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PRAGMATISM NOISE RISKS AND ORCHESTRAS

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1 INTRODUCTION

Almost ten years on from the Noise at Work Regulations, it is difficult to find a British orchestra that complies with the letter of the law. The situation in the rest of Europe seems no better, and information from North America is ambiguous, but there appears to be some activity in the Antipodes.

With backing from the EU, the Association of British Orchestras [ABO] commissioned a project to construct a generic assessment of the noise risks in member orchestras, recommend measures to control noise risks, develop a package for training the players, and draft guidelines for managers, players, venues and others.

As well as reviewing the published reports, the project appealed to orchestras to release [in confidence] any relevant unpublished materials – these included assessments, reports on efforts to control noise [including re-building], audiograms [not UK], contacts with enforcing agencies, etc. This pooling of knowledge will be propagated as the project establishes a databank of exposure estimates and recommends the establishment of expert noise teams who compare notes. The project also sought the views of players, through a questionnaire administered via the Musicians Union – this element was underway at the time of writing.

The ABO represents 63 symphony, opera, chamber and other orchestras, 37 opera and music theatre ensembles, and 80 other organisations ranging from conservatoires to composers and concert venues. Through ABO membership of PEARLE, the Performing Arts Employers League Europe, the project findings will also be made available across the EU.

From the outset, it was apparent that there are strong reasons for the lack of compliance. This paper explores the reasons for non-compliance, outlines the generic assessment, and describes the approach to controlling noise risks.

2 REASONS FOR NON-COMPLIANCE

Reasons for non-compliance fall into three categories: [1] although noise is harmful to hearing, music is not; [2] the noise levels in orchestras are not that high; [3] reducing noise levels in orchestras defeats the whole purpose of the exercise, is difficult, and introduces other significant problems. The first two apply strongly in some cases, and not at all in others, but the difficulty of controlling exposure applies in all orchestras and demands a pragmatic approach.

2.1 'Music is not Harmful'

The idea that 'music is not harmful' is partly an instinctive belief, and partly based on science. It does, indeed, appear that pleasing noise causes less hearing damage than random noise, so musicians may be at less risk than is supposed. However, the studies also show that music which is disliked, or just plain boring, causes more harm than random noise. Furthermore, the nice/nasty risk modification is related to levels of stress in the listener.

2.1.1 Musicians are Stressed

Available statistics on stress levels in orchestral musicians damage the argument that the harm from noise should be diminished:

20% have used beta blockers before a performance, 6% use alcohol.
70% have become so anxious it affected their performance [16% said more than once a week]
32% have had periods of prolonged anxiety in the last year
67% often have a rapid heart rate during performance
56% often have sweating hands during performance
56% often experience increased muscle tension during performance
46% often experience trembling and shaking while trying to play
10% do not experience physical effects of stress while playing

2.1.2 A Selected Population with Special Needs

Musicians frequently show less than expected hearing loss. But, some of these studies are based on worst-case exposures [rather than real averages] and most compare musicians with typical populations whereas the process of becoming a professional musician must weed-out many who are not otologically normal. Furthermore, even if a musician does suffer less threshold shift than an industrial worker exposed to similar noise energy, they can hardly suffer less harm from the reduced sensitivity and frequency selectivity, the diplacusis, recruitment and tinnitus.

What is beyond dispute is that musicians suffer more damage than age-matched, unselected, controls, and brass and woodwind suffer significantly more than the strings. Because of the tiny sample sizes, it is difficult to be sure of the percussion, but those players with hearing damage are typically worse than the brass.

2.2 'Exposures are Acceptable'

There are studies showing exposures below the second action and peak action levels. Some 'bleep over' exposures above 90, others are based on workloads as light as 15 hours a week [whereas UK orchestras may be working 38 hr weeks, 3 session days, 6 day weeks, etc. More to the point, these studies are based on measurements taken at a distance from each player. Two studies[1] show that at-ear measurements are several dB higher than 'phantom player' readings - even fiddles and violas have at-ear levels 3dB higher than free-field equivalents, and in the worst case measurements to the left of a horn can be 10dB too low. Own instrument exposure dominates – even when cellos are in front of trumpets.

A final issue in the 'levels aren't that high' debate is that none of the studies takes account of personal practice, or of other work.

2.2.1 What the Players Say

A study of players' experiences of and concerns about hearing damage and noise control is underway as part of the ABO project. In the meantime, useful inferences can be drawn from a study of 1639 orchestral musicians[2] which showed that hearing damage is as worrying as muscle pain, and from a Canadian study which found that 9/10 musicians seeking treatment for musculo-skeletal disorders also had measurable hearing loss[3].

