Noise induced hearing loss in the entertainment sector

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INTRODUCTION

In 2003 the European Union introduced the new noise directive (EC 2003). One of the new requirements in the directive was that all member countries must develop a code of conduct for music and entertainment sector. The European Agency for Safety and Health at Work (2005) has published recommendations for the entertainment sector. In these recommendations it is identified that noise reduction can be obtained by organisational measures, through technical and architectural measures and by using hearing protection. For practice rooms a size of 17 m^3 is recommended. Good acoustic design and proper absorption are recommended to reduce the sound levels.

In Finland the code of conduct is intended to be used as a checklist by labour inspectors. It does not provide any practical solutions, how to achieve the goal, but it provides an overall view of the requirements and possibilities. Also the Health and Safety Executive (HSE) provides a similar overall view in their webpage (HSE 2007). The instructions are given by the type of music: concert halls and theatres, amplified music, studios, schools and colleges, pubs and clubs and marching bands. Also the needs of different worker groups, like technicians and freelancers, are identified in a similar way to the Finnish code of conduct.

The Finnish code of conduct divides the workers into 12 groups based on their work tasks and type of employment (Table 1). To make things even worse one worker may belong to several groups. For example many of the music teachers act as part-time musicians.

Table 1: Division of the workers based on employment type and character of work and examples of workers belonging to each group

Employment	Performers	Teachers	Technical staff	Service work
Regular	Theatre/opera musicians, actors	Regular teacher	Theatre technical staff	Waiters, safety officers
Odd job	Restaurant musician, actors	Part time teacher	Constructors of outdoor event	Waiters, safety officers
Own company	Restaurant musician		Constructors of outdoor event	

The major problem with the code of conduct is that it does not provide a practical solution. As a consequence there is a confusion in the music and entertainment sector, how to implement the conduct in the field. A second problem was found that research is needed before any implementation can be made. This paper describes the research made in Finland to implement the code of conduct.

RISK ASSESSMENT

In the music and entertainment sector there are acute and chronic hearing losses. The acute hearing losses are due to special effects (Figure 1). Our survey found in two theatres (Finnish National Opera, Tampereen Työväenteatteri) and in YLE (Finnish Broadcasting Company) over 50 firearms (from machine gun to start pistol), 20 different firecrackers (Figure 1c), and self made bombs (Figure 1a). In addition tanks, canons (Figure 1b), and rockets were available.

a) suicide bomber in Tampere b) Historical canon c) fireworks on scene theatre shooting presentation

Figure 1: Examples of impulse noise sources in the entertainment sector

The measured peak levels of these blasts varied from 163 dB (canon, explosions) to 110 dB (firecrackers). The peak levels of the shots in the shooters ears varied from 155 dB to 132 dB depending on the gun and amount of powder. The shooter was not the only exposed one, also the several other actors/musicians could be exposed to peak levels exceeding 140 dB.

The risk of acute acoustic trauma is not known, because the good statistics about it is missing. However, in Helsinki region alone at least 20 cases of acute acoustic traumas have occurred during the past few years.

The exposure of non-performing personnel can be evaluated from the exposure of the broadcast personnel, because they are moving in same places than the non-performing personnel. The highest exposure was found in concerts and sports events. Depending on the location the exposure could be 99 dB(A) in concerts and 93 dB(A) in sport events (Table 2). In addition sound exposure could also exceed the 140 dB peak level in concerts.

Table 2 : Noise exposure in various public productions (Järvinen et al. 2004)

Production	Average (dB(A))	Range (dB(A))
Concert	88	68-99
Sports	85	69-93
Others	77	69-86

The noise exposure of classical musicians was measured among five orchestras in Helsinki region. Most of the musicians were exposed to levels exceeding 90 dB(A) (Toppila et al. 2011; Laitinen et al. 2003). Depending on the instrument the major source of exposure could be personal rehearsals or performances. Typically for percussionists, flautists and some brass players the exposure in personal rehearsal were the most important one.

EFFECTS OF NOISE

The effect of noise on the hearing of musicians has been debated for a long time. The distribution of hearing losses among classical musicians correspond to that of non-exposed population according to ISO 1999 (1990). By dividing the classical musicians to high and low exposure groups and adjusting to the effects of age, the effect of sound exposure can be shown (Toppila et al. 2011). Although musicians are not susceptible to hearing loss, there is a high prevalence of other hearing symptoms (Laitinen 2005). Temporary ringing in the ears was experienced sometimes by 17%, quite often by 8%, and always by 6% after orchestra rehearsals. The corresponding figures after personal rehearsals were 10%, 5%, and 3%. In GB, temporary ringing in the ears was experienced a bit more in orchestral rehearsals. It was reported that 15% of women, and 18% of men had permanent tinnitus.

