



## MUSIC, NOISE AND HEARING: HOW TO PLAY YOUR PART

A GUIDE FOR MUSICIANS

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## HOW'S YOUR HEARING?

- Do you avoid parties and noisy restaurants because you can't hear conversations?
- Do you often have to ask people to repeat things, or spell things out?
- Do people say you have the TV on too loud?
- Do you listen to music or podcasts on public transport?
- Do you ever worry you're playing / singing out of tune? Or too loudly / too quietly?

Listen to these three clips of the third movement of [Brahms' Fourth Symphony](#). You should be able to hear the differences within a few seconds.



[1. Brahms 4 as it should sound](#)



[2. As it would sound with age-related hearing loss](#)



[3. As it would sound with noise-induced hearing loss](#)

Whatever the state of your hearing, the message is the same: you must look after your ears. For you as a musician they are your most important tools of the trade, and your hearing health is vital to your quality of life.

This guide is for musicians playing acoustic instruments and singers working with orchestras, as well as being a reference tool for ensemble and venue managers, sound engineers and teachers. It shows how you can look after your hearing inside and outside your noisy workplace. It's about how you can maintain the highest artistic standards and ensure a long, healthy career as a musician.



## HOW TO USE THIS GUIDE

There are three ways you can use this guide:

- If you are in a hurry, follow the yellow 'speed-read' boxes only. You can get through them in 10-15 minutes and print off a handout at the end. Follow the 'fast forward' » arrows.
- If you have more time, or to find out more, read the white sections and 'sound bites' (case studies and quotations from colleagues developing real-world solutions).
- If you are a manager or a Health & Safety representative, the *Toolkit for managers* (Part II) covers the compliance aspects in more detail. This should be read in conjunction with the official publications *Controlling Noise at Work* (L108) and *Sound Advice* (HSG 260), the Sound Advice website [www.soundadvice.info](http://www.soundadvice.info) and the ABO's *A Sound Ear II* ([www.abo.org.uk](http://www.abo.org.uk)).



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**Part II: Toolkit for managers** is available as a separate document at [http://www.bbc.co.uk/safety/pdf/Safety-Musician\\_noise\\_guide\\_PartII.pdf](http://www.bbc.co.uk/safety/pdf/Safety-Musician_noise_guide_PartII.pdf)

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# PART I: GUIDE FOR MUSICIANS

## WHY DO WE NEED THIS GUIDE?

■ “The BBC is a significant employer of musicians. As an organisation it therefore has a duty of care towards them, not least to help them to look after their hearing. In recent years we have been playing a leading part in developing thinking in this area. I am delighted that our 2008 research initiative looking at noise exposure in our five orchestras and the BBC Singers has evolved into an important cross-sector collaboration from which many more musicians (and the musicians of the future) can benefit.” – Roger Wright, Controller, BBC Radio 3 and Director, BBC Proms

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### GOOD HEARING IS VITAL FOR YOUR CAREER AS A MUSICIAN AND FOR YOUR QUALITY OF LIFE

You only get one chance with your ears. But there are many things you can do to look after the hearing you have:

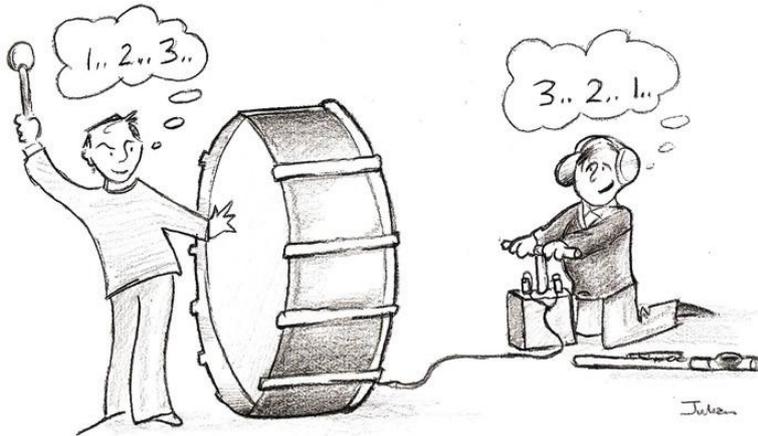
- Get into good habits – protect your hearing inside and outside work.
- Invest in your hearing health and learn more about your ears.
- Don't ignore any problems.
- Talk to your colleagues. Sharing the responsibility makes things easier.



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We all know of musicians whose hearing is not what it was and yet still have a busy and rewarding career. We may also know of musicians who have stopped because they feel it's too scary to play when they're not sure how their sound is going to come out, or because it's physically too painful to their ears. Between these two sit the majority of musicians: those who are worried about their hearing, those who think it's just part of the job, or those who wish they had taken better care of their hearing from the start – or who fear they are missing vital musical or verbal cues in rehearsal or in performance.

Making music is physically demanding and a career as a musician will take its toll on your body. At all stages of your life and your career, and whatever the current state of your hearing, you should get into the habit of looking after the hearing you have.



■ “It’s not that I have anything against my colleagues, it’s just that I don’t like the noise they make.”

You work in a noisy business. The fact that it’s hard to control noise in your particular workplace doesn’t excuse inaction. There are things you can do for yourself, and there are things your managers are obliged to do under the Control of Noise at Work Regulations.

This guide is aimed at all involved in the performance of orchestral music. It covers what we all need to know about hearing, sound, noise and it explores how we can work together to ensure musicians have a long, healthy and musically rewarding career. It does not cover noise exposure of audiences, as they are not covered by the Noise Regulations. The focus is on noise at work, and in work-related contexts, but the contribution of non-work-related noise exposure must not be ignored.

■ “In my twenties I played in a rock band as well as an orchestra. It never occurred to me to worry about my hearing then. But now I make a big thing of telling my son to wear earplugs when he’s playing with his band” – violinist



# SOUND, HEARING AND THE MUSICIAN'S EAR

## HOW OUR EARS WORK

The more we learn about our hearing, the more amazing it becomes. Yet it's still one of the areas we know least about. This section aims to address the many questions musicians have asked about sound, hearing and our ears. It discusses how the ear works and how our brains perceive and process sounds, and what can go wrong with our ears. To find out what to do about the problems described, see the section on 'Looking after your hearing health'.

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### WE HEAR WITH OUR BRAIN, NOT WITH OUR EARS

- Outer ear (*pinna*): captures vibrations and sends them down the ear canal to the ear drum; two for stereo sound.
- Middle ear: eardrum oscillates and three tiny bones transmit vibrations to the inner ear's stapedius muscle and Eustachian tubes located here.
- Inner ear (part of the brain): cochlea translates signals and sends them to the brain; vestibular system for balance.



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## OUTER EAR

The outer ear (or *pinna*) captures the vibrations caused by tiny movements of air (sound waves) and sends them down the external auditory canal to the ear drum or *tympanum*. The folds and channels of the pinna determine the precise journey of the sound waves to the ear drum. The fact that we have two ears – *binaural hearing* – helps us to locate sounds in the space around us, as the sound waves arrive at each ear at slightly different times. This is why it's not generally a good idea to block or modify messages from one ear by wearing only one earplug, as it makes it harder to judge where it is coming from and how loud it is.

## MIDDLE EAR

In the middle ear a mechanical process takes place. The ear drum oscillates like a drum skin and converts vibrations of the air into mechanical vibrations; it transmits these via three tiny bones, the *hammer*, *anvil* and *stirrup* – or *malleus*, *incus* and *stapes* – to the *oval window*, at the entrance to the inner ear. The three bones act to amplify or attenuate the vibrations and optimise both the frequencies and the sound pressure on their way to the inner ear. A very important muscle, the smallest skeletal muscle (ie, muscle that moves bones around) in our bodies, is the *stapedius* muscle. Its function is to disengage the *stapes* to stop us from being deafened by the sound of our own speaking voice, and it is assumed, by analogy, that this reflex is triggered by any sound that we control ourselves.



The *stapedius reflex*, or *aural reflex*, seems to be good news for musicians: if we generate the sound ourselves or if we know it is coming (by marking up an imminent cymbal crash in the score, for example), we trigger the stapedius reflex to protect ourselves. However, bear in mind the reflex does depend on a muscle. Like any muscle, it is less efficient if you are tired or under the influence of alcohol or drugs.

The *Eustachian tubes* connect the middle ear with the pharynx (throat) and equalise the pressure with the external environment. If this mechanism is not working properly it can cause problems for musicians, not

only because it is uncomfortable, but also because it can interfere with your sense of pitch.

#### *Stapedius sound bites:*

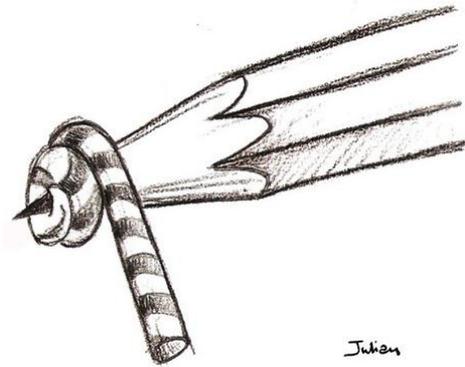
- The BBC Singers found that when they are *not* singing the sound from a singer behind is incredibly loud – regardless of voice part.
- Sopranos say that once they have started singing a high note they can't hear much else.
- The Canadian Audiologist Marshall Chasin has written widely on the theory that rock musicians who sing or hum along as they play are triggering the stapedius reflex and protecting their ears as they do so. Try it yourself in a noisy passage ...
- Nageris *et al* conducted a study of soldiers in the Israeli army and found that, regardless of whether they were right- or left-handed, the left ear showed more noise-induced hearing loss. Nageris suggested this is because the stapedius reflex is less efficient in the left ear.

## INNER EAR

Whereas the middle ear is filled with air, the inner ear is filled with fluid. From now on the processes are chemical (or electrochemical) rather than mechanical. The inner ear is, strictly speaking, part of the brain. It contains the three semicircular canals or *vestibular system*, which governs balance; this mechanism enables us to hear equally well whatever our body posture (handy for opera singers who have dying scenes).

Also located in the inner ear is the *cochlea*. About the size of a pea, it is the snail-shaped structure that houses the *organ of Corti*, a transducer that turns mechanical signals into nerve impulses. On the inner surface is the *basilar membrane*, which covers thousands of tiny flexible hair-like cells or *stereocilia* arranged in rows. The stereocilia bend in response to sounds and release potassium ions that send impulses via the cochlear nerve to the auditory cortex (the 'hearing' part of the brain). Under normal circumstances the stereocilia bounce back and you get an effect like a Mexican wave along the basilar membrane. The higher frequencies are processed at the front end or *base* of the cochlea, while lower frequencies are processed at the *apex* – the far end.

- The cochlea looks like a drinking straw wrapped 2½ times around a pencil. Click to see and hear the [cochlea](#) and [stereocilia](#) in action.



The cochlea analyses frequencies (the pitch) and preserves the temporal structure (the timing) of incoming sounds, and performs a volume-control function (automatic gain control) so that quiet sounds can be picked out among loud sounds. This last function accounts for our ability to pick out specific sounds across an orchestra – and conversations (and gossip) across a noisy room: the cocktail party effect.

This is a very simplified version of a complex and fascinating process, one that is all the more interesting and mysterious when you factor in music, our brain and our emotions. Later in this guide you will find suggestions for further reading if you want to learn more.

## WHAT CAN GO WRONG WITH YOUR HEARING?

Hearing problems may or may not affect your career as a musician; there are many skills and tricks that you develop: muscle memory, habit, breathing together, responding to visual cues and to vibrations rather than sounds, and so on. On the other hand, hearing problems will affect your social life and general wellbeing if, for example, you start to avoid social situations because you can't hear your friends.

Individual differences play a huge part in the story of our hearing and hearing health. Two musicians who sit side by side will not have the same hearing history, and there is no infallible way of predicting what will happen to our hearing. Hearing problems can have many causes besides noise: genetics, head injury, childhood illnesses, certain drugs and other ototoxic (poisonous to the ear) substances – or simply bad luck (the literature talks about 'tough' and 'tender' ears). It's important not to leave it to chance.

Here are some of the main hearing-related problems reported by musicians. It is not an exhaustive list, but focuses on some of the things we can do something about (as well as ageing, which we can't do anything about).

