Sound exposure and the hearing of musicians

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Summary

Since the implementation and enforcement of the European Union Physical Agents Directive (Noise) the Acoustics Group has collaborated with the Royal Academy of Music. Over the past eight years more than 2500 students have had their hearing tested and all instrument groups have undergone dosimetry to establish typical sound dose over a working day. The paper will compare sound levels, working hours and audiometry health surveillance results for a selection of the students that demonstrate some unusual results. We know that these highly talented artists must be able to practice, rehearse, and perform safely. Our job as acousticians is to ensure that they are able to.

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1. Introduction

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 noise at work regulations. Since 2008, with the introduction of the new Control of Noise at Work Regulations 2005 (HSE, 2005) [1] in the UK, hearing health surveillance 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 to start the implementation of a health surveillance programme and to continuous collect data on the hearing acuity of their music students. This paper presents the approach of the Royal Academy of Music on the issue of health surveillance for classical music students and discusses the findings of audiometric hearing tests conducted during 2007-2014, updating the results presented at ICBEN 2011 [2] (Zepidou and Dance 2011).

2. The Approach

The Royal Academy of Music took an inclusive view whereby every new student had to compulsorily take an automated audiometric screening test during the first week of his or her studies at the Academy (Fresher's week). The testing closely followed the methodology outlined in the Control of Noise at Work Regulations. Students, prior to testing, attended a targeted 1-hour hearing seminar, which amongst others, informed students on the purpose and procedure of the audiometric testing. To minimise the influence of any Temporary Threshold Shift (TTS), students were asked to avoid exposure to any loud noise a day before their testing and the use of smartphones while travelling to the test. One-to-one interviews with each student and an Otoscopic examination were used to identify any factors, which may influence the health surveillance results.

The test was based on a pure-tone air conduction Bekesy test (frequencies 500 Hz to 8 kHz), using Amplivox automated screening audiometer with TDH49 audiocups. The test was conducted in the audiometric soundproof booths at the Acoustic Laboratory of London South Bank University (LSBU); see Figure 1. Both booths used met the criteria given in ISO 8253-1:2010 [3]. Once the test and questionnaire was completed, each audiogram was categorised according to the Health and Safety Executive (HSE) categorisation scheme (HSE, 2005). Students received a copy of their audiogram with the original being sent to the Academy for their records. Results were discussed individually with each student and advice has been given on protection from noise exposure, including advice on most suitable hearing protection option based on the instrument played.

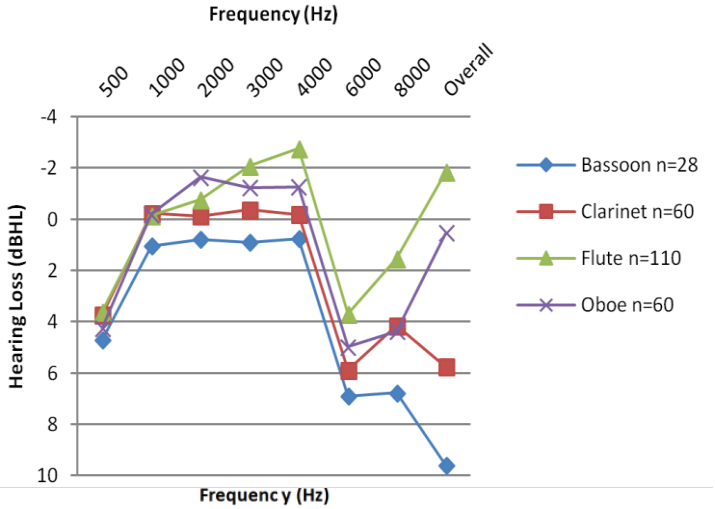
Figure 1: Audiometric booths and audiometers