Hyperacusis is also common among musicians (Laitinen 2005). Musicians experienced hyperacusis sometimes in 27 per cent of the case, quite often in 13 % of the cases, and always in 3% of the cases. No significant differences existed between the orchestras. The pain musicians felt was described as smart, sharp pain, ripping, grating, jarring pain, sense of pressure, distortion of sounds, humming in the head.

The non-auditorial effects of high music levels were questioned among broadcast personnel (Järvinen et al. 2004). They reported that after high noise exposure events 75% of workers had at least sometimes sleep disturbances, 30% reported vertigo at least sometimes and tinnitus over 50 % of the workers.

REDUCTION OF EXPOSURE

The Finnish code of conduct recommends that exposure should be reduced by selection of instruments, appropriately designed rehearsal rooms and use of hearing protectors. We have tested the effect of rehearsal rooms and inquired about the use of hearing protectors.

The Code of Conduct (Ministry of Social Affairs and Health 2006) gives requirements for the space needed for the instruments: grand piano and drum set at least 80 m^3/person, wind instruments at least 20 m^3/person, and other instruments at least 10 m^3/person. These numbers are seldomly achieved in real life.

The Code determines the acoustic properties of the facilities by using SFS 5907 (2004), Acoustic classification of spaces in buildings, where the reverberation time for special class rooms is smaller than 1 s, and sound isolation R'w (ISO 140-4, 1998) is bigger than 57 dB. When building new or renovating old facilities, the Code provides class B to be used for music facilities (reverberation time 0.8-0.9 s and the sound isolation R'w bigger than 65 dB). A Class B is a very demanding facility to achieve in sound insulation, especially when renovating old. Class B almost always requires an acoustician to plan it. However, even Class B is not enough when band practise facilities are built.

The effect of good design was tested in a music school in Espoo. No effect to the noise exposure was observed (Koskinen et al. 2010; Table 3). Still the musicians felt that renovations had a positive effect to the work satisfaction.

Table 3: Sound exposure measurements before and after renovation

Facilities	*Instrument*	L_{Aeq}, before dB(A)	L_{Aeq}, after dB(A)
Classroom I	trumpet	85	84
Classroom II	drums	91	93
Classroom II	drums	87	85
Classroom III	French horn	80	84
Classroom IV	accordion	84	75
Classroom IV	accordion	81	71

The usage of hearing protectors (HPD) was inquired with a questionnaire in five orchestras in Helsinki region (Laitinen 2005; Figure 2).

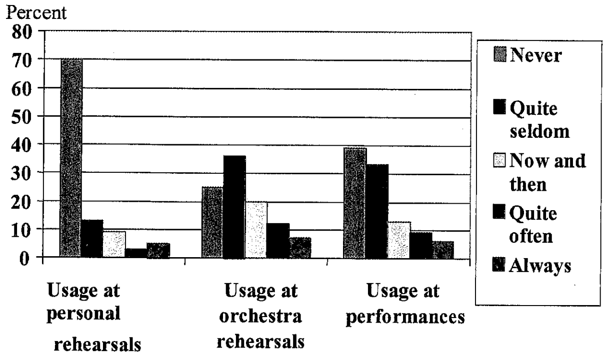

Figure 2: Hearing protector usage in work

Usage rate of HPDs was clearly affected by the hearing symptoms (Figure 3). In personal rehearsals, HPDs were used often or always by 2% of musicians without hearing symptoms, and by 12% of musicians with hearing symptoms. The same tendency was shown in orchestra rehearsals (9% versus 22%) and performances (7% versus 20%).

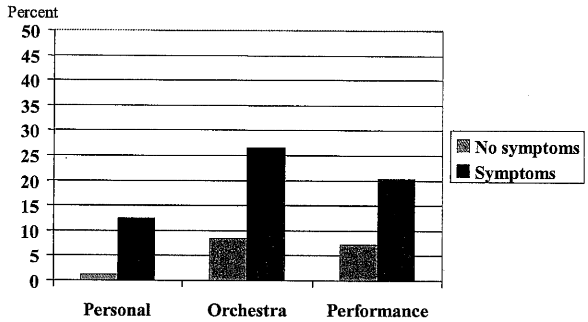

Figure 3: Effect of hearing symptoms to the use of HPDs

DISCUSSION

The Finnish code of conduct has raised confusion in the music and entertainment sector. It is listing many requirements but does not provide any solutions how to fulfill these requirements. It has not taken into consideration the special effects, because the risk was not identified at the time of development. To help the entertainment sector to implement the requirements of code, so far two implementation guides have been developed. The first one is for music schools and the second one is for every one using special effects. The special effect implementation guide is a web-based guide (tehoste.noiseproject.info (in Finnish)). It contains information about the peak levels of different special effect as function of distance and angle, risks and legal requirements. It contains also a section of audience safety, because it was found during the project that poor design can cause high peak levels among audience.