### AGE AND NOISE: A POTENT COCKTAIL

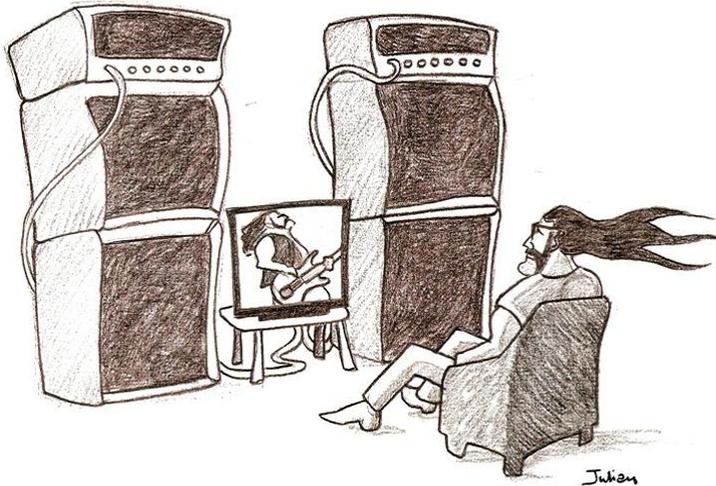
- Ageing: you lose the ability to hear the higher frequencies as you get older. You can't do anything about that.
- Noise: you lose the ability to hear 4-6kHz (including the consonants in speech); noise can trigger tinnitus or hyperacusis. You *can* do something to prevent the effects of noise.
- The combination of age and noise will exacerbate hearing problems.



- Workers in the Lancashire cotton mills were routinely taught to lip-read in the expectation that they would lose their hearing as a result of their noisy jobs. The Les Dawson character Cissie (as in Cissie and Ada) demonstrates this skill in action.
- Present-day deaf musicians such as flautist Ruth Montgomery talk about focusing on teamwork, understanding the language and the shapes: “When people say to me ‘You must feel the vibrations’ I just sigh – that’s not the only thing about music.”

## AGEING

Our hearing deteriorates as a natural part of the ageing process. Age-related hearing loss is known as *presbycusis* (or *presbycusis*). After the age of about 20 our ability to hear the higher frequencies (usually above 16kHz) decreases, and this continues as we get older. The extent of presbycusis depends on family history, gender (men’s hearing deteriorates more markedly than women’s), and luck (again). It happens slowly so we don’t notice it– we just assume everyone else is mumbling, but we are losing our ability to hear the higher frequencies, which includes the consonants in speech.



- “My hearing’s fine. But young people these days don’t know how to speak properly. They all mumble.”

## OUTER AND MIDDLE EAR PROBLEMS

Problems affecting the outer or middle ear can result in *conductive* hearing loss. Processes in these parts of the ear are more or less mechanical, and can often be fixed: one of the theories is that Beethoven’s deafness was caused by *otosclerosis* – a condition which can be treated nowadays, sometimes by replacing the tiny bones of the middle ear.

The middle ear is prone to infections and some musicians are more susceptible than others. *Perforated eardrum* can be caused by an ear infection or trauma. Fortunately the eardrum can heal quickly, and so the condition is usually temporary, though repeated occurrences mean the healing process becomes less effective because of the increase in scar tissue.

## OUTER AND MIDDLE EAR PROBLEMS

- Conductive hearing loss
- Ear infections and perforated eardrum



## INNER EAR PROBLEMS

Problems affecting the inner ear can result in *sensorineural* hearing loss. Noise-induced hearing loss (NIHL) is sensorineural, and there is currently no cure. If the stereocilia are subjected to constant high sound levels they lose their ability to bounce back once they have sent the message to the brain. They can even break in response to extremely high sound levels. Though medical research is working on regenerating damaged stereocilia, it is a long way from finding a way of restoring hearing to its former healthy state.

Exposure to prolonged high levels of sound leads to auditory fatigue. This is known as a *Temporary Threshold Shift* (TTS). After a long day in a noisy environment we need to turn up the volume if we want to hear what we think are the same levels (which is why your car radio is invariably turned up higher on the way home from a noisy show). It is assumed that TTS builds up and leads to a *Permanent Threshold Shift* (PTS) – actual physical damage – if you don't give your ears a sufficient chance to recover after a period of exposure. Hence it is vital to rest your ears often.

Noise-induced hearing loss (NIHL) is a result of exposure to high levels of sound over a long period. It has specific characteristics that are recognisable on an audiogram: a 'dip' in the audiometric curve at 4-6kHz. Often NIHL and other hearing problems co-exist, but you may equally well have tinnitus and a normal audiogram.

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### INNER EAR PROBLEMS

- Auditory fatigue
- Temporary and eventually permanent threshold shift
- Sensorineural hearing loss



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■ The Australian audiologist Robert Patuzzi devised an elaborate experiment (albeit only on himself) whereby he exposed his ears to intermittent and constant sounds, in order to find out, by measuring oto-acoustic emissions, the extent of temporary threshold shifts and recovery times. He found that if there were enough quiet moments between periods of noise the ears would recover.

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*Tinnitus* is commonly reported among musicians. It can manifest itself as a ringing, buzzing, whooshing, or any number of other unwanted noises – noises that don't exist in the real world – in one or both ears. It may be more troubling in a quiet environment, or in a noisy environment, or when combined with stress or fatigue, and it may be temporary or permanent. It can interfere with your sense of pitch, especially if you have perfect pitch. Possible causes are one or a number of: noise exposure, stress, certain medications, or lifestyle factors, grinding teeth (known as *bruxism* – which is often related to stress), and problems with the *temporomandibular* (TMJ – jaw) joint. If you are lucky the tinnitus will go away of its own accord, especially if it has been brought on by stress, illness or medication. But it is equally likely that it will start to appear for longer, even to the point where it can stay with you all day and night. Tinnitus may or may not be accompanied by a measurable hearing loss as shown on an audiogram. People have very different responses to tinnitus:

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there's a world of difference between someone who 'has' tinnitus and is able to ignore it, and someone whose tinnitus stops them from sleeping or concentrating.

Tinnitus is not well understood in the medical profession; brain research is increasing our understanding but a cure is a long way off. In the meantime, there are ways of managing your symptoms. Speak to your GP and your dentist as well as your audiologist, to rule out any other underlying causes. A dentist may also prescribe a mouth guard to make it impossible to grind your teeth. Some violinists chew gum to keep their jaw relaxed, though this may not be appropriate on stage.



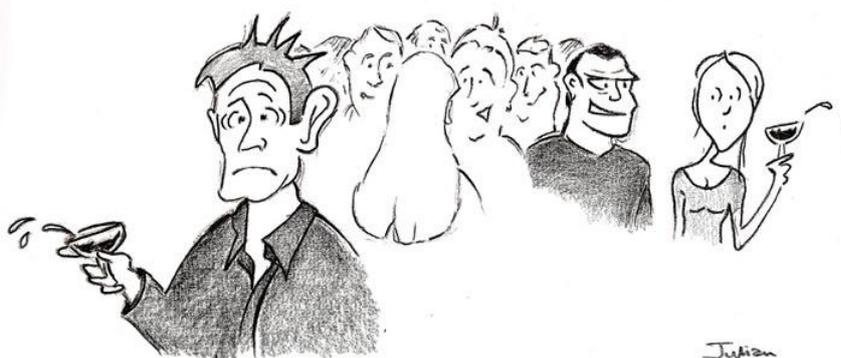
With tinnitus the best approach is education and prevention.

- Some manifestations of tinnitus: ['buzz off'](#) and [screechy violin](#) courtesy of the RNID.
- Smetana's tinnitus can be heard in the last movement of his Quartet no. 1 *From my life* – the first violin's high E cutting through. Martinů wrote his (head-injury-induced) tinnitus into his Sixth Symphony.

**Hyperacusis** is an increased sensitivity to certain sounds. It seems to be a problem with our brain's *automatic gain control* (AGC – volume knob) associated with certain frequencies. It can be brought on by overly loud sounds – or even moderately loud sounds – at a certain pitch, and can create huge discomfort. The anticipation of a loud sound can be as bad as, or worse than, the sound itself. As with tinnitus, relaxation and behavioural therapies can help.

**Recruitment** is another example of the AGC going wrong. It is a loss of ability to cope with an increase in dynamics, and sounds get much louder all of a sudden. It is assumed to be linked to damage to the stereocilia, as the healthy cells are compensating for the lost cells.

**Diplacusis** is the term used to describe the situation where the brain does not process the information from each ear in the same way. Asymmetric hearing problems make it more difficult to locate a sound and to assess its intensity and pitch.



The **cocktail party effect** refers to our ability to pick out specific sounds or frequencies when there are high levels of

background noise. It's a skill we take for granted until we lose it. It seems to be related to the fact that we have binaural hearing, and can hear across the frequency and dynamic ranges. If you lose that ability it means not only failing to hear cues in an orchestra but missing out in social situations too.

**Acoustic trauma** is a loose term referring to symptoms musicians have described after sudden exposure to a blast of exceptionally loud noise. This can cause perforated eardrum, it could destroy the stereocilia instantly, or it could leave you with tinnitus. If accompanied by other factors such as stress and fatigue, it can cause temporary, long-term or permanent damage. It's another case where prevention is vital. If you do experience this, you should get your hearing checked out as soon as you can after the event.

**Other.** The hearing problems described above are linked to exposure to high levels of sound, and are commonly mentioned in the literature on musicians' hearing and reported by musicians themselves. Other conditions that can affect hearing are Ménière's disease and other problems that affect balance, acoustic neuroma (also known as vestibular schwannoma) which is a benign tumour in the brain. These are rare, but as with all medical concerns, you must seek proper help.

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## HEARING PROBLEMS AND WHAT YOU CAN DO ABOUT THEM

- Act sooner rather than later if you have any concerns.
- Get the most out of your occupational health provider, GP and/or audiology service.
- By all means use the internet to learn about hearing, but remember it is not specific to your particular case and it is not a substitute for medical help.



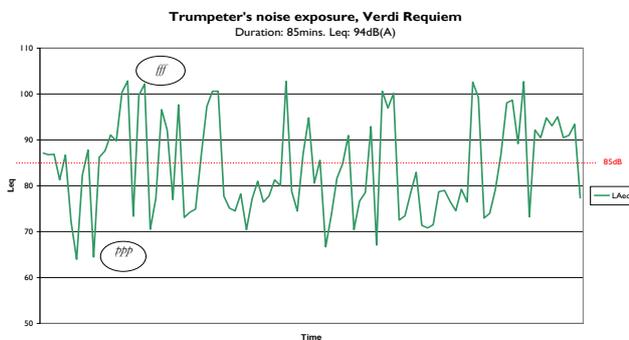
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## WHAT DO WE KNOW ABOUT MUSICIANS' HEARING?

We really don't know if musicians' hearing is better or worse than that of the general population. Musicians do perform well in hearing tests; the years spent training your ears means you're used to detecting the quietest sounds. However, studies done on musicians to date have been on a relatively small-scale; the large-scale historical studies were done on populations of workers in heavy industry. Furthermore, much of what we know about hearing is based on work on human cadavers or live animals. The literature is only just beginning to take into account the leisure-noise exposure of the 'iPod generation'. Though it is too early to see the long-term effects on the hearing of iPod users, it has already had a sufficiently high profile to have been the subject of a major study funded by the European Commission.

Here are some well-documented theories that may tip the balance in favour of musicians. Remember, though, that these are usually small-scale studies using a tiny sample (that may also include rock musicians) and so it is risky to extrapolate. Follow up the references cited in the Literature Review document for more information on this.

*Stapedius reflex.* The stapedius reflex, or acoustic reflex, comes into play at the onset of a loud sound. Hence the importance of marking up the score in advance to protect yourself. It is also thought that humming can trigger the stapedius reflex. However, it is not clear whether the reflex can be trained or whether it loses its efficiency and ultimately expires with continued use. It seems to be more effective at lower frequencies. Don't rely on it.



*Intermittent nature of classical music.* Unlike industrial noise, (classical) music is characterised by its wide dynamic range: typically 40-50dB difference between the loudest and quietest passages. During the quiet passages your ears get a chance to rest, possibly by resetting the stapedius muscle. That's why it is vital to find quiet places to spend your breaks.

*Training effect.* It has been suggested that training can strengthen certain processes (known as olivocochlear systems) in the brain, just as physical exercise improves general health.

*Liking the music.* There is some evidence in the literature that if you like the music, the blood supply to the cochlea is more efficient – possibly because you are producing antioxidants that 'mop up' free radicals that can harm hearing. However, there are no doubt occasions in any musician's career when you find the music hard to like. Moreover, there are many rock stars of a certain generation who are now prepared to speak out about their noise-induced hearing problems; we can only assume they liked the music they were making ...

■ Case study: In 1995 Kähäri *et al* re-tested the hearing of a group of 56 classical musicians at the Gothenburg Symphony Orchestra who had been the subject of a study 16 years earlier. They found that on the whole the musicians' hearing had not deteriorated significantly more than that of the general population in that time. However, the male musicians' hearing had deteriorated more than the female musicians' hearing (which is typical in the general population). [Unfortunately there are not many studies like this.]

It must be emphasised that science still has an incomplete picture. It will take many years to investigate the effects of exposure to high sound levels over a career in music – not to mention the contribution of lifestyle factors. Meanwhile, it is vital to take the risks seriously.

