented in Table 1. From the results in Table 1 it can be seen that there are only small differences between the attenuation performances at different locations except for the adjacent position. Here the use of the hard surfaced shield provides a reflection which significantly increases the level and hence exposure, at the adjacent position of up to 4 dB.

Table 1: Attenuation test results with various spectra weighting for various measurement positions (dB)

Distance	1.01		1.10		1.20		Adjacent Position	
Goodear/Plastic	G	P	G	P	G	P	G	P
A-weighted	8	8	8	7	7	6	0	-4
C-weighted	5	4	4	4	4	3	0	-2
Unweighted (Z)	5	5	5	4	4	4	0	-2

DISCUSSION

The attenuation provided by the shields was about 7 or 8 dB when measured directly behind the shield in the normal use position. A 3 dB reduction in level represents a 50% reduction in overall exposure. Because of the non-linear nature of the decibel scale an attenuation of 8 dB results in an 84% reduction in the sound exposure. This reduction in exposure is quite significant in terms of future hearing health as the risk of noise injury is proportional to the exposure level. Thus there is an obvious advantage for musicians in high noise locations using a barrier to reduce their exposure risk.

Measurements taken adjacent to the sound source in a position where an accompanying musician would be located showed that the use of an equivalent sound shield made of a hard, plastic material increases the sound level in the adjacent position by roughly 3 dB. In real terms this is equivalent to doubling the sound exposure for the adjacent musician(s). So using a shield with a non-reflecting surface such as the Goodear reduces exposure for more musicians.

Some commentators have mentioned the fact that the Goodear is not transparent and hence could interrupt the line-of-sight to the conductor or other musicians. This has not generally been found to be a problem as the Goodear is situated below the top of the player's head and hence the line-of-sight remains clear. This is also the case when the musicians to the rear are situated on risers.

The use of the Goodear as an acoustic barrier has specific advantages for orchestral musicians by reducing the overall noise exposure without affecting the sound quality of the performance for the musicians, the conductor or the audience. The noise exposure levels of musicians may not be extremely high on one particular occasion, however over the course of a full musical career there is a degree of risk of noise injury and subsequent hearing loss from noise exposure. The use of barriers such as the Goodear seeks to solve the exposure problem without involving significant cultural change to the orchestral setting.

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