In addition the Finnish National Opera and YLE (Finnish Broadcasting company) have developed their own hearing conservation programs. Taking into account that a hearing conservation program is mandatory, this is a very low number.

The hearing conservation program (Toppila et al, 2001) of the Finnish National Opera was built early in 2001 and updated to take into account the effects of special effects in 2011. It is built of four modules:

- Motivation and training: An information package was made for the use of occupational health care and safety engineers.
- A tutorial how to take in use HPDs in the orchestra. The tutorial gives recommendations, which plugs to choose, how to start to use them gradually and what kind of problems can be expected and how to avoid them.
- In every production, a check to ensure that no unnecessary exposure occurs.
- Possibilities to make changes in rehearsal rooms and design of the stage are checked periodically to reduce the exposure.
- The group rehearsals are timed in such a way that the larger rooms can be used.

Activities are supervised by Hearing Protection committee, composed of the representatives of different artist group and safety engineers.

So far the work has been concentrated on large institutional partners in the music and entertainment sector because they have the resources to develop required actions to protect the hearing of their personnel. The situation becomes more complex with small scale partners in the field. They are lacking resources, knowledge, and they have not the required good will. Simple examples are available from Sweden and Germany, so there is no big need for research. As the researchers have been the most active people in developing methods, it is easy to understand that this kind of implementation has not taken place in Finland.

CONCLUSIONS

There is a underestimated risk of acute acoustic trauma in the music and entertainment sector. Most of the work has been concentrated on musicians completely forgetting the existence of the personnel involved. Their exposure may be even higher than that of musicians.

ACKNOWLEDGEMENTS

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The influence of room acoustic aspects on the noise exposure of symphonic orchestra musicians

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INTRODUCTION

Musicians in a symphonic orchestra are exposed to the noise of a large number of different sound sources. The noise exposure can vary largely and has many aspects of influence. One group of aspects are musical aspects, like the orchestra size and composition, the musical piece and its interpretation by the conductor and orchestra. The other group of aspects are architectural and room acoustic related which may contribute to a variation in noise exposure, independent of the musical aspects to some extent. On one hand, the size of the stage or orchestra pit may determine the distance between the musicians, which typically influences the direct and early reflected sound paths. Besides that, the room acoustics of the stage and the hall can increase the noise exposure dramatically. In this research, the contribution of stage size and acoustics to the total noise exposure and instrument balance is investigated for 7 concert halls A to G as described by van Luxemburg et al. (2009).

METHOD

A model for the prediction of sound levels within a symphonic orchestra is used to investigate the influence of the architectural and room acoustical aspects. This model is based on measurements of the sound power L_W and directivity Q of the various instruments, a generic orchestra setup and measured values of the room acoustical parameters sound strength G and the early to late reflection ratio LQ_{7-40} [Braak & van Luxemburg 2008] in different concert halls. The background of the model is described in Wenmaekers et al. (2010, 2011) and is briefly summarized in Figure 1. For every source and receiver pair, the direct sound level L_{direct}, early reflected sound level $L_{early;refl}$, late reflected sound level $L_{late;refl}$ and total sound level L_{total} is estimated.

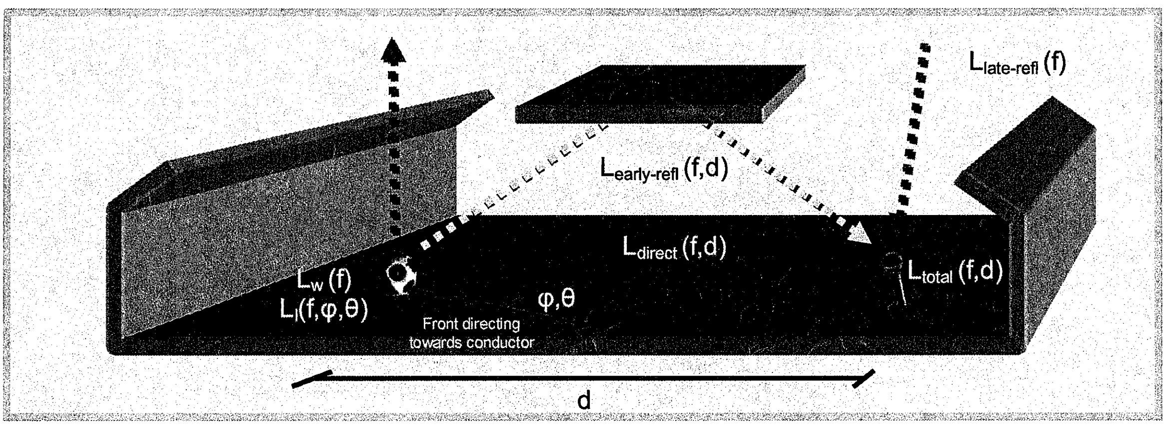

Figure 1: Summary of the source – receiver model