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## Introducing acoustics to classical musicians

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Since the enforcement of the UK Control of Noise at Work Regulations for the entertainment sector in 2008 and over the last five years, the Acoustics Group of London South Bank University (LSBU) has been collaborating with the musicians and management of the Royal Academy of Music (RAM). The aim of the RAM noise project was to protect musicians from excessive sound exposure and the risk of noise-induced hearing loss and has been, from the very start, focused on the education of young and professional musicians. A series of seminars have been prepared for the musicians, explaining basic acoustic principles in more music related terms. Presentations are also enhanced by live musical demonstrations. This paper presents the approach taken in educating musicians in acoustics and audiology to help them understand the dangers and risks of excessive sound exposure and protect themselves from further/future hearing damage. The evolution of educational techniques during the RAM project, as a result of successes and failures, and their application on the professional musicians of the London Philharmonic Orchestra, (LPO) is also discussed.

## 1 Introduction

It has been four years since the enforcement of the new Control of Noise at Work Regulations (CoNAWR05) for the entertainment sector in the UK [1]. Following the European Union Directive 2003 [2], the aim of the new Regulations is to protect anyone working in the entertainment sector from excessive sound exposure and associated hearing damage.

Performing artists must be able to practice, rehearse, and perform safely. With respect to hearing and the “noise” of performance however, the nature of their work and the dedication of performers themselves may mean that they are placed in a difficult position when complying with new (international or national) noise at work regulations. This naturally led to a sceptical and mostly negative attitude towards the new regulations.

Since 2008, hearing health surveillance combined with the provision of training is necessary for any employee at risk of high noise exposure. Being at the forefront of classical music education, the Royal Academy of Music decided two years before the enforcement of the new regulations to start the implementation of a health surveillance/educational programme and the continuous collection of data on the hearing acuity of their music students.

## 2 The Royal Academy of Music Noise Project – Educational Methodology

Educating both young and professional musicians studying or working at the Royal Academy of Music was, from the very start, a main focus of the noise project. Providing information and training is critical to the health and safety of musicians and one of the key solutions to the sound exposure problem. Educating musicians during early stages of their music career can promote good practice and help protect them from future hearing damage, during and after their course.

The educational part of the RAM noise project, although constantly evolving and adapting new ideas, is based on the provision of compulsory seminars for all first year students during Freshers week at the Academy. The seminars attempt to explain basic acoustic principles and issues related to sound exposure and hearing damage in more music related terms.



Figure 1: Educational seminars at RAM.

Each presentation, see Figure 1, is divided into five sections - principles of acoustics, noise exposure (assessment and results), hearing loss, health surveillance and mitigating measures. These topics needed to be understood, and hence the musicians are broadly divided into instrument groups.

### 2.1 Principles of acoustics

As with most introductions on the principles of acoustics, presentations start with the decibel being introduced as the fundamental unit, and the logarithmic nature described by analogy with earthquakes and the Richter scale. Examples of sound levels, which the students can relate to, are presented; see Figure 2. This is followed by the CoNAWR05 exposure action values/limit, averaged and peak.

Noise	Location	Sound level dB(A)	Peak sound dB(C)
Traffic at kerbside (light traffic)	Marylebone Road	76.2	107.1
Underground train	Bakerloo Line	84.0	96.0
Library in Academy	Library	40.9	83.6

Figure 2: Typical sound levels around London.

As the Academy is interested in protecting the students outside of their time spent at the school, examples of listening levels (both music and speech) through earphones and headphones in different environments are given [3]; see Figure 3. Noise levels inside London Underground trains, a common reference for environmental noise in London, are also presented [4]. Experience has shown that relating noise exposure to musicians' favourite and/or common activities

increases their interest in acoustics and it's applications to daily life but more importantly it's potentially damaging effects on their hearing health.





Output from iPod	A used in a quiet environment dB(A)		As used on a Bakerloo underground train dB(A)	
				
Pop	73.1	76.9	82.0	90.2
Rock	72.2	78.6	80.9	93.2
Speech	63	66.3	78.9	88.0

Figure 3: Examples of iPod listening noise levels using standard earphones and Bose headphones.