## DON'T PLAY RUSSIAN ROULETTE WITH YOUR EARS

You can reduce the likelihood of damaging your hearing if you:

- reduce the volume of the sounds to which you are exposed
- reduce the duration of the exposure (by giving yourself breaks, and by saving up your allocation for when it really matters)
- mark up the score
- wear hearing protection whenever you can.



## MUSIC AND NOISE - AND THE BIGGER HEALTH PICTURE

A frequently used definition of 'noise' is an 'unwanted signal'. Clearly, most industrial noise can be defined like that, but music is something deliberate and wanted. However, it would be disingenuous to say that *all* music is wanted: the tinny sound that leaks out of your neighbour's mp3 player in the quiet carriage of a train may not be loud but it will certainly annoy you. Equally, if you are playing repertoire you don't like, or if you are not in the best frame of mind, you will respond negatively to what you hear, even if it is not 'loud'.

There is evidence, from studies published by the World Health Organisation (WHO), of increased cardiovascular risk and other long-term health risks associated with exposure to 'nuisance' noise, even where levels are not high. In 2011 the WHO published a report called *The burden of disease from environmental noise*. Studies also link unwanted noise exposure to a decreased ability to concentrate.

For a musician, the sound of your colleagues' instruments may well contribute to increased stress levels, for example between the back desks of the strings and the trumpets or piccolo, or between the horns and percussion, but in general players of louder instruments are receiving higher doses themselves. Perhaps counter-intuitively, the received wisdom is that you receive half of your noise dose from your own instrument, though it is difficult to assess this. Similarly, dissonances (deliberate or not) can seem louder to our ear and set up a 'beating' effect that can be fatiguing and/or stressful. In this case relaxation techniques can be beneficial to hearing as well as decreasing blood pressure and improving general wellbeing.

It is important to bear in mind that 'stress' is notoriously difficult to define and means different things to different people. The adrenaline rush you thrive on in performance can turn under certain circumstances to unhealthy stress that is associated with raised blood pressure, compromised immunity and changes to metabolism. Musicians describe aspects of their careers as stressful, without adding unwanted noise into the equation: being on tour, long hours, job insecurity and any number of other factors may conspire against your health in general and your hearing health in particular.

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### YOU CAN'T SWITCH YOUR EARS OFF

- We often don't realise what our noise exposure is.
- Though we may like the music we make, we can't assume it's not harming us.
- If we don't like it we can become more fatigued and stressed by it.



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We still have an incomplete understanding of the link between exposure to high levels of musical sound and hearing problems. Hearing research is one of the least well-funded areas of medical research, but it is an exciting field. Acousticians are working with architects to improve the comfort of many workplaces, new and refurbished. In spite of these improvements, you have a responsibility towards yourself to look after your ears.

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# WHAT MUSICIANS SHOULD KNOW ABOUT SOUND AND NOISE

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## DESCRIBING AND MEASURING 'SOUND'

- The *sensory* experience that can't be measured but can be described subjectively.
- The *physical* phenomenon that can be measured in terms of pitch, sound energy (intensity) and duration.
- Sound can be measured in terms of pitch, intensity and duration.



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Of course, musicians know a great deal about sound. You can describe the effects of the sound you make, or what you need to do to modify a sound. This is sound as the intangible, sensory experience. Fewer musicians are fluent in the language to describe the physical, measurable phenomenon. What follows are the basics of the science of 'sound' as a physical phenomenon. It doesn't do justice to the complexities of music and hearing, but it does go some way to helping us understand those aspects we can do something about.

Sound can be measured in terms of pitch and sound energy or intensity. The other measurable aspect is duration – exposure over time.

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## PITCH ESSENTIALS

- Frequency (pitch) is measured in *Hertz* (Hz) or cycles per second.
- The human hearing range is 20-2,000Hz (less as we get older).
- Noise-induced hearing loss (4-6kHz) means missing out on upper harmonics in music and consonants in speech.
- High frequencies are easier to block out.
- Certain sounds can tire you (eg. a pure tone or a dissonance).



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## FREQUENCY (PITCH)

Pitch is the 'human' version of frequency. It is measured in *Hertz* (Hz) or cycles per second. The range of human hearing is between 20Hz and 20,000 Hz (20 kiloHertz, or 20kHz). Below 20Hz we feel a vibration but can't hear anything. The upper limit of hearing perception decreases as we get older. Children can hear 20kHz and above, but the ability falls off with age, so that by the age of 50 it is rare to hear 16kHz. The loss of high frequencies with age tends to be more marked in men than women, and the left ear is usually less resilient than the right.

The frequency we all recognise is 440Hz – concert pitch. The octave below that is 220Hz and the octave above is 880Hz. Each octave is a doubling or halving of the frequency. As a

pure tone 1,000Hz or 1kHz is a sharp B<sub>5</sub> or flat C<sub>6</sub> (two octaves above middle C). The C at the top of the piano is about 4kHz.

For humans the most sensitive range is 1-5kHz. But we also need frequencies above that for music (for the upper harmonics). For understanding speech 4kHz is vital because that is where the consonants such as s, t, and k are; vowels are at lower frequencies. *Noise-induced hearing loss* (NIHL) is characterised by a decreased ability to hear sounds between 4-6kHz.

Sound waves reflect off surfaces in a room (which is why it can be unsatisfying to perform in the open air) – and can be absorbed by things such as drapes around the walls and the bodies of the audience or your colleagues, as well as distance. The trained, healthy ear, or rather, a pair of ears and the brain, plus your musicianship and experience, can adjust to these acoustic variations, and create a consistent performance regardless of the space.

Sound waves at different frequencies behave differently. High frequencies are more directional, and it's easier to stop them in their tracks – which means it is possible to create a barrier between the bell of a trumpet and a viola player, or for the trumpeter to adjust the angle of playing (within the bounds of what is appropriate for the repertoire, obviously). It's also why the drum kit should ideally be put inside a 'goldfish bowl' in crossover music.



Meanwhile, a trombone sound cannot be stopped so easily. Low frequencies are less directional, and it is harder to stop them travelling or absorb them, as anyone who has played a gig with loud bass guitar will know. But low frequencies can also provide a 'cushion' so we perceive the sound levels to be lower. A large orchestra with full string strengths playing *fortissimo* Wagner tends to feel less loud than a modern work, where the orchestration may be sparser. This is because the frequency content of the Wagner is richer. It's like with speaking voices: a high-pitched voice cuts through background noise but you won't want to listen to it all day.

## DECIBEL ESSENTIALS

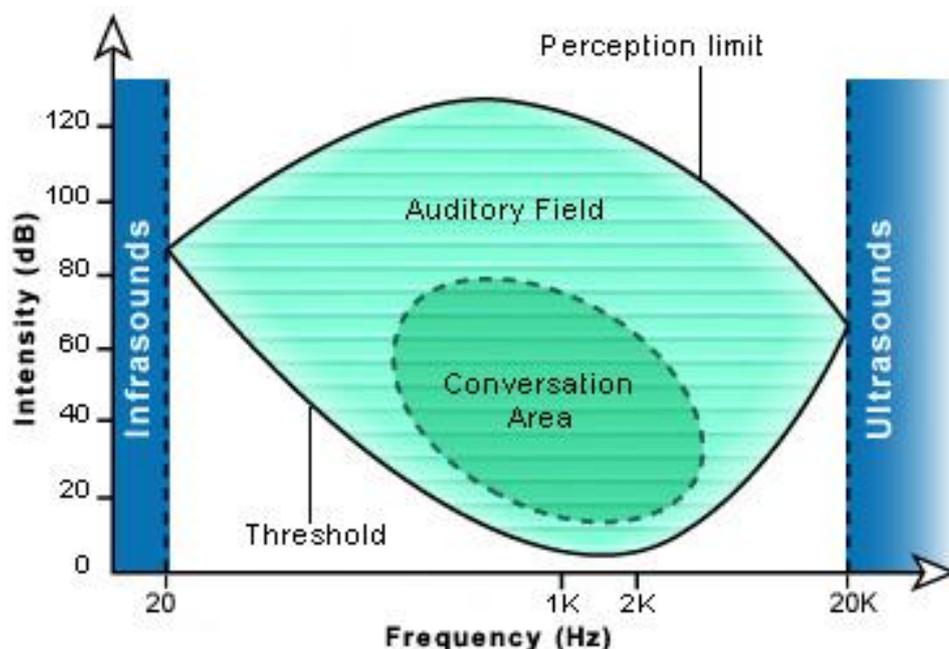
- Sound intensity is measured in *decibels (dB)*.
- A reduction or increase of 3dB is a halving or doubling of sound intensity.
- Key figure to remember: 85dB(A) over an eight-hour period.
- Some examples – typical sound levels taken over a short duration:
  - 20dB(A) – rustle of leaves in a forest
  - 80dB(A) – *solo piano*, cello, double bass
  - 85dB (A) – *solo violin*, oboe playing *mf*
  - 90dB(A) – *solo trumpet*, horn playing *mp*
  - 130dB(C) – cymbal crash.



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## SOUND PRESSURE LEVEL AND THE 3DB RULE

Sound intensity (sound pressure level, sound energy) is measured in *decibels (dB)*. The absolute threshold of hearing is 0dB or, more realistically, around 20dB taking into account background noise and the sound of your own pulse and breathing. The threshold of pain, where noise can do instantaneous and irreversible damage, is 140dB – though it can be much lower. This is the level of a jet engine taking off, or a gunshot, or a balloon bursting in a confined space. In reality, hearing thresholds vary for different frequencies; the bass/treble or the ‘loudness’ button on a car radio is there to help you hear over engine noise. In addition, acousticians talk about the ‘threshold of discomfort’ and the ‘threshold of annoyance’, especially in relation to high frequencies and dissonances. While these won’t necessarily harm you, they can add to fatigue or stress and affect your concentration.



Drawing by S. Blatrix  
from Promenade  
around the cochlea  
[www.cochlea.org](http://www.cochlea.org) by R  
Pujol et al. INSERM and  
University of Montpellier.

The ‘3-decibel’ rule is a useful thing to remember. Decibels are expressed on a logarithmic scale, like the Richter scale. A 3dB increase is a doubling of the sound pressure level (SPL), while a 3dB decrease is a halving of the SPL. A 10dB increase is ten times the sound energy. However, we only perceive a 10dB increase as being twice as loud, not ten times as loud. Or, to put it another way, to make your orchestra seem twice as loud you need ten times the forces. This is because of the ‘automatic gain control’ function in a healthy ear.

*Sound energy* is measurable but *loudness* is subjective, which means you don’t realise how much exposure you are getting. Sound energy decreases with distance. If you double the distance from a single sound source, you reduce the sound pressure by 3dB in the real world (in an anechoic chamber with no reflective surfaces or in the open air it would be 6dB). In an ensemble, you will halve the exposure by doubling the distance between yourself and the sound source, though it won’t feel like that if you are not in control of the sound.

The ‘A’ *weighting*, used when measuring intensity, reflects the fact that we don’t hear all frequencies equally. It gives increased weighting to the frequencies we are most sensitive to (1-5kHz). The ‘C’ *weighting* is used for high-intensity sounds, where the frequency content is

irrelevant. So a continuous level of sound ( $L_{eq}$ ), or a daily dose ( $L_{epd}$ ), is expressed in dB(A) while an instantaneous peak is expressed in dB(C).

Pitch and decibels work together and as we lose the ability to hear certain frequencies we need to boost those frequencies to aid comprehension. We usually just turn the volume up to enable us to hear the consonants. Because this is a slow process we adjust over the course of a long musical career and use other cues to keep us in tune and in time.

- At 20 years old we hear 5kHz and 2kHz at the same intensity
- At 40 years old we hear 5kHz approximately 8dB less than 2kHz
- At 60 years old we hear 5kHz approximately 25dB less than 2kHz.

## DURATION

Apart from when talking about high instantaneous peaks, decibels only make sense when the duration of exposure is taken into account.

The  $L_{eq}$  or Equivalent Continuous Sound Level gives an average Sound Pressure Level over a period (T), such as the duration of a rehearsal or a piece. The  $L_{epd}$  is the Daily Personal Exposure Level, an individual's dose averaged out over an eight-hour working day. Both are usually 'A' weighted; they are properly expressed as  $L_{Aeq}$  in dB,  $L_{eq}$  in dB(A) or  $L_{EP,d}$  in dB(A).

### DURATION ESSENTIALS

- $L_{eq}$  (or  $L_{Aeq}$ ) refers the level over a given period of time (T).
- $L_{epd}$  is exposure calculated over an eight-hour day: aim for 85dB(A)  $L_{epd}$ .



### MAKE FRIENDS WITH THE 3DB RULE

3dB is a doubling or halving of the sound pressure level.