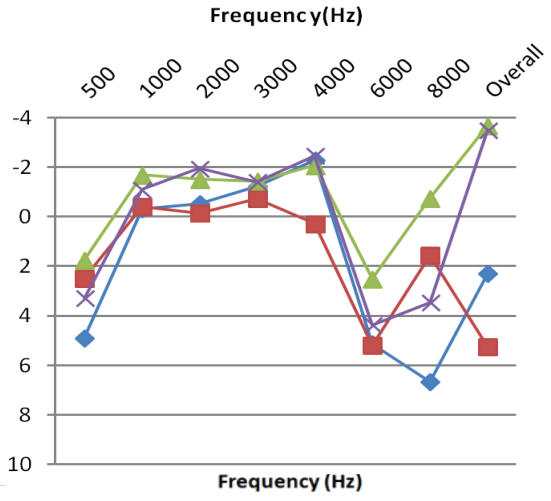
3. Results

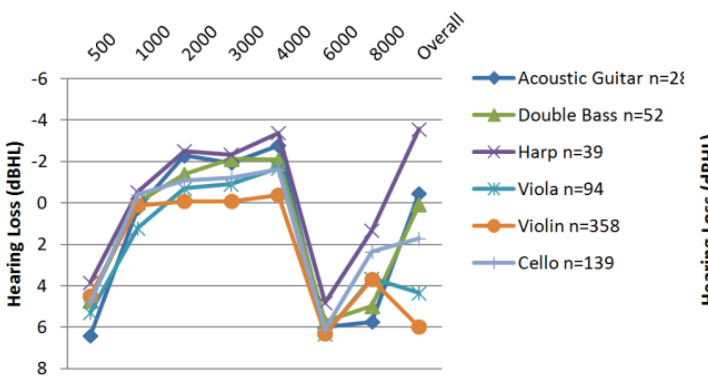
As a result of the testing over the last eight years, a large audiometric database has been developed, holding over 2500 student audiograms. By categorising the audiometric according to HSE overall assessment criteria, a sum of 1, 2,3, 4 6 kHz hearing losses, 94% of the Academy students have what is considered to be good hearing, 4.5% of students showed a mild hearing impairment (warning) and only 1.5% of students had poor hearing (referral). Among the later, most recorded referral cases were due to genetic hearing problems or accidents that occurred in the past and can't therefore be associated with noise induced hearing loss. For the general population, percentages for warning and referral levels are set at 20% and 5% respectively. This indicates that young musicians have excellent hearing. Please note that another reason behind the excellent hearing results recorded among music students may be the fact that with their well-trained ears and developed sensitivity to sound/changes in pitch, music students could simply be better at detecting pure tones than general population of same age. On the other hand, noise induced hearing loss has a dose-response relationship, and hence may take up to 20 years to become apparent amongst classical musicians.

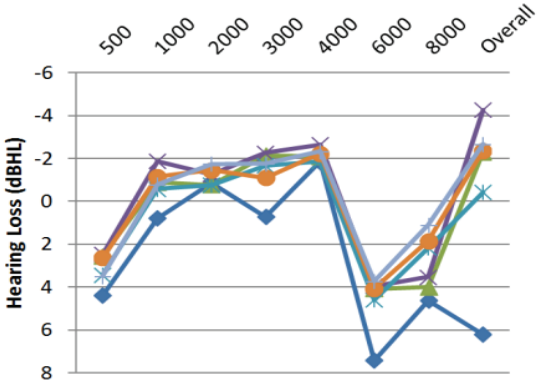
3.1. Instrument Groups

The 2500 students have been divided into 4 broad instrument categories: woodwind, strings, keyboard and brass. In each of these categories the number of instrumentalist is given, as well as the average hearing loss for each frequency has been calculated. Finally, the HSE overall assessment criteria is given for each instrument group, figures 2-5.