The students are then shown a sound map of a traditional symphony orchestra, providing some initial indication of their likely sound exposure within an orchestra; see Figure 4. Only then is the time-energy trade off presented, as the students tend to ask about the effect on their exposure of a two-hour concert compared to a normal 8-hour working day.

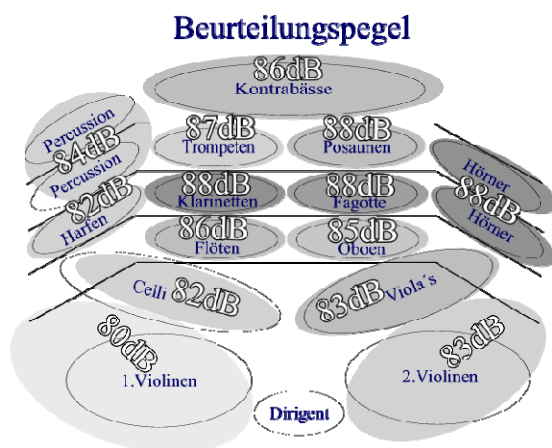


Figure 4: Typical exposure levels within a symphony orchestra [5].

In order to further narrow and hence target the information provided to the students, at this point the presentation splits into the following four identified instrument groups: Strings/Keyboard, Voice, Woodwind/Brass and Timpani/Percussion. The students are given information on typical noise levels produced by their instruments, typical peak levels ranked from most impulsive to least impulsive, and solo sound exposure as calculated if playing for a full eight hours (levels were collected during noise monitoring at the Academy and were not available during the first year of seminars).

Please notice the use of the term 'sound', rather than 'noise'. Relating music with noise, noise exposure and hearing damage is usually, and justifiably, not well received by musicians that spend years studying, practising and are constantly preparing themselves for highest levels of performance.

## 2.2 Noise exposure assessment - Dosimetry

The students and music professors are introduced to noise exposure measurement equipment; see Figure 5. The RAM continuous noise monitoring programme is explained and their cooperation during measurements is requested. This programme has allowed an extensive database of sound exposure readings to be built. Each instrument group is then presented with representative dosimetry results of measurements taken in previous years whilst rehearsing or performing, from a variety of ensembles, repertoire and Academy rooms. Please note such information was not available during the first year of seminars with information (and therefore educational material) significantly increasing over the years. The compliant and non-compliant readings are highlighted.



Figure 5: Noise exposure monitoring equipment used at RAM.

## 2.3 Hearing loss

The students are introduced to the subject of hearing loss and the various types possible. Appropriate, for their age, examples are used. These can include the effects of visiting a nightclub and the associated recovery time needed (temporary threshold shift). A demonstration is used as to how tinnitus might sounds. Permanent threshold shift is presented as irreversible, although stem cell developments are mentioned.

How hearing naturally changes over time is presented using a live audio demonstration [6]. This allows students to assess the impact of age and noise-induced hearing loss on their hearing and evaluate the importance of protecting themselves from (further) hearing damage. Effects of noise and age induced hearing loss on both music and speech is presented.

## 2.4 Health Surveillance

Students and music professors are introduced to the subject of hearing surveillance, in particular screening audiometry. Its' purpose to warn individuals that might be suffering early signs of hearing loss and give them the opportunity to start protecting themselves from further damage, is underlined. A discussion on the RAM health surveillance programme and its significance leads to the provision of information on the students' personal hearing test. This includes details on where the audiometric testing takes place, the audiometric testing procedure, its duration and requirements for valid audiometric testing results. An



audiogram typical for their age and profession taken from past years testing and its trace is presented and discussed. The analysis and evaluation of results based on the CoNAWR05 categorisation scheme [7] is then explained. The students are also informed on the questionnaire they will be given before or after their test, the questions that will be asked and how this is linked to their audiometric testing results validation and analysis.

Following the discussion on audiometric testing, overall statistical results from previous years are presented [8]. Hearing categorisation results are presented per age group, gender, instrument group and the number of individuals and hence statistical significance of the people measured is given. As the CoNAWR05 categorisation scheme is used for identifying only overall existing damage (sum of losses at 1-6 kHz) suffered by general population, specific indicators for music-induced hearing loss (6 kHz dip) and early signs of hearing loss (20 dB hearing loss in any high frequency, 1 - 8 kHz, in either ear) were introduced [9]. Following this, the 8 kHz frequency was added, since 2009, to the testing procedure (not applicable during the first two years of testing at RAM).