- *Doubling* the number of (identical) sound sources *increases* the level by 3dB:
  - if 1 trumpet @ 1m distance = 93dB
  - 2 trumpets @ 1m distance = 96dB
  - 4 trumpets @ 1m distance = 99dB.
- *Doubling* the distance from a single sound source *reduces* the level by c.3dB:
  - if 1 trumpet @ 1m distance = 93dB
  - 1 trumpet @ 2m distance = 90dB
  - 1 trumpet @ 4m distance = 87dB.
- *Doubling* the duration *increases* your exposure by 3dB, so to *halve* your daily dose you need to *halve* the exposure time:
  - 85dB over 8hrs is the equivalent of:
  - 88dB over 4hrs (time to reach 85dB  $L_{epd}$ )
  - 91dB over 2hrs
  - 94dB over 1hr
  - 97dB over ½hr (eg solo trumpet; if you reach these levels so quickly you must consider what other exposure you have during that day).

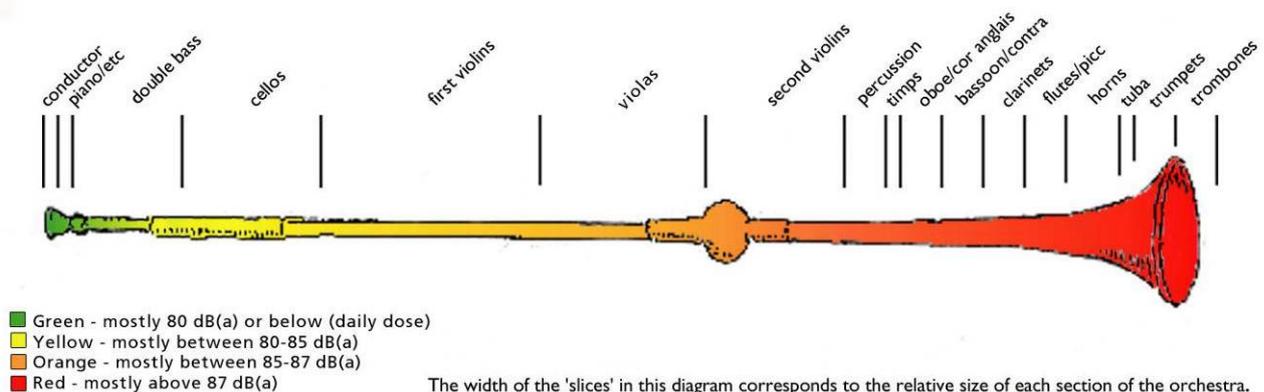


Again, the 3dB rule helps: a 3dB reduction in sound pressure means you can double the exposure time, and (in theory at least) a 10dB reduction means you can increase the exposure time tenfold. So 85dB(A) over an eight-hour day is the same as 88dB(A) over four hours. That does not take into account any other exposure such as practising, warming up, teaching, commuting or listening to the radio. Also, it is only practical to use the 3dB rule for certain levels and over a decent time scale: for three or four minutes' exposure it is not useful. Exposure levels below 75dB are currently considered insignificant to hearing health, though other factors do have a bearing on general health, especially night-time noise and unwanted low-frequency noise.

## MEASURING YOUR DAILY NOISE DOSE

As a musician it helps if you take your own measurements, so you can see your exposure levels for yourself and build up your own picture. Noise meters that are available as an app can give a useful indication of noise levels. You need to spend a few pounds rather than using the free ones (£10 or more will buy you a reasonably accurate version provided it is calibrated properly), but even then they can only be used for information purposes as they do not conform to any British Standard. If you really want to make sense of the data you should use a dose badge and place it as close to your ear as you can – or use a hand-held meter – and note the Leq or average. You may be surprised by what the meter tells you.

### Who has the highest noise dose?



*This chart shows relative sizes of sections of an orchestra and typical daily dose of each. It is based on data collected over a range of projects at the BBC during 2008/09. Singers are not shown but they would be at the right of the diagram.*

### IT ALL ADDS UP

- Consider measuring your noise dose inside and outside the workplace.
- Your ears don't differentiate between 'at work' and other exposure.
- You *do* have some control over your daily exposure.
- You can reduce your daily dose by using earplugs.
- By taking off 3dB you halve your daily dose.



As far as the Noise Regulations are concerned, 85dB over an eight-hour day is the key figure to remember. Musicians don't often work eight-hour days, so you need to calculate the exposure level for the actual working day. Roughly speaking, if you work six hours in a typical two-session day your continuous exposure figure will go down by about 1dB when averaged out over eight hours. It will also go up by about 1dB if you work a three-session day. This is because of the way decibels work.

The Regulations allow the dose to be calculated over a week, but it doesn't help unless your daily dose varies by more than 5dB from one day to the next. On the other hand, if you are having a noisy week you should limit your other noisy activities so that you give your ears a rest. Your 85dB(A) daily dose or Lepd translates to 88dB if your day is only four hours long, and likewise if you are exposed to 91dB over two hours it still amounts to an 85dB Lepd.

It must be stressed that your noise exposure 'at work' in the music business is rarely your only exposure. To calculate your daily dose you could look at your exposure in terms of Leq (average) over a specified duration, and then calculate what that means over a longer period. You can use this simple online [Noise calculator for musicians](#) from any browser, or if you have Excel you can use the HSE's online [Noise Calculator](#). Here are some worked examples of how a musician's typical daily exposure adds up (Leq unless otherwise stated).

#### DAILY AND WEEKLY DOSE: SOME WORKED EXAMPLES

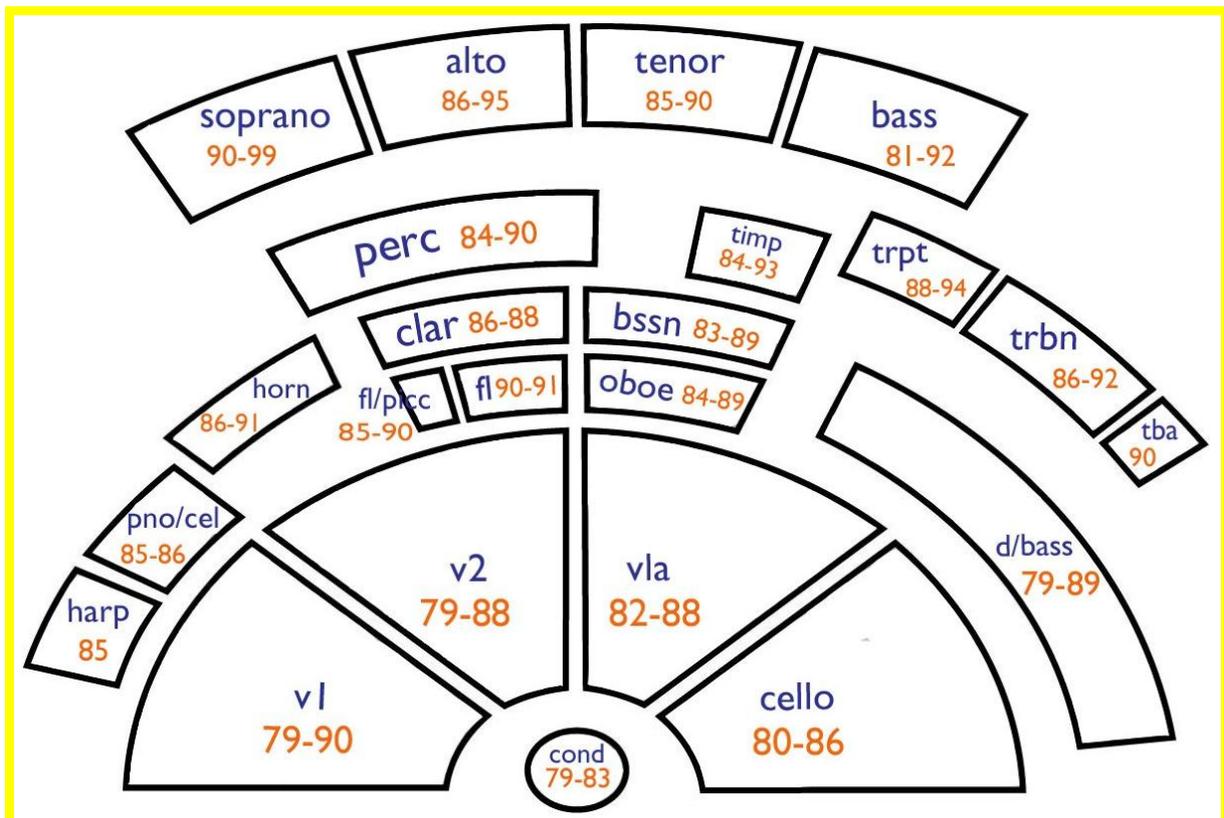
<p><b>AN OBOIST'S DAY</b></p> <p>1hr commute (tube) 83dB(A)            3hr session – <b>Leq</b> 88dB(A)            1hr lunch (canteen) 85dB(A)            1hr commute 83dB(A)            1hr teaching (home) 83dB(A)            1hr practising 85dB(A)  <b>TOTAL 86dB(A)</b>  <b>Lepd</b></p>	<p><b>A (BUSY) BASSIST'S DAY</b></p> <p>¾hr commute (bicycle) 77dB(A)            3hr session (orch) – <b>Leq</b> 84dB(A)            ¾hr commute (bicycle) 77dB(A)            1hr teaching 82dB(A)            1hr commute (car/R4) 81dB(A)            1hr jazz reh + 2hr gig 91dB(A)            1hr commute (car/jazz on radio) 87dB(A)  <b>TOTAL 88dB(A)</b>  <b>Lepd</b></p>	<p><b>A HORN-PLAYER'S DAY (NO EARPLUGS)</b></p> <p>½hr commute (m'bike) 93dB(A)            3hr session – <b>Leq</b> 93dB(A)            1hr lunch (canteen) 85dB(A)            3hr session 94dB(A)            ½hr commute (m'bike) 93dB(A)            1hr DIY w/ drill 90dB(A)  <b>TOTAL 93dB(A)</b>  <b>Lepd</b></p>
<p><b>A TRUMPETER'S DAY OFF</b></p> <p>1hr practising on &amp; off: 98dB(A)            7hrs walking in country, reading paper, etc – <b>Leq</b> 77dB(A)  <b>TOTAL 89dB(A)</b>  <b>Lepd</b></p>	<p><b>A FREELANCE VIOLINIST'S WEEK</b></p> <p>Mon (day off) – <b>Lepd</b> 78dB(A)            Tues (rec session) 85dB(A)            Wed (rec session) 85dB(A)            Thurs (rec session) 85dB(A)            Fri (crossover reh+gig) 90dB(A)            Sat (oratorio gig) 87dB(A)            Sun 3hrs string quartet 86dB(A)  <b>TOTAL 88dB(A)</b>  <b>Lepw</b></p>	<p><b>A HORN-PLAYER'S DAY (WITH 9dB ATTENUATING EARPLUGS)</b></p> <p>½hr commute (m'bike) 84dB (A)            3hr session – <b>Leq</b> 84dB(A)            1hr lunch (canteen) 85dB(A)            3hr session 85dB(A)            ½hr commute (m'bike) 84dB(A)            1hr DIY w/ drill 81dB(A)  <b>TOTAL 85dB(A)</b>  <b>Lepd</b></p>

You may wonder why you need to worry about what seem like only a few decibels. It's because of the 3dB rule. You can double your exposure time if you reduce the exposure by 3dB. So look at your day and protect your hearing (taking off say 9dB by wearing musicians' earplugs) for the periods when you feel you can. It all helps. Bear in mind it's notoriously

difficult to be exact about measuring sound levels in the real world over a period of time; the figures below are intended to give a rough idea. Consider creating your personal 'noise diary' so you can see for yourself how much noise you are exposed to over a given period.

Exposure from instantaneous peaks is measured with a single figure and is 'C' weighted. The main people at risk from peaks are those sitting near the noisy percussion instruments, though an unexpected howl from a foldback monitor may be unpleasant, and can trigger tinnitus, headaches or nausea. There have been reports of adverse reactions to sudden loud noise reported for exposure of 118dB(C) or lower.

## WHAT'S YOUR DOSE? SOME TYPICAL EXPOSURE FIGURES



Ranges given above are based on typical daily doses ( $L_{eqd}$ ) for two-session days in BBC Maida Vale studios or Studio 7, Manchester, of rehearsals or studio concerts of classical repertoire (not recording sessions, not concert-hall concerts and not amplified repertoire). String readings come from tutti players; violin 1 upper figure is high because some readings were taken from in front of percussion or piano.