% Experiencing Moderate or Severe Stress Due To -

73	confidence-sapping conductor
63	making a mistake
61	incompetent conductors
57	medical problems affect work
52	over-demanding conductor
48	noise may impair hearing
48	experiencing muscle pain
46	having backache
48	feeling tired
45	playing in a difficult acoustic

The BPAMT study did not address the prevalence of hearing impairment, but comparisons can be drawn with the prevalence of musculo-skeletal effects:

61%	have had a loss of embouchure or lip seal
58%	have had pain when playing their instrument [52% more than once a week]
41%	have suffered disobedient fingers
22%	have been forced to stop performing because of pain
8%	lost more than a month to ill health in the last year

The four most frequent stressors were: confidence-sapping conductors, muscle pain, incompetent conductors, and fears that noise may impair hearing. Taken together, we see that hearing damage is a significant concern to players, but control measures which make it harder for them to play or which give the conductor cause for doubt, may make the situation worse.

2.3 Exposure Control is Difficult

Even when people are convinced that orchestral work can and does harm hearing, it is difficult to control noise exposures in an environment where making noise is the whole point of the exercise, and separation from source can only produce a 2-3dB reduction. Where there is a will, there is not necessarily a way. Almost anything that reduces orchestral noise exposures can adversely affect ensemble, communication, individual performances, artist-attractiveness, audience-attractiveness, stress levels, payroll, etc. In the case of screens, measures to protect one person can increase risks to another.

There is one silver lining: There are players, particularly in the brass, who like making a lot of noise. But, brass players have shorter careers than other sections – they are forced out by over-use injuries to the mouth or breathing support. Some of the measures to reduce noise exposures can be re-framed as measures allowing the brass to play with less force – and less dulling – by raising them above sections who are obstructing their output. Metre-high risers can cut brass exposures by 2-4dB, and cut the high-frequency exposure of neighbours by up to 7dB. Woodwind players also benefit from reduced obstruction.

2.3.1 Drawbacks of Control

Screens – do not protect if you perch on the front of your seat [must be within 7" of target's head]. If too close to the source, will increase exposure of the source, demand more work of source [increasing exposure still further], and reduce high frequency content [dulling the source's output]

Ear Plugs – quiet passages vanish; over-emphasises skull-conducted element of own instrument; reduces intelligibility of conductor and principal; reduces contact with other sections; reduces confidence in own tuning and volume; can result in over-playing. Also, there is a certain illogicality in telling people it would be difficult to play with hearing damage, and then insisting they simulate that damage by wearing ear plugs.

Risers – need the equipment and space, can end up very high [risks of access / vertigo / falling], other sections hear less of elevated section, elevated section takes a while to reduce output

Quieter Programmes – interfere with artistic strategy, may be wasteful of human resources

Reconstruction of pits and stages is expensive, even where it is practicable

Stress – is inevitable with this degree of change, and people are already quite stressed. Some compulsory use of control measures is inevitable, and may upset relationships between players and management.

Assumptions – screens and some personal hearing protection are visible from the audience, and may lead to bias in assessing the quality of a performance – by critics or by paying customers.

3 Generic Assessment

Assessments of orchestral noise doses are time-consuming, expensive and detailed, and generally available after the event. Two studies[4] assessed long-term exposures [partly to determine if weekly doses would be helpful]. From these, it is possible to ball-park the risks to players as follows

Brass	90
Woodwind	88
Back strings	86
Front strings	84
Percussion	83/4 – but exceed Peak Action Level
Conductor	83
Audience	insignificant – although pieces with *fff* brass passages have been known to cause temporary pain

Chamber orchestras and ensembles using period instruments are about 2-3dB lower.

Pit orchestras may be 2-3dB higher.

There seem to be no records of daily doses above 98dB [although there are plenty at 97/96]
The brass generate transients in the high 120s

Many 'noisy' modern pieces are, in fact, not as loud as well-loved belters. However, if players dislike a piece then the risk to hearing may be higher, so the estimated dose may need to be adjusted upwards.

Own instrument exposure dominates, although neighbours can add 2-3dB. However, it is neighbours, not sources, who complain of pain and shock [including inability to play] as a result of 'blasts' from [in particular] the trumpets and percussion. The pain and shock experienced by neighbours is generally worse than that experienced by the source because of the psychological element of control [encompasing choice, and knowledge of the precise moment of impact]. [Some suggest the source may have an element of protection from 'learned' stapedial reflex and from the valsalva manoeuvre, but this is not obviously reflected in their audiograms].