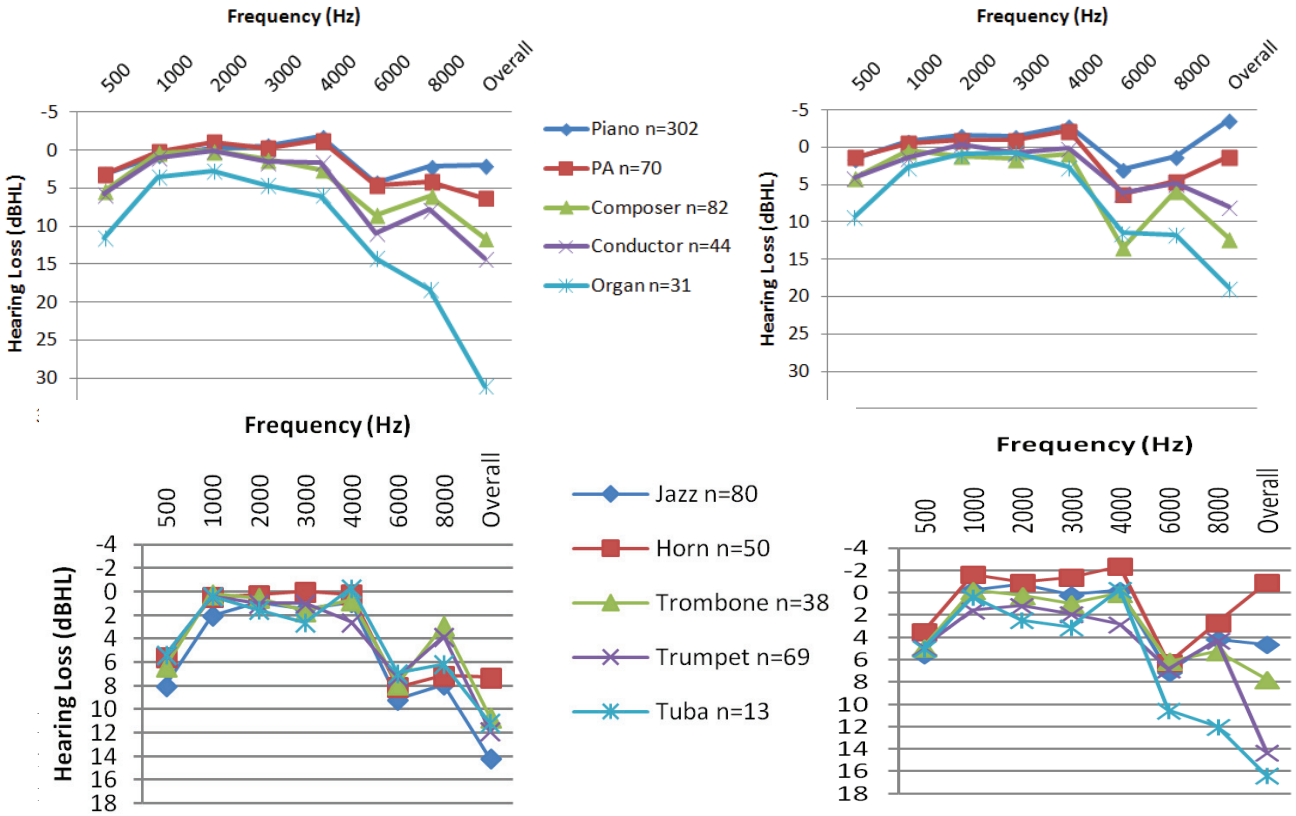


Figure 2: Left and Right Ear Averaged Hearing Thresholds of n Instrumentalists

Finally, when comparing averaged hearing loss per frequency for each instrument group, a 6 kHz notch, i.e. an increase in hearing loss at the 6 kHz frequency when compared to the adjacent 4 and 8 kHz frequencies was found. This is a sign of noise induced hearing loss also linked with musicians' noise exposure [4-8]. Please note that headphones used were properly placed on musician's head and have no known artefacts that could have increased thresholds at 6kHz

3.2 Overall Results

When analysing the averaged audiometric data across all 2500 audiograms for each type of instrument it became apparent that every result showed an increase in hearing loss (although at very low levels) at 6 kHz compared to the 4 kHz normally associated with noise induced heairng loss, see figure 6.