### Some typical noise measurements for non-work activities ( $L_{eq}$ over a period):

Cycling (½hr in Central London)	77dB(A)
Motorbike (½hr on A40)	93dB(A)
Quiet coach on a train	79dB(A)
Tube in rush hour (1hr on Central Line)	83dB(A)
iPod levels (figure to add when listening on public transport)	Add 4-10dB(A)
Busy canteen (1hr)	85dB(A)



# THE NOISE REGS AND YOU: PUTTING IT INTO PRACTICE

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## THE NOISE REGULATIONS ARE FOR YOU

- Take advantage of them to help you to look after your hearing (and that of your colleagues and pupils), whilst maintaining the highest artistic standards.
- They apply whether you are employed on a contract or as a freelancer.



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## WHY DO WE HAVE NOISE REGULATIONS?

Everyone has the right to expect not to be harmed by their work. We have had health and safety legislation in the UK since 1833. The key piece of legislation now is the 1974 Health & Safety at Work Act, which obliges employers to protect employees from risks in the workplace. It covers three types of obligations: a *moral* obligation to look after employees and colleagues (and ourselves), a *financial* obligation, and a *legal* obligation: employers not complying can be prosecuted in the criminal courts, and there is provision for civil claims, with implications for compensation and insurance.

Noise is long established as a health risk; as long ago as 1963 the British Ministry of Labour and Central Office of Information published a leaflet called *Noise and the Worker*. The 2005 Control of Noise at Work (CNAW) Regulations replace the 1989 Noise at Work Regulations and are based on a European Directive 2003/10/EC. The Regulations have applied to all workplaces without exception since 2008.

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## WHAT DO THE NOISE REGULATIONS SAY?

- Regulation 4 sets out the exposure levels.

Five Regulations require action on the part of the employer, but to translate them in terms that relate to you as a musician...

- Assessing risk: how to identify what might go wrong? (Reg 5)
- Controlling noise: what can be done about it? And what can *you* do? (Reg 6)
- Hearing protection: what are your options? (Reg 7)
- Hearing health surveillance: how can you invest in your hearing? (Reg 9)
- Instruction, information and training: how do you find out more? (Reg 10)



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Applying the Regulations to acoustic music and musicians poses particular challenges. Your 'workplace' can range from a state-of-the-art studio or concert hall to an acoustically challenging teaching room or domestic workspace. You may work one, two or three sessions a day, often in more than one workplace and for more than one employer (or on a voluntary basis). And you may not feel making 'noise' describes what you do. Music you

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make yourself is not unwanted, but because it is 'at work' or arising 'in connection with work' it comes within the scope of the legislation. The Regulations exist because of the link between prolonged exposure to noise and hearing problems. In the general population noise-induced hearing loss is one of the most common industrial diseases, though it can take many years to manifest itself; it is said to have a 'long latency'.

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## THE FIGURES

- Daily dose (Lepd) over an eight-hour working day:
  - 80dB(A) = LEAV (Lower Exposure Action Value)
  - 85dB(A) = UEAV (Upper Exposure Action Value)
  - 87dB(A) = ELV (Exposure Limit Value) (with hearing protection).
  
- Peaks:
  - 135dB(C) = LEAV
  - 137dB (C) = UEAV
  - 140dB (C) = ELV
  
- LEAV: *at the Lower Exposure Action Value the employer must provide information and training and make hearing protection available.*
- UEAV: *at the Upper Exposure Action Value the employer is required to do as above plus implement reasonably practicable measures to reduce noise exposure, to enforce the wearing of hearing protection and provide hearing health surveillance.*
- ELV. *The Exposure Limit Value is what you need to aim below when taking into account the effects of hearing protection.*



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There is also a requirement that management and employees work together to find solutions. In the case of music, where venues and employers are usually separate entities, venue managers should collaborate with ensemble managers.

Health and safety law does not differentiate between freelance and employed workers. The only exception to this is that employers are obliged to provide hearing health surveillance to musicians on contract but not to freelancers. However, it is recommended that ensembles employing the same freelancers on a regular basis should provide hearing surveillance as well.

The next two sections cover those Regulations requiring action by managers, looking at them mainly from the perspective of the musician, in terms of what you can expect to see, and how you can play your part. The first section discusses how you can look after your hearing health and your options for hearing protection, and the second section explores your contribution to assessing risks and to controlling noise exposure (an activity that should extend beyond the workplace). The corresponding sections in Part II, the 'Toolkit for managers', cover the same topics from the managers' perspective.

## LOOKING AFTER YOUR HEARING HEALTH

### HEALTH SURVEILLANCE ESSENTIALS

- Invest in your hearing health and learn how best to protect yourself.
- Take advantage of regular hearing tests if your employer offers them.
- Don't put off a visit to your GP or an audiologist.
- Ask as many questions as you need to at the hearing test.
- If you have a problem, help is available and you *can* carry on making music.



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Hearing tests are an important way of investing in your health and longevity as a musician. As with many health problems, you may think ignorance is bliss, but not getting your hearing tested won't change your hearing – and it will go a long way to identifying any problems at an early stage. Indeed you may find out that any worries you had were unfounded.

Whatever your employment status, you should get your hearing tested regularly, and don't ignore any problems you may be aware of. If you do find you have a problem, you need to work extra hard to protect the hearing you have, inside and outside the workplace.

Health surveillance is intended to help identify early signs of a problem so that you and your managers can intervene appropriately. The hearing test, or audiometry, used in hearing health surveillance provides evidence of the state of your hearing based on your responses to pure tones presented at octaves. We know that age-related hearing loss is identified by a decrease in the ability to hear at the higher frequencies, and that noise-induced hearing loss is characterised by a 'dip' or threshold shift at 4-6kHz and (usually) a recovery at 8kHz.

Your employer bears the cost of audiometry. This may be delivered in-house, by a university department or teaching hospital, a commercial audiologist or some arrangement with the NHS. In some cases the audiologist also takes the impressions of your ear canal for custom-moulded earplugs. If employed, you should have a hearing test on joining the organisation, then after one year and subsequently at intervals as agreed by the audiologist (2-3 years is typical, but this may be more frequent). Some of the 'freelance' orchestras are moving towards this model too and if offered, it is wise to take advantage of this.

If you are self-employed, you will have to pay for the audiometry, but discounts are available through the MU, ISM, Equity and BECTU, and BAPAM via the Musicians' Hearing Passport.

### WHAT HAPPENS IN A HEARING TEST?

Your hearing test will take up to 30 minutes in all. You should ensure that you have not been in a noisy environment for at least 12 hours (some texts recommend as long as 24 hours but 16-18 is adequate if you have no choice) because you are likely to have a *temporary threshold shift* that will skew the results. If you have been in a noisy concert the night before, or if you have just stepped out of a rehearsal, make sure the audiologist is aware and notes it on your record.

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Before the test you will be asked to fill in a questionnaire with relevant aspects of your medical history and that of your family (hearing problems often run in families). You will be asked about tinnitus, hyperacusis, any head injuries, dizziness, relevant medications and childhood illnesses as well as significant past exposure and relevant lifestyle factors such as smoking. All of this will be put on your record; this record is confidential but for in-house tests you consent to the broad hearing category being communicated to your manager.

You will be given an *otoscopic* examination to check the health of the ear canals and eardrums. The presence of (excessive) wax will affect the results of your test so you may need to get your ears syringed and make another appointment. If you do have tinnitus you should describe it to the audiologist who may then adjust the way the test is carried out.

The test itself will take place in a soundproof booth or studio, or failing that a quiet room (the test should not be carried out if there is background noise over 35dB). It lasts about seven to 10 minutes, and you will need to concentrate quite hard throughout.

Pure tones in octave bands (with a few extra frequencies in between) are presented randomly through headphones and you will be given a clicker to signal that you have heard the tone. The most common test is Pure Tone Audiometry (PTA) but occasionally the Békésy test is used, which gives a pulsing sound. You will feel a bit confused and wonder if you can hear things or not. This is normal, and the test is designed to take this into account.

Occasionally *oto-acoustic emission* (OAE) testing is used to measure the vibrations in the ear canal, or a bone-conduction test may be used to detect a problem in the middle ear. Both are currently rare in occupational health surveillance.

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■ “It took me ages to get round to making an appointment – but it’s better to know what’s going on with your ears rather than sit around fearing the worst” – *freelance violinist*.

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## WHAT DO THE RESULTS MEAN?

The audiometry machine will generate a paper report with the results on – or occasionally the audiologist will plot the results manually. It will show two curves, one for each ear, with the hearing thresholds at all the frequencies measured. Ask as many questions as you need to, so you understand the shape of the curves and what that means for you. Ask for a copy of this report and keep it for future reference.

If the test has been provided by your employer, a summary report will go back to your manager categorising your hearing into very broad bands that are adjusted for age and gender. This category is derived by adding up your responses in each ear at 1, 2, 3, 4 and 6 kHz. You will be tested at frequencies above and below this and sometimes at intermediate frequencies too – but these are not used to calculate the category in health surveillance.

- *Category One: normal hearing*. Your hearing is within the normal range for your age and gender.
- *Category Two: warning*. Mild hearing impairment. In the general population this is the level experienced by one person in five.

- **Category Three: referral.** This may suggest significant hearing loss. In the general population this is the level experienced by one person in 20.
- **Category Four: rapid hearing loss.** If there is a reduction of >30dB in three years (or less).

If the totals for each ear are significantly different (40dB or more) this shows a unilateral hearing loss and you will see (u) plus L or R referring to the ear with lower thresholds.

If your hearing shows Category 3 or 4, or if you report any unexplained ear pain, dizziness or severe or persistent tinnitus, the audiologist will refer you to an ENT specialist either direct or via your GP. In practice many audiologists choose to refer musicians at Category 2 as well. If you find your GP or audiologist is unfamiliar with the specific needs of musicians, you should take time to explain things to them; alternatively you can seek out the musician-friendly practitioners via BAPAM. You may be able to access grants to help with funding any treatments you need from the Musicians' Benevolent Fund.

## LOOKING AFTER YOUR HEARING GENERALLY

Your ears are at risk from other things as well as noise. Flying can cause problems with your middle ear, especially if you fly with a cold, but discomfort is usually temporary. The standard advice is to drink a lot of water (not alcohol as it dehydrates), be awake when landing (the Eustachian tubes don't work properly when we are asleep), and to yawn and/or swallow to open the Eustachian tubes. Using a Valsalva-type manoeuvre is a dramatic way of solving this problem but it can do more harm than good.

Ear infections can be more troublesome for musicians as they can affect your sense of pitch. If these are painful and the pain lasts, you must get medical help. Ear wax is our ears' own cleaning system, but if it builds up too much or too quickly it can affect your hearing. This is one of those things some people suffer from while others are spared. DIY solutions to removing it are not recommended. Get your ears syringed by a health practitioner.



If you are prescribed medication for other conditions, ask your GP about any potential side effects on hearing.

Don't dismiss the idea of a hearing aid on aesthetic or musical grounds. Hearing aids are getting smaller and more sophisticated all the time. The important thing is how it is programmed, and you need to be sure the audiologist understands your needs as a musician. Getting the settings right for music is a process of trial and error and you may have to wait longer on the NHS than if you go privately. Do get specialist help, and do persevere.

■ “I've been a professional opera singer for 30 years despite having a severe/profound, progressive hearing loss. There is some great technology out there. Digital hearing aid quality today is just fantastic, with specific channels for music. Take heart. Being deaf most certainly doesn't mean the end of your career!” – *Janine Roebuck*

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## HEARING PROTECTION

Protecting your hearing is not just about earplugs in the workplace. It's about making the right choices outside work as well. If you are not ready to wear hearing protection at all times in the workplace (and not many musicians are), think of yourself as having a daily allocation of noise and make your own decisions about how to spend it.

Active noise-cancelling headphones are a wise investment. They cancel out unwanted external noise on planes and tour buses, which means you don't increase your iPod volume too much; they prevent headaches and of course help prevent NIHL. On the other hand, they do cut you off from the world around you. Remember that when you are crossing the road...

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### PROTECTING YOUR HEARING

- Your ears are an important tool of your trade – invest in them:
  - at work (rest, earplugs),
  - on tour (noise-cancelling headphones, especially when flying),
  - at leisure (protect your ears during noisy hobbies and when swimming).



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### PROTECTING YOUR HEARING WITH EARPLUGS

Earplugs (hearing protectors) are classed as personal protective equipment (PPE). They should be used as a last resort when other means of reducing noise exposure have been explored and exhausted. Unfortunately, in the music workplace other interventions to control noise may not result in a sufficient reduction, so earplugs will be the only available option. Fortunately there are a number of different types available to suit personal preferences or different projects. While some musicians find wearing hearing protection very straightforward, others need time to get used to them and there are some who feel they will never be able to do their job properly wearing ear plugs.

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### EARPLUG ESSENTIALS

- Use just enough protection (don't reduce your exposure more than you need to).
- Find something that suits you (your ears, your instrument).
- Always carry your earplugs around with you.
- See it as a long-term project. Don't expect to get used to them immediately; your brain needs time to adjust.
- Don't expect to cope if you stick them in just before you go on stage.
- Use them for private practice and rehearsals.
- Use them to protect your ears in other situations (plane, tube, amplified concerts).