The risks from noise in orchestras include non-auditory effects: Playing through obstructions increases musculo-skeletal strain; excess noise from neighbours causes startle and pain, and can disrupt playing. In both instances, noise effects feed into the anxiety / tension / muscle injury cycle.

4 Controlling Risks

The ABO report recommends that each orchestra establishes [within its own staff] an expert team. This team will 'traffic-light' the exposure assessments for a given day [deciding that the day is obviously low, obviously high, or somewhere in between] and select appropriate control measures. The team will also take a longer view, looking at the choice of programmes, venues and artists for a season or tour, and – where appropriate – recommending structural alterations to a venue. [The team therefore needs a certain seniority].

The expert team would base their assessment on a comparison of the programme with a databank of measurements for various pieces, taking account of the numbers of instruments and the intensity and duration of loud passages, the preferences of the conductor, the acoustic and stage layout of the venue, etc. 'Assessment drift' can be restricted by comparing notes with other expert teams.

The approach accepts that effective control will not be achieved on every day, and that there will be some mis-classifications, particularly at the red/amber boundary. However, the approach will accumulate greater control over noise exposure than has ever before been achieved, and this control should improve as the expertise of teams increases and the various control measures become normal.

There are substantial change-management issues around the introduction of noise controls

The menu of control options is as follows:

- Do not double-rank the brass
- Place trumpets on risers at least 50cm and preferably 1m high
- Maintain a clear path between the audience and the first uncovered hole of a woodwind instrument or the bell of a brass instrument
- Place perspex screens close to the head of the person requiring protection from noisy sections, but only if the risk of backfire is acceptable. [Do not allow screens to be used as personal protective equipment]
- Use floor-level screens behind the horns, angled at 45°
- Use sectional rehearsals [where applicable] to reduce the numbers exposed
- Select quieter pieces
- Use quieter instruments, or at least discourage acquisition of noisier instruments
- Balance noisy pieces with something quieter – within a day, or a week
- Rotate people to 'share the misery' of sitting close to noisy sections
- Have 2m clear space in front of the orchestra
- Have 1m clear between an overhang and the heads of the fiddles
- Use personal hearing protection, and don't dismiss ear muffs or ear caps.

One study[5] found screens give no protection below 250Hz, 9dB at 1kHz and 17dB at 8kHz. Another[6] found that screens used in conjunction with 50cm risers gave 18dB protection compared with 7dB when used alone.

Table of mean attenuation data for least unusable personal hearing protection. Assumed protection data are not used, since musicians are as much concerned with over as with under-protection.

	SNR	63	125	250	500	1000	2000	4000	8000
ER15	≈15		17.5	17.6	18.0	16.3	17.3	16.8	20.8
ER20	21	14.3	15.3	18.1	20.8	21.8	26.3	21.5	27.0
Guymark Blue	?	0	0	0	5	15	20	20	25
Quiet Please*	13	?	?	?	?	?	?	?	?
Bilsom 817 NST	27	12.0	14.8	24.2	27.1	24.3	28.6	30.6	33.2
Bilsom 707 Impact*	29	17.7	14.1	20.4	28.6	33.7	31.3	42.2	35.3
PerCap	24	16.6	19.0	17.9	16.1	19.9	27.2	31.5	34.5

* amplitude sensitive device

The PR risks of noise control must also be addressed: Conductors need to be briefed or consulted about the measures to be used, to avoid [for instance] comments such as 'those screens are making the trumpets flat'. Critics may need to be educated about 'visible' control measures, and it may be worthwhile communicating the changes to the orchestra's Friends.

5 Epilogue

One aspect of orchestral exposure assessment needs more attention: It is clear that the Percussion exceed the Peak Action Level. But, there is no useful information about when this happens.

There is obvious scope for an experimental study to map the peak levels and wave forms associated with different intensities [and different pitches] on the various instruments.

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[1] An anonymous contribution to the project, and Kahn SW, Proc IOA Vol 16 Part 2 [1994] p313

[2] British Performing Arts Medicine Trust, Questionnaire Survey of Musicians [Orchestral], March 1997

[3] Chasin M and Chong J [1992] A clinically efficient hearing protection programme for musicians. *Medical Problems of Performing Artists*, 7[2], 40-43

[4] Unpublished, released to the ABO project in confidence

[5] Camp JE, Horstman SW, Musician sound exposure during performance of Wagner's Ring cycle, Medical Problems of Performing Artists, June 1992, p37

[6] van Hees, OS, Hearing Impairment in Orchestral Musicians, BPAMT Conference, 1997