## 2.5 Mitigating measures

Presentation and discussion on various possible mitigating measures has been an integral part of the educational seminars at the Academy. Having explored the nature of a musicians' noise exposure, but also the demands of their profession, main focus is given primarily on culturally accepted educational and mitigating measures [10]. These include the use of an iPhone as an educational/prevention tool (through the application 'sound level meter' which measures  $L_{Aeq}$  with a high degree of accuracy for non-impulsive instruments) [11], the use and proper set up of orchestra pit screens and acoustic shields in the concert hall and orchestra pit, the use of the sound absorbing mirror in the practice rooms (LSBU patent 09165797.3 – 1240, 2009), see Figure 6, but also the use of the 'Sound Ear', a device installed in four of the main rehearsal rooms, which indicates levels of sound exposure.



Figure 6: Sound absorbing mirror at RAM.

Last but not least, the unavoidable, in some cases, use of earplugs is discussed with the students. All available types

of hearing protection, from disposable ear plugs to custom fitted musician's earplugs, together with their suitability for each instrument are presented. The advantages versus disadvantages and cost of each hearing protection option are also mentioned.

## 2.6 Questions and Answers

The last part of the educational seminar is a 10 minute question and answer session. Of the four groups of musicians that are given the presentation - the musical theatre students are always the most interactive. The custom fitted moulded earplugs are discussed and approximately 1 in 10 students make appointments with local agent.

## 3 Professional musicians

As part of a collaboration between the Acoustics Group of LSBU and the London Philharmonic Orchestra that aimed to assess professional musicians' noise exposure, similar educational seminars were given to all members of the orchestra (both musicians and management team). Presentations were given before and an extensive programme of noise exposure measurements undertaken between 2008-2009, see Figure 7.

Following the structure of seminars given to the Academy students, LPO members were introduced to basic principles of acoustics, noise exposure and hearing loss. Detailed results from the years' noise monitoring were presented identifying instruments, concert/rehearsal spaces and repertoire that resulted in excessive sound exposure. All culturally acceptable and at the time developed mitigating measures (including hearing protection) were identified and discussed. With the help of a brass player, a live demonstration of the effectiveness of the sound absorbing mirror was given and questions were answered. The importance of health surveillance and any confidentiality issues arising from audiometry testing were also discussed. Finally, room acoustic measurement results from all main LPO rehearsal and concert spaces were presented and recommendations for improvements were made.



Figure 7: Noise exposure measurements at the LPO.

Comparing educational seminars at RAM and LPO and the approach taken by musicians, it is important to note that, professional musicians expressed more concerns related to their hearing, based on already identified personal

problems and daily experience during rehearsals or concerts, and showed a particularly increased interest on acoustics, exposure results and more importantly mitigating measures. The significant role of the conductor in educating and controlling/preventing noise exposure was underlined in both seminars and discussed with the LPO's principal conductor.

## 4 Conclusions

Since 2006 and over the last five years, the Acoustics Group of London South Bank University has been collaborating with the Royal Academy of Music on the implementation of an educational programme for all young and professional musicians. This is based on the provision of compulsory seminars for all first year students that attempt to explain basic acoustic principles and issues related to sound exposure and hearing damage in more music related terms. Each presentation is divided into five sections - principles of acoustics, noise exposure (assessment and results), hearing loss, health surveillance and mitigating measures. An adapted version of the presentation has also been given to professional musicians of the London Philharmonic Orchestra.

Based on musicians interest, involvement during the seminars and feedback provided, it has been concluded that educating musicians on acoustics during all stages of their music career can have a very positive effect on their profession and personal hearing health. Professional musicians, understanding the impact that future hearing loss may have on their career, tend to express an increased interest in discussions related to noise exposure and control measures.

It has been agreed that educational seminars at RAM, being an integral part of the Academy sound protection plan, will be continued and adapted to account for new developments in the field of noise exposure and hearing loss among musicians.

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