## THINGS TO BEAR IN MIND WHEN CHOOSING HEARING PROTECTION

- *Dynamic range of music.* Industrial noise and amplified music tends to have a consistent sound level, whereas classical / acoustic music has a much wider dynamic range, with the typical difference between the quietest and loudest parts c.40-50dB. You need to hear the quiet parts, and you need to get used to how loud it sounds to the outside world when you are wearing earplugs (rely on the conductor to balance the ensemble).
- *Frequency range of music.* You need to hear across the whole frequency range (20Hz up to 20kHz), and if you shut out high frequencies you miss out on the upper harmonics.
- *Occlusion effect.* Our ears emit vibrations that escape via the ear canal. If the ear canal is blocked, as with an earplug, the vibrations don't have a chance to escape and create a 'boomy' effect that is particularly disconcerting for brass and wind players and singers.
- *Hands-free and comfort.* It's tricky to keep inserting and removing earplugs when you need both hands for holding your instrument. If you can't manage to wear them at all times, you need to find a way of keeping them handy without dropping them. If they fit properly you should be able to wear them for long periods – even under studio lights.
- *Attenuation (noise reduction).* It is not advisable to reduce exposure below 70dB; below that figure the risk is insignificant, and you need to hear sounds below 75dB in order to hear your colleagues (and yourself). This should be taken into account when choosing hearing protection. Look at the figures on the pack. Hearing protection sold in the UK must carry this information. It will say, for example: SNR 22, SNR 28 (Single Number Rating – one-size-fits-all). 'Real-world' adjustment is c.4dB. Sometimes you will see (for example) SNR=28, H=30, M=24, L=22. This refers to the attenuation at different frequency ranges – high, medium and low (this can be useful if you want to block out a specific frequency range). Look at your exposure levels: you need to aim for a daily dose of 80dB, so an earplug that takes off 20dB or more when your dose is 90dB is too much. For string players 9dB is plenty; musicians who play noisier instruments may need more. Either way it is a good idea to have a choice, depending on the repertoire and the venue.
- *CE mark.* This is required on hearing protection sold in the UK; it may be on the earplug itself but you are more likely to find it on the pack or instruction / specification sheet.

## OTHER THINGS TO TAKE INTO ACCOUNT

- *Peer-group pressure.* Do what's right for you and don't take any notice of colleagues who tell you it's impossible.
- *'I can't hear the conductor'.* An enlightened conductor will be aware that the musicians are wearing earplugs and will speak louder, addressing all players and not just the front row of the strings. If you can't hear the conductor, say so – you're probably not alone!
- *'I don't like the sound I make with earplugs in'.* The easy response to this is to say your job is to make a sound that the paying public will like. However, we do need to get pleasure out of the sound we make. Once again it's a balancing act. And indeed, many players find they can hear themselves better with earplugs in.

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## WHAT TYPE IS BEST FOR ME?

Hearing protection is a fast-changing field and you should keep abreast of developments. Broadly speaking there are three main types of earplug on the market and in general the more expensive ones provide better protection whilst not cutting out the speech frequencies. There follows a summary of the features of each type:

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### TYPES OF HEARING PROTECTION

- Foam disposable (cheap, but can over-protect)
- Pre-moulded re-usable (more subtle protection)
- Custom-moulded (vented version also available).



#### FOAM DISPOSABLE



- Attenuation can be in the high 20s+, possibly too much as they cut off valuable musical and speech information.
- Attenuation is more efficient in the higher frequencies.
- They have a habit of easing themselves out of your ear.
- They need to be inserted properly: rolled up so they can go as far as possible into the ear canal.
- They are porous, and if you keep putting your fingers in your ears to readjust them you risk getting an infection.
- If you are on TV the camera people don't like the loud colours they come in (but don't let them veto them).
- Fine for emergencies but not ideal. Treat yourself to something more appropriate.
- There are some more sophisticated versions on the market, made of mouldable soft silicone or wax, or foam with a rod in the middle.
- Cost: max 20p a pair, some venues and orchestras provide them free of charge.

#### PRE-MOULDED RE-USEABLE



- Attenuation is usually 15-20dB.
- The attenuation is more 'linear' or flat than the foam ones, and they don't muffle speech so much.
- They are relatively easy to insert. You can get them with a cord attached so you can remove them.
- They need to be kept clean: the flanges can harbour dirt and they are easy to drop if they don't have a cord.
- They should be replaced at intervals as they lose their effectiveness with time.
- Cost: between £10 and £15.
- Also known in the trade as 'Christmas tree' or 'mushroom'.

## CUSTOM-MOULDED



- Attenuation can be 9dB, 15dB or 25dB. The attenuation is much more even so you get the full frequency range of the sound you are hearing – but quieter.
- They are not cheap because they are custom moulded to fit your own ear.
- You may find they stop working so well in time as your ear canal changes shape. You may need to have the impressions re-done; four years is the recommended shelf life.
- You can get a range of filters so you can change the attenuation according to the project you are working on.
- The *occlusion* effect is problematic for some (especially brass and wind players and singers). There is a ‘vented’ version available called the PRO series; it allows the vibrations to escape, and so lessens the effect of occlusion. Attenuation for these is 15, 17 and 20dB. A 10dB attenuating earplug is in development.
- Cost: £140-165 or more; often part of a package including audiometry. Discounts via MU, ISM, Equity, BECTU and BAPAM (Musicians’ Hearing Passport).

## OTHER



- Cotton wool and tissues are not hearing protection. They make no difference whatsoever.
- Don’t fall into the trap of believing earwax will protect you ...
- Foam ear plugs or even industrial ear defenders should be used when you are doing noisy DIY. Musicians’ custom earplugs do not provide enough attenuation.

## SOME SUGGESTIONS FOR DIFFERENT MUSICIANS

Here is a summary of musicians’ experiences of different types of hearing protection and some suggestions as to what might work for you. It is vital to find a solution that works for your own circumstances, so you should experiment. If you need glasses to correct your eyesight you will know that it can take a while to find something that enables you to see everything you need to see. The same applies to hearing protection.

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## UPPER STRINGS

- You need to hear your own high-frequency sounds.
- Left ear is exposed more (and left ear does seem to be more susceptible to hearing problems anyway).
- You need to be protected from piccolo (especially) and/or brass behind.
- If you sit downstage you may need to be protected from big-voiced solo singers.
- Earplugs that remove only high frequencies are not suitable.
- Flat-response ER9s are usually adequate.
- Avoid the temptation to use hearing protection in one ear only.

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■ “I find the moulded earplugs make it easier to hear myself.” – *viola player*

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■ “I wear the custom-moulded earplugs as much as possible, especially in crossover stuff. If ever I forget them I use the foam ones and the top notes of the violin just disappear. Very disconcerting.” – *violinist*

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## LOWER STRINGS

- You need to hear your own instrument which is a long way from your ear.
- You need to hear low frequencies from your own instrument (and your own instrument is quieter than your neighbours’).
- If you sit close to the trumpets you need to be protected from their sound.
- You may find you only need 9dB attenuation.

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■ “It’s quite calming to wear earplugs when you’re doing an amplified gig. But I do have to watch out I don’t relax so much that my performance is too laid back.” – *double bassist*

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## WOODWIND

- For a piccolo player it is especially important to protect your ears.
- Piccolo players and flautists don’t seem to suffer the effects of occlusion so can cope with flat-response custom-made earplugs.
- Clarinetists, oboists and bassoonists can find the occlusion effect a problem and it is difficult to monitor your own sound levels. The buzzing of the reed on clarinetists’ teeth is particularly difficult. Pre-moulded, reusable earplugs seem to be more comfortable, and the vented custom-moulded earplugs may be appropriate.

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■ “I practise with my musicians’ earplugs all the time so I can get used to the sensations and the sound I make with earplugs in.” – *piccolo player*

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■ “I wore the Christmas tree earplugs for years when I was playing in an orchestra. I was a bit of a pioneer at the time, but it was just a sense of self-preservation. I wanted to look after my hearing for the long haul.” – *bassoonist*

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## BRASS

- The occlusion effect and the pressure that builds up in your head can make custom-moulded plugs tricky.
- You may think you will never get used to them – but then, people said that about seat belts in cars ...
- There may be situations when wearing them is out of the question. If you are playing an exposed passage with very little rehearsal you won't want anything to put you off.
- If you have longer to prepare, you can experiment. Record yourself with and without earplugs; hear for yourself the difference in the sound you make (there may not be any, though it may feel different), match the sensation rather than the sound in your head.
- Vented earplugs may work if you can't cope with the non-vented custom-made plugs.

■ “When the chunks of railway line come out behind us, the earplugs go in, without fail.” – *trombonist*

## TIMPANI AND PERCUSSION

- You may be sitting for long periods without playing.
- If you over-protect your ears you may not get the levels right when you do need to play.
- Flat-response earplugs should work for you.

■ “I'm sitting at the end of a row of eight horns in the *Rite of Spring*. Definitely a case for earplugs.” – *percussionist*

## PIANO, HARP, CELESTA

- You can be *tacet* for long periods next to noisy instruments.
- You must protect your ears while *tacet* at the very least.

■ “In some venues you can be right up against a wall, counting bars rest. Without earplugs it makes it a long evening.” – *orchestral pianist*

## SINGERS

- You may be standing *tacet* behind a row of horns and/or percussion for long periods.
- The sound in your head will feel strange; get used to the earplugs when you don't need to deliver – as for brass players.
- Custom-moulded or vented earplugs.

■ “I've developed a discreet way of putting them in when the horns and percussion are going all out.” – *singer*

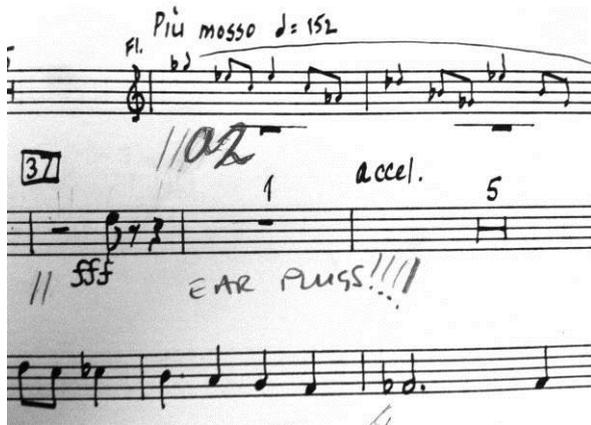
## GENERAL POINTS

It is not recommended that you wear hearing protection in only one ear. We have two ears to enable us to locate sounds in space – and so we need to get information in both ears.

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Don't be surprised if you find it hard to cope. It's well documented that it takes a while to adjust. But persevere. It may not be as hard as you thought. And once you have got used to it, spread the word to colleagues and students.

Finally, and crucially, remember the Noise Regulations require the manager to enforce the wearing of earplugs (it's probably written in your contract in some form too). You need to discuss this with your manager if there is a real problem.



Score extract on this page and those on page 38 are from *Lady Macbeth of Mtsensk*.  
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## ASSESSING AND CONTROLLING NOISE RISKS

### RISK ASSESSMENT: DOING YOUR BIT

- A risk assessment is more than a form; it's the practical steps that are being taken to protect your hearing.
- Everyone has a role to play in health and safety.
- Be an extra pair of eyes and ears.
- Remember, you have a unique perspective on the noise risks in a project.
- Speak up if you have concerns.



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### WHAT DOES A MUSICIAN NEED TO SEE IN A RISK-ASSESSMENT DOCUMENT?

Assessing risk is the managers' responsibility; it is a process that might relate to a series or a one-off project. Managers of venues and ensembles are expected to produce a written record that this process has taken place and you are entitled to see the resulting document unless there is anything confidential in there (relating to an individual's health, for example). In it you can expect to see these questions answered:

- What significant risks might there be in this project? And who might be affected?
- What specific precautions are being taken to eliminate or reduce these risks?

You can expect to be informed (though not necessarily in writing) what will happen if things change on the ground, and also how we can capitalise on what we have learned, to make sure things are better next time around. A risk assessment must be specific in describing risks, but can be generic in relation to the usual activities of the ensemble. However, anything out of the ordinary should be reflected in a document that refers to venue(s) used for the rehearsal and performance, to the repertoire being played and to individual needs.

### HOW CAN MUSICIANS CONTRIBUTE TO THE RISK-ASSESSMENT PROCESS?

Every musician will have a unique perspective on the noise risks they are exposed to. You know better than anyone where the noise 'hot-spots' are, and you should communicate this to the management, so that they can put into place suitable controls, often working with the venue management. This is equally true of a newly built or refurbished venue and of a venue you have been using for years. You may be the first one to point out a problem relating to the layout for a particular piece. You can also help managers to persuade the venue management to invest in acoustic improvements. In short, you can provide an extra pair of eyes and ears – and conscience – to flag up potential problems and suggest solutions.