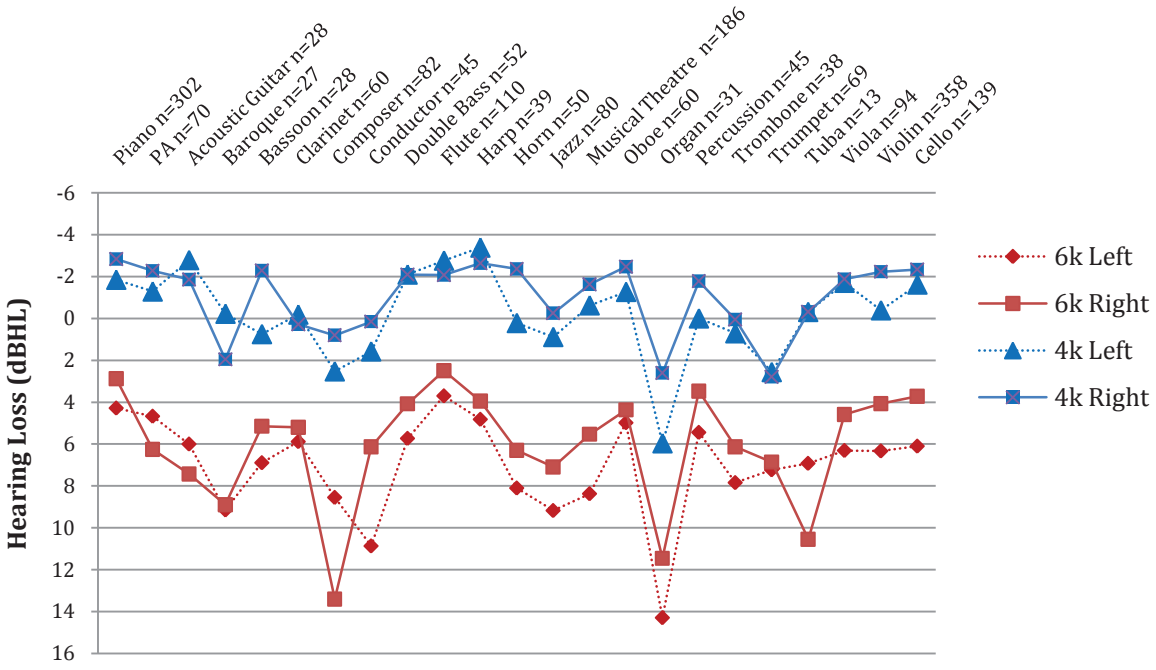


Figure 6 Left and Right Ear Average Hearing Thresholds for 4 and 6 kHz for 2500Musicians

When comparing the results in terms of overall hearing assessment for each type of instrument, see figure 7, it can be clearly seen that the left ear is consistently worst than the right ear and the organist suffer from the greatest hearing loss of the non electrically amplified instruments, it using mechanical amplification.

