

SOUND LEVELS IN THE NETHERLANDS BALLET ORCHESTRA

A STUDY OF THE RISK OF HEARING DAMAGE IN ORCHESTRAS

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Introduction Since high sound levels can contribute to the development of hearing damage, it is necessary to assess such sound levels very accurately in order to quantify the risk of hearing loss. Many short investigations have been undertaken concerning sound levels in orchestras, but their representativeness is limited by their relative disregard of factors such as the physical condition of the orchestra pit, the arrangement of the orchestra and the repertoire played. Both the composition of the orchestra and the position of the various musicians can vary, on the dimensions and shape of the orchestra pit. Another important factor is the length of rehearsals or performances. As International Standard ISO 1999 describes, hearing loss depends on a combination of two factors: duration and sound level. In order to produce an accurate assessment of the risk of hearing damage, it is essential to continue an investigation over a long period so that all the factors described above can be taken into account. My investigation involved monitoring all the activities of the Netherlands Ballet Orchestra (NBO) - both rehearsals and performances - over a period of a year. Different repertoires and compositions of the orchestra were taken into account, and measurements were taken (so far as possible) at different positions within the orchestra. A symphonic orchestra was chosen because this type of orchestra (classical music) represents an important group of musicians. The Netherlands Ballet Orchestra was selected because it was assumed that the sound in orchestra pits would be louder than that on stage and the main task of this orchestra is to accompany ballet performances (from the pit).

Methods Measurements were carried out using the NBO. This orchestra's main task is to accompany ballet performances. Every year it undertakes about eighteen projects. Five of these involve a small orchestra (< 65 musicians), approximately six a medium-sized orchestra (about 70-80 musicians) and around another six a large orchestra (> 80 musicians). The aim of the investigation was to obtain representative data for the noise exposure of the different sections of the orchestra in the course of a year. For the measurements, a number of sections were defined. The maximum possible number of activities (both rehearsals and performances) were measured. In practice this meant taking measurements at eight different positions during 178 of the 258 activities. The data was acquired by means of:

- A Direct measurement.
- B Calculation of values on the basis of measured values in identical circumstances ('first order extrapolation').
- C Calculation of values on the basis of measured values in a nearby position ('second order extrapolation').

For all the projects, the average equivalent sound level was calculated over the whole year. Then, the sound exposure levels $L_{EX,T}$ were calculated on the basis of the equivalent sound levels and the matching time spans. Finally, the Noise-Induced Permanent Threshold Shift (NIPTS) was calculated.

Results The sound exposure level $L_{EX,T}$ is the average sound exposure of a member of the orchestra over an average 8-hour working day. This quantity determines the risk of hearing impairment. The NIPTS expresses the relationship between the sound exposure level and the shift in the hearing threshold for people of different ages. By calculating the NIPTS, it is

possible to estimate the potential hearing loss due to noise. The table below shows the results of calculations of possible hearing impairment after 30 years' exposure to the measured sound levels.

Section	Average exposure level $L_{EX, TOTAL}$ over 260 days	2000 Hz	3000 Hz	4000 Hz	6000 Hz
Horns	86	2	5	7	4
Brass	86	2	5	7	4
Tympani	83	0	2	4	2
Percussion	84	1	3	5	3

Full-time players in all of these sections - horns, brass, tympani and percussion - run a real risk of hearing damage.

Discussion The damaging effects of sound on musicians working in an orchestra pit were investigated over a whole year using the Netherlands Ballet Orchestra. After monitoring sound levels, I calculated the potential risk of hearing impairment. The results of the investigation relate to members of the orchestra working full-time (i.e. participating in all the orchestra's activities in that year). Since no record of actual attendance was kept, the average exposure levels cannot be linked to individual musicians. The investigation shows that nine of the 20 sections in the orchestra (about 46 musicians, including all the strings in the front and middle, and the piano) were exposed to an average daily dose under the 80 dB(A) limit at which hearing impairment may be expected to occur. For five other sections, the average daily dose was slightly above the 80 dB(A) limit for daily exposure (violins and cellos at the back of the orchestra, harps, oboes and bassoons). In the remaining sections (flutes, clarinets, horns, brass, tympani and percussion) the average annual dose was significantly higher than the 80 dB(A) exposure level described in the ISO 1999 standard. This means that 30% of the musicians in the orchestra are exposed to a sound level that is prohibited in industry without hearing protection. Ear protection for musicians needs not only to be comfortable in wear, but also to permit the player to hear the music with no loss of sound quality. Another issue to be considered is whether determination of the A-weighted equivalent sound level is the only appropriate method of calculating the risk of hearing damage to orchestral musicians. In Holland an impulse adjustment of 5 dB is used, if impulsiveness is an essential characteristic of the noise. Possibly an adjustment for musical sound may be appropriate. Furthermore, this investigation predicted only the risk of a threshold shift; future studies will be needed to take account of possible consequences like tinnitus, hypersensitivity to loud noises and diplacusis, which makes the listener perceive pitch in a totally different way. The influence of nuisance also needs to be evaluated.

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