Anyone who has concerns can raise them. If you are freelance you should find out what the communication routes are for the ensemble you are working with. You may prefer to do this via the orchestra's Health and Safety Rep, rather than the manager or section leader, but don't let the fact that you're only there for a short time stop you from speaking up.

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## TIMING IS EVERYTHING

You can contribute to this process at various stages:

- In the *long* term you can help shape your ensemble's noise 'policy' or any protocols as they are being developed. You can take part in discussions about scheduling, to ensure there are suitable gaps between sessions. You may even be able to influence artistic planning, as you know what a venue is like from your own perspective.
- In the *medium* term you can have some input into the stage or pit layout: for example, on a layout plan instruments may look close together but if the noisy instruments are only playing a few bars in the whole piece it won't be so bad.
- In the *short-term*, if the conductor makes changes in the rehearsal (with the layout, for example), you can say how it affects you.

Don't hold back. You do have a right to be listened to, but you should also bear in mind that there will be many perspectives, and the management may need time to implement what you are asking for. The important thing is to communicate your concerns at the appropriate point. If you wait until the end of the rehearsal before the concert it may be too late for anyone to be able to do anything about it.

## CONTROLLING AND ELIMINATING NOISE: YOUR CONTRIBUTION

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### CONTROLLING NOISE: WHAT CAN YOU DO?

- There is rarely one single solution.
- Two things to aim for: actual reduction in dBs *and* giving your ears a rest.
- Technical solutions: screens, layout.
- 'Soft' solutions: marking up the score, breaks, careful practice and warming up, communication.
- Earplugs as a last resort.



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Regulation 6 of the Control of Noise at Work Regulations requires managers to eliminate noise risks or reduce the risk to as low a level as is reasonably practicable. The 1999 Management Regulations state that *organisational* solutions to workplace safety (and health) risks should have priority over *individual* solutions. Attempts should be made to 'engineer the problem out' before the use of personal protective equipment is required.

In our workplaces the noise risks are experienced by individual musicians, and this varies according to the venue or repertoire. Hence the responsibility must be shared.

The section below gives an idea of the difference various protective measures can make to noise exposure, with some discussion of the issues around their use. It is impossible to differentiate between technical and 'soft' solutions, and everything requires a conversation with colleagues. Bear in mind that, while some measures will result in an actual reduction in

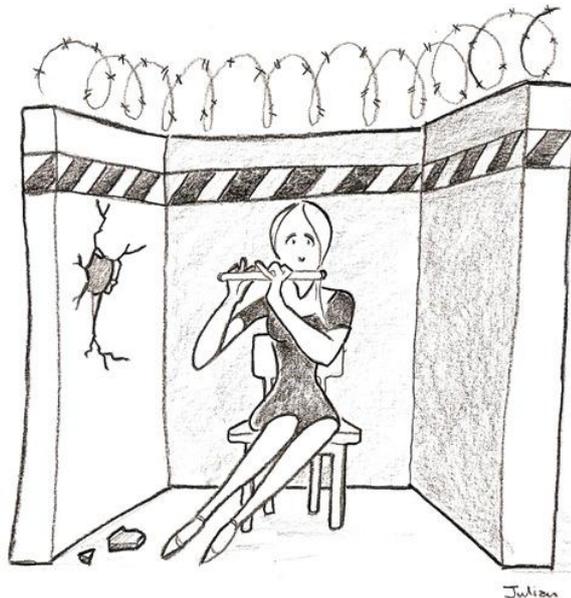
the decibels you are exposed to, more often the benefit is to give your ears a rest and reduce the build-up of temporary threshold shift (TTS) which reduces stress and fatigue.

## ACOUSTIC SCREENS

■ Typical reduction: 3-6dB(A) if used properly. Take care not to convert your own reduction into an increase for the player behind you.



- The effectiveness of screens depends on distance from the musician's ear, height, which instrument is behind and how much they're playing, spacing of musicians and screens, angle and shape of screen.
- Manufacturers of screens rarely make claims for the attenuation. This is because there are so many variables. When used inefficiently they can halve a viola player's exposure, whilst doubling the dose of the trumpeter behind and creating a 'beating' effect. You need to check with colleagues that the screen is not doing more harm than good.
- There are limits to the usefulness of screens: musicians who play in pits sometimes say they prefer to have extra elbow room and leg room rather than to use a screen that takes up valuable space. Otherwise, look out for a 'zero-footprint' screen.
- Acoustic screens are more useful for protecting you from high-frequency instruments, not so good for low frequencies.



### Acoustic screens: dos and don'ts

- Mirror, signal, manoeuvre – discuss with the person behind to let them know you need it, check they are not being blasted by their own sound (for example the tacet second trumpet when the principal has a solo).
- Be fair: if the piccolo only has a few notes to play in a piece, both the piccolo player and the second violin will benefit from the extra leg room if you don't use a screen.
- Put the screen as close to your head as possible (20cm).
- It is meant to protect *you*, not wreck the hearing of the person behind you (put it close to you not to them).
- Make sure your ears are in the middle of the screen; adjust the height.
- Try tilting at c.45° to deflect trumpet sound upwards if you can.
- Make sure it is on a stable base.
- Look at the 'footprint': how much space is it taking up on the floor?
- You also have a right to a screen if you are on TV – regardless of what the director says.
- Don't use it as a coathanger (good for absorption but makes the screen very unstable).

### Case study: the Bournemouth Symphony Orchestra Brass Experiment

■ The brass section of the BSO wanted to find an acoustic screen that would protect the string players in front whilst not adding to their own noise dose. One player designed various prototype screens (soft cover, hard cover, flat, curved...), a colleague measured noise exposure while the trumpets played the fanfare from Dukas' *La Péri* ten times. The preferred screen was flat and covered with acoustic foam on the back: it took off 5dB for the players in front and made no measurable difference to the brass players behind. BSO took the findings to Bournemouth University who commissioned a design project to make the screen available more widely. The process has also helped with dialogue between brass and viola sections, including an understanding that if there are no risers at a venue, the solid screens can't be used because they interfere with sight lines.

■ Sound bite: a bassoonist was offered a screen in a cramped pit. He asked the percussionist behind how much that particular instrument (a xylophone) was going to be used, marked up his score to prompt him to put earplugs in, and opted for extra leg room.

## SHIFTING YOUR POSITION SLIGHTLY

In theory, 3dB reduction for every doubling of distance from the sound source.



- Even moving 20cm to one side can make a difference.
- This is a balancing act between the needs of the ensemble and the need to reduce noise exposure. When making a recording, players are often spread out more to minimise 'bleed' for the microphones.

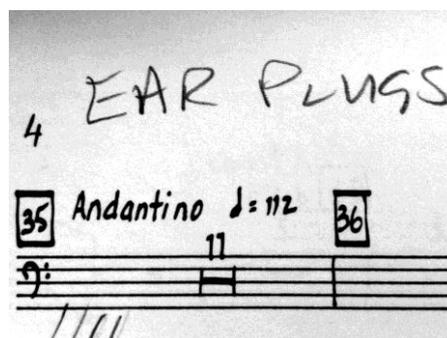
## MARKING UP THE SCORE

It won't affect Leqd but you can avoid peaks of 120dB and over (you can also use it as a cue to put your earplugs in).



- If you're playing a new piece for the first time, find out when the loud passages are and put a note in your part. When the parts are re-used by another ensemble, your markings will prove useful too.

(Lady Macbeth extracts: see credits p 38)



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## HOW YOU SPEND YOUR BREAKS

You could reduce your daily exposure by 1-2dB if you made a choice to spend your breaks quietly.



- This is an area where you have a choice: you should prioritise giving your ears a rest in the breaks. The worst thing you can do is spend your 15 minutes practising for another gig: it's not fair on your colleagues either.
- Ask yourselves: do you really need to have the telly on in the green room?

■ Noise exposure figures for two musicians during a long pre-concert break were compared: the musician reading a book had a dose of 76dB(A) while the one who went outside to make a long phone call in the street had a dose of 86dB(A) – that's ten times as much over that period – and over the course of the day it could make 1-2dB difference.

■ When developing their noise 'Code of Conduct' the players of the BBC Scottish Symphony Orchestra agreed to hold off practising the tricky passages for a minute or two after the end of a rehearsal or the beginning of the break. It gives colleagues a chance to get out of the way with a bit of peace and quiet.

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## HOW YOU WARM UP/DOWN/PRACTISE

Don't overdo it. Spare your ears (and those of your colleagues) and find other ways of practising.



- One hour of private practice on a trumpet has been measured at 98dB(A) Leq; 40mins of oboe practice came out at 87dB(A) Leq; a soprano singing for an hour can average 103dB(A) Leq.
- For brass players, use a practice mute when you can.
- Remember, a lot of this work can be done without making a noise (better for your joints and muscles too).
- Bear in mind when you're practising in the studio or performing space you're not the only one whose noise exposure is increasing. Be fair.

*Case study: mental rehearsal.*

■ There is a growing body of literature on the benefits of 'mental practice' which involves imagining a performance of a piece rather than playing or singing it for real. It will benefit your joints and muscles as well as your ears. It is common in sports psychology and has been used by the likes of Pablo Casals and Anton Rubinstein in the past. Your colleagues will also appreciate the lower sound levels if you can master the art of mental practice during the rehearsal breaks. It has been written up in Williamon, A (ed.) *Musical Excellence*, Oxford: OUP, 2004. See Chapter 12.

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## COMMUNICATION

Can take many forms, for example, a 3dB reduction for any conversation that results in a doubling of distance. There are also benefits to workplace harmony if you discuss potential problems and how you might be affected.



- All in all, the most important 'control measure' is communication with colleagues. In the longer term this may be about engaging with the development of policies and protocols, and in the shorter term it may make a practical difference (such as making screens more efficient).
- This also goes for communication with the conductor: you could agree not to give a full *fortissimo* in rehearsal, especially if the rehearsal space is smaller than the performing venue. Remember the conductor's job is to balance the forces for the show. If a singer is facing you in the rehearsal and stopping you from hearing your own instrument, ask the conductor to have them face away from you.
- Section heads and rank-and-file players should talk together about noise; a long-standing string section leader may have forgotten what it is like to be in front of the piccolo in a Shostakovich symphony.
- Communication between musicians and management can take many forms: formal and informal; direct and via reps or section leaders. The main thing is to keep the issue out in the open.
- Musicians have many roles: if you also work as a conductor, don't forget how it feels to be in the middle of the ensemble.



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## REDUCING YOUR NOISE EXPOSURE OUTSIDE WORK

Noise reduction figure varies but reducing your non-work exposure means you can save up your noise exposure for when it matters most.



- It is easier said than done, but you should find ways of saving your noise exposure for the workplace. Your workplace is noisy, but you can protect your ears when commuting (for example). Be aware how loud you are listening to your car radio, or your iPod on public transport.
- iPods are currently under scrutiny but it is too early to see the effects across the population that uses them. Research has shown that you only need to listen to them for five hours per week to exceed the exposure limits for noise at work. Because they are usually listened to in noisy environments, it's easy to have them on too loud. Levels of

93dB(A) have been measured if you add the iPod to the background noise on the tube. That's the same as a trumpet blowing in your ear for the duration of the journey. Furthermore the mp3 format allows the use of use compression to make the lower and higher frequencies audible against background noise, and this can become fatiguing if the dynamic range is narrow.

- The charity Deafness Research UK suggests you use the 60:60 rule for iPods: use it at no more than 60% of the volume for no more than 60 minutes a day.
- When on tour or commuting on public transport, use noise-excluding or active noise-cancelling headphones so that you don't turn the volume up to drown out the plane, coach or train noise.
- You will add to your noise dose if you spend your spare time on noisy hobbies: for example, if you do DIY, use proper hearing protection when using power tools.
- If you're in a restaurant and you can't hold a conversation with the person across the table, ask the staff to turn the music down. You'll find that many people will be grateful to you – including the restaurant staff who are struggling to take your order (they are subject to the Noise Regulations too).

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■ “Something you don't hear: ‘Went to a great gig – lasers shining right in my eyes for four hours – couldn't see a thing for a week afterwards! It was terrific!’ You don't hear people boasting about abusing their eyes, and it's not cool to brag about abusing your ears either.” – *David McApline, Director, UCL Ear Institute*

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## LOOKING TO THE FUTURE

It won't make a difference to your own hearing, but you can help the next generation of musicians and encourage them to get into good habits from the outset.



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- If you teach, encourage your students to practise with earplugs in and get used to the sound they make.
  - If you have 'side-by-side' or shadowing schemes, take the opportunity to talk about noise and hearing to the young musicians who are shadowing you.