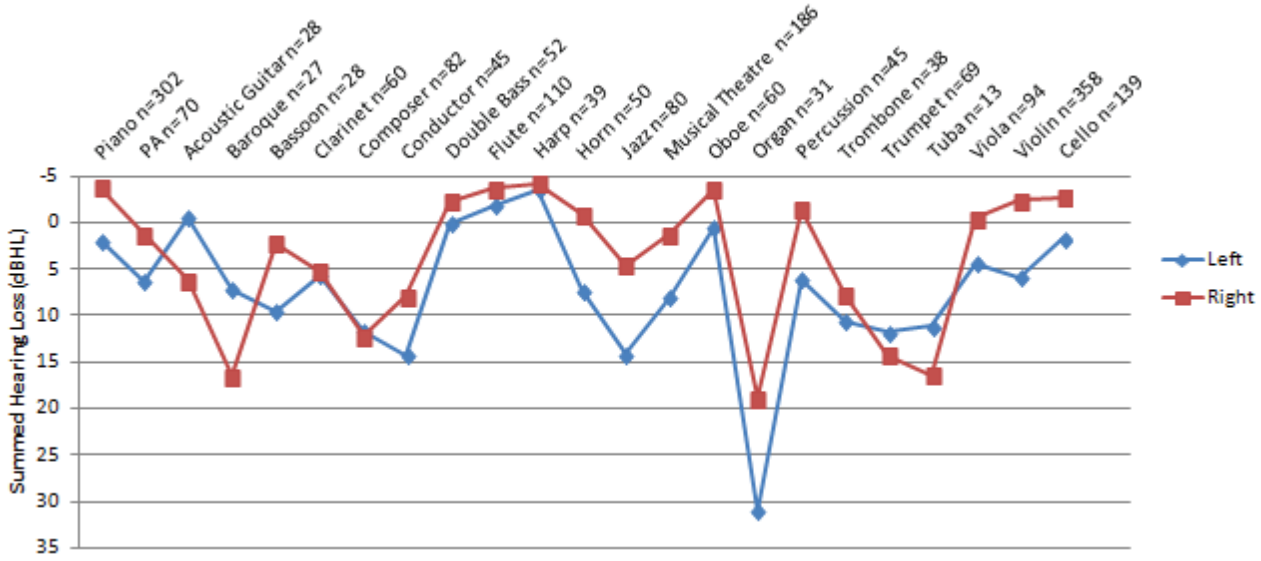
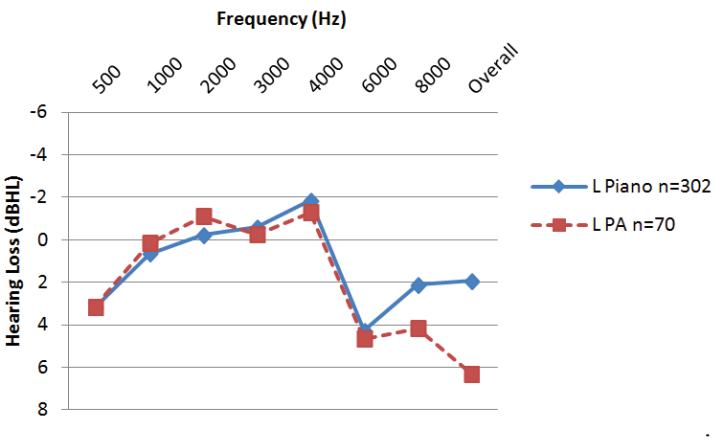


Figure 7: Left and Right Ear Overall Health and Safety Hearing Score

3.3 Effect of other music on musicians hearing

By investigating the hearing of pianists and piano accompanists it is possible to establish the effect of other music on a musicians hearing. The accompanists play for singers and hence are subjected to sound coming from their right hand side, due to the design of the piano. The sound level produced by vocalists are high, typically an L_{Aeq} of 85-110 dBA [9].



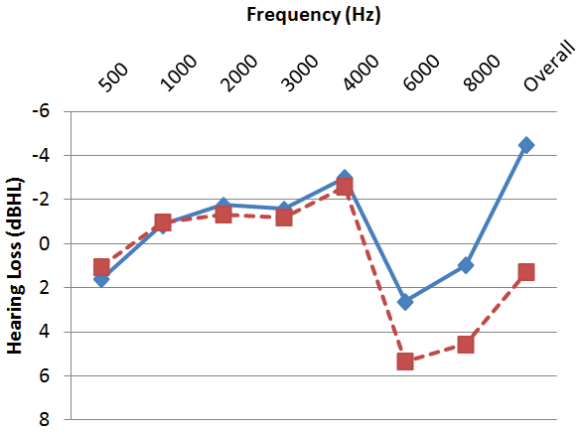


Figure 8: Left and Right Ear Averaged Hearing-Thresholds for Piano and Piano Accompanists

The effect of the high singing levels on the pianists can be clearly seen from figure 8. The left ear has very similar average hearing losses for 4 and 6 kHz and a 2 dB difference at 8 kHz, with the a 4 dB difference in the overall criteria. However, looking at the right ear there is now a 4 dB difference at 6 and 8 kHz and a 6 dB difference in the overall criteria with no difference at 4 kHz between the 302 pianists and the 70 piano accompanists, on average.