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■ “Education of the next generation of professional musicians is critical. The Royal Academy of Music places a particular focus on the education of its students as to the dangers of noise exposure to musicians and the protection of their hearing. This is achieved through a series of seminars, audiometric tests and the involvement of students in monitoring, measuring and managing noise levels and testing new solutions.” – *Nicola Mutton, Director of Artistic Planning, Royal Academy of Music*

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## TRAINING AND INFORMATION

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### TRAINING AND INFORMATION ESSENTIALS

- It's vital to be aware of your noise exposure and its effects.
- Employers are obliged to provide information and training related to noise and hearing.
- Music, noise and hearing are fascinating subjects and vital to your career as a musician. Learn more, and spread the word.



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Noise, acoustics and hearing are big, complex subjects and there is a lot to learn. But they are at the centre of your career as a musician. It's often said that musicians pay more attention to looking after their instrument than to looking after their own health. Some might find it all a bit technical, while others might find it endlessly fascinating, but either way you owe it to yourself to have an understanding of the basics and what they mean to you.

This short section covers the essentials you're entitled to know, and how to find out more without getting overwhelmed. If you teach, use your position to instil good hearing-conservation habits and inspire a fascination for the subject in the next generation too.

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### WHAT YOU SHOULD FIND OUT FROM YOUR MANAGERS

- Likely noise exposures.
- What's being done to reduce exposure.
- What can you do for yourself (earplugs, screens, mark up the score).
- What to do if there is a problem.



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### WHAT INFORMATION TO EXPECT FROM YOUR MANAGERS

Your managers have obligations under Regulation 10 of the Noise Regulations. As a minimum, they should inform all musicians, regardless of status, of the following:

- Likely noise exposures and potential risk to hearing.
- What is being done to control noise exposure.
- Where to get hold of hearing protection, acoustic screens and so on, and where to go for advice on their use.
- Lines of communication if there are problems (this is particularly important on a complicated project where third-party contractors are involved).
- Responsibilities under the Noise Regulations.
- What hearing health surveillance you will be provided with (if relevant).

Information can be provided in a range of ways. For example: on your notice-board; an announcement before a rehearsal for a loud piece about what is in store and how to get

hold of screens; discussions or workshops involving some or all colleagues. Some ensembles have a 'noise team' whereby representatives meet regularly to discuss noise issues.

Even if this seems potentially repetitive, there are usually some colleagues hearing it for the first time, and it is always good to be reminded. Furthermore, there are invariably hazards that are specific to a venue or a programme and these need to be communicated.

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## WHAT YOU SHOULD FIND OUT FOR YOURSELF

- Your other non-work exposure.
- Your family hearing history.
- How we hear and how to look after your ears.



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## WHAT YOU NEED TO FIND OUT FOR YOURSELF

As we have seen, noise 'at work' is not all you are exposed to, so you should do some of your own work to complete the picture. Here's the kind of thing you need to find out for yourself, with some suggestions as to how to go about it:

- Work out your noise exposure outside the workplace. It doesn't have to be accurate, but you may not realise how much your teaching, commuting or hobbies contribute to your daily dose. Even a simple noise meter such as you can get on your phone can give you an indication, but you need to pay £10 or more to get one that is reasonably accurate, and bear in mind they can be used for information purposes only. Use a noise exposure calculator such as the one [here](#).
- Find out about the hearing-health history of people you are related to. It will go some way to predicting what is in store for you, as a predisposition to certain types of conductive and sensorineural hearing loss is inherited.
- Learn more about how sound works and how your ears translate it to messages in your brain.

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## JUDGING THE VALUE OF INFORMATION

Ask:

- Who wrote it?
- Why?
- Is it relevant for your circumstances?



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## WHAT INFORMATION IS OUT THERE AND HOW DO YOU KNOW IF IT WILL MEET YOUR NEEDS?

There's a great deal of information on the internet relating to sound and hearing. You could easily become overwhelmed. Here are some questions you can ask yourself when trying to assess how relevant and how authoritative it is:

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- Who wrote it? An academic? A publicly funded organisation? A patient? A commercial company?
  - What are the credentials of the author? Has the material gone through the peer review process for academic publishing?
  - What is the evidence base? What's the science behind it?
  - Why are they writing it? To sell you something? To share what they know? To make a political point?
  - Is it written for a UK audience?
  - Is it specifically about classical musicians?
  - Remember how you feel when you read something on the internet on a subject you know a lot about ... you may feel it doesn't do justice to the subject, or there may be factual errors. The same applies to a subject you don't know as much about.
  - Even if your GP needs to go away and do some research, it is infinitely preferable to get a diagnosis from a medical practitioner than to attempt to self-diagnose via material you find on the internet.

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*Case study: the London Philharmonic Orchestra Noise Day*

■ The LPO and London South Bank University undertook a joint research / information project and towards the end of the project set aside a three-hour session involving the whole orchestra, management team and principal conductor, to present the findings of the noise-measuring exercise and discuss noise-management strategies and hearing-protection options. For more information on the partnership see the 'Toolkit for managers'.

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*Case study: BBC Singers' Noise day*

■ The BBC Singers wanted to find out the implications of altering the spacing between them as they sang. With their Chief Conductor they performed one short piece (a Bruckner motet) in their usual layout and with increased horizontal and vertical space between them. As well as the exposure measurements, the Singers were asked to give subjective feedback about how they experienced noise levels, their own voice, the rest of their voice part and the rest of the ensemble. The results were surprising, in that exposure was generally higher when the singers had more space around them: they felt more like soloists and sang louder to fill the space. This was an initiative that came from the musicians themselves, and it generated interesting discussion in the ensemble and with managers.

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## **FINALLY ...**

Health and safety is everyone's responsibility. The Noise Regs were introduced to protect you, and though they focus on managers' responsibilities, there's a lot you can – *must* – do for yourself. And you should take opportunities to pass on good habits to colleagues and the next generation of musicians.

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**CLICK ON THE STOP SIGN TO SEE AND PRINT THE 'SPEED-READ' SUMMARY**

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# LINKS, REFERENCES AND DEFINITIONS

## ORGANISATIONS AND KEY PUBLICATIONS

<p>The <i>Health and Safety Executive</i> (HSE) provides its own guidance on Noise in the Music and Entertainment Sector, <i>The Control of Noise at Work Regulations 2005</i>, and supports subsequent industry-led guidance, <i>Sound Advice</i>. This is the recognised source of guidance for compliance with the law, and can be found on its website at <a href="http://www.hse.gov.uk">www.hse.gov.uk</a></p>	<p><i>Musicians' Union</i>: <a href="http://www.musiciansunion.org">www.musiciansunion.org</a>          MU members' handbook contains a section on health and safety. Regular features on noise and hearing in the quarterly journal <i>The Musician</i>.</p>	<p><i>Incorporated Society of Musicians</i>: <a href="http://www.ism.org">www.ism.org</a>  <i>Equity</i>: <a href="http://www.equity.org.uk">www.equity.org.uk</a>  <i>BECTU</i>: <a href="http://www.bectu.org.uk">www.bectu.org.uk</a>          Members of all of these, plus MU, are entitled to discounts on hearing tests.</p>
<p><i>Association of British Orchestras</i>: <a href="http://www.abo.org.uk">www.abo.org.uk</a>  <i>Sound Ear II</i> (2008) downloadable from the site. The <i>Healthy Orchestra Charter</i> is a joint initiative with the <i>Musicians' Benevolent Fund</i> <a href="http://www.mbf.org.uk">www.mbf.org.uk</a> on health and wellbeing in orchestras.</p>	<p><i>British Association for Performing Arts Medicine</i>: <a href="http://www.bapam.org.uk">www.bapam.org.uk</a>          Clinics and information on all aspects of performers' health. <i>Association of Medical Advisers to British Orchestras</i> (AMABO).</p>	<p><i>British Association of Concert Halls</i> (BACH). Forum for managers of concert halls and theatres. Secretariat provided by Sue King <a href="mailto:s.king2@cardiff.gov.uk">s.king2@cardiff.gov.uk</a></p>
<p><i>RNID: Action on Hearing Loss</i>: <a href="http://www.rnid.org.uk">www.rnid.org.uk</a>          Activities include information, awareness-raising campaigns and funding research.</p>	<p><i>Deafness Research UK</i>: <a href="http://www.deafnessresearch.org.uk">www.deafnessresearch.org.uk</a>          Information, research. Provides the <i>Bionic Ear Show</i>, a fun, interactive guide to how the ear works.</p>	<p><i>British Tinnitus Association</i>: <a href="http://www.tinnitus.org.uk">www.tinnitus.org.uk</a>          Advice line and information on all aspects of tinnitus.</p>

## SELECTED FURTHER READING AND LISTENING ON SOUND AND MUSICIANS' HEARING

<p>Text of the EU Directive <i>2003/10/EC</i> can be found at <a href="http://eur-lex.europa.eu">http://eur-lex.europa.eu</a> (search by CELEX number: 32003L0010).          ISO 7029 (age-related hearing loss).          ISO 1999 (noise-induced hearing impairment).</p>	<p>During 2008/09 a literature review was carried out of the peer-reviewed literature on noise, acoustics, hearing and music. The Q&amp;As that prompted them are <a href="#">here</a> and the literature review is <a href="#">here</a>. <i>Music Matters</i> extract (10') on <a href="#">musicians and tinnitus</a>.  <i>Twenty Minutes: The Pleasure of Noise</i>.</p>	<p><i>British Flute Society</i> article (not only for flautists) on psychoacoustics for musicians: <a href="http://www.bfs.org.uk/psychoacoustics.htm">www.bfs.org.uk/psychoacoustics.htm</a>          Williamon, A (ed) <i>Musical Excellence</i>. Oxford: OUP, 2004. (Chapter on 'Mental skills training').          Oliver Sacks <i>Musicophilia: tales of music and the brain</i>. London: Vintage, 2007.</p>
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## LINKS QUOTED – IN FULL

<p>To locate video clips on YouTube:  <i>Tinnitus</i>: “RNID Buzz off”, “RNID Tune out tinnitus”  <i>Cochlea</i>: “cochlear animation”, “dancing hair cell”.</p>	<p>Noise calculators:  <a href="http://www.hse.gov.uk/noise/calculator.htm">www.hse.gov.uk/noise/calculator.htm</a> (needs Excel)  <a href="http://www.xpglobe.com/bbc/noise/calc/">www.xpglobe.com/bbc/noise/calc/</a></p>	<p>Audio clips: all © BBC:          Brahms Symphony No 4 in E minor, BBC SO, rec Maida Vale Studios, 20/04/11. <i>Music Matters</i> extract, broadcast 02/04/11. <i>Twenty Minutes</i> broadcast 18/02/11.</p>
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## YOUR OWN CONTACTS: SUPPLIERS OF AUDIOMETRY AND ACOUSTIC SOLUTIONS, ETC

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## ACRONYMS AND SELECTED DEFINITIONS

'A' weighting	Used for Leq (qv), it gives additional weight to the frequencies the human ear is most sensitive to
'C' weighting	Used for peaks, it treats all frequencies equally
AGC	Automatic Gain Control (your ear's volume knob)
dB	Decibel – measurement of sound intensity
High frequencies	Usually means above 5kHz
Hz	Hertz – cycles per second
Lepd	Daily personal noise dose
Lepw	Weekly personal noise dose
Leq	Equivalent continuous sound level (=average)
Low frequencies	Usually means frequencies up to 300Hz (D <sub>4</sub> )
Mid frequencies	Usually means between 300Hz and 5kHz
NIHL	Noise Induced Hearing Loss – characterised by a notch in the audiogram at 4-6kHz
OAEs	Otoacoustic emissions – vibrations in the ear canal
PTA	Pure-tone audiometry
PTS	Permanent threshold Shift
Reasonably practicable	Reducing noise to as low a level as reasonably practicable involves weighing a risk against the trouble, time and money needed to control it
SNR	Single number rating (for hearing protection)
The 3dB rule	Reduction or increase of 3dB is a halving or doubling of sound intensity
TMJ	Temporomandibular – jaw joint.
TTS	Temporary Threshold Shift

## ACKNOWLEDGMENTS

This guide is the result of many years' work in the BBC and around the sector, and dozens if not hundreds of people have contributed along the way.

When the Noise Regulations came into force for the music and entertainment sector in 2008 the six BBC Performing Groups (PG6), together with the Controller of Radio 3 Roger Wright and Radio 3's Head of Station Management Ben Woolland, agreed to fund a one-year project to investigate what more could be done in the BBC's five orchestras and the BBC Singers. That year involved a great deal of measurement and many conversations with musicians, managers, acousticians, engineers and doctors, and two main conclusions emerged: one, solutions have to be found for individual musicians as well as for workplaces and ensembles, and two, controlling noise requires