By way of comparison the hearing acuity of asymmetric instrument players were investigated, for example the violin (left side) and the French horn (right side), see figure 9 and 10 respectively

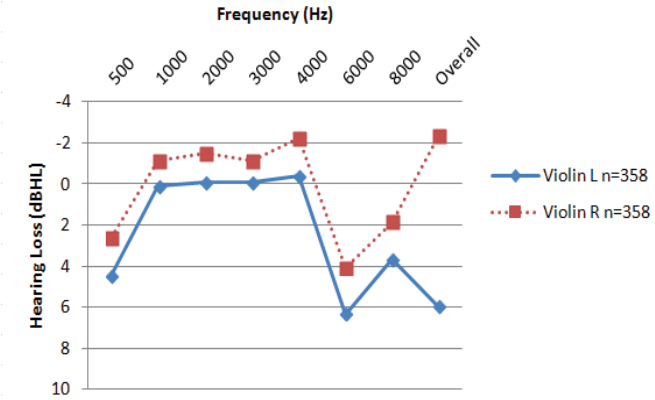


Figure 9: Left and Right Ear Averaged Hearing Loss for Violinists

It is clear from figure 9 that the left ear, as expected, is worse than the right ear for Violinists, at all frequencies. An overall difference of 8 dB has been found.

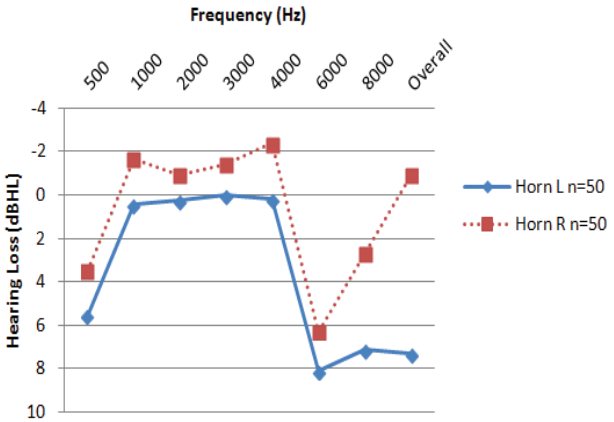


Figure 10: Left and Red Ear Average Hearing Thresholds for French Horn players.

The average hearing thresholds of the Horn players, see figure 10, shows a reversed result with the left ear being significantly worse than the right ear, an 8 dB difference, even though the instrument is right sided. An hypothesis is the adjacent instrumentalist is effecting the hearing of the players. This hypothesis is undergoing further investigation.

4. Conclusions

Since 2007, the Royal Academy of Music has been following a management policy to assess the hearing acuity of the musicians at the start of their career. Results of over 2500 hearing tests revealed that music students have excellent hearing and less hearing problems than those of general population and same age despite their, already accumulated, hearing exposure. Highest incidence of students with mild hearing impairment or poor hearing was found among organist. Finally, averaged hearing thresholds per frequency for each instrument group

showed a significant threshold notch at 6kHz for all instrument types. This clearly shows the effect of music is different from the effect of noise on hearing, where the notch is found at 4 kHz.

As a hypothesis: musicians have learnt to control their Stapedius Reflex, to protect themselves from their instrument's noise. The analysis of the hearing threshold's of pianists compared to piano accompanist indicated that there is evidence to suggest the validity of the hypothesis.

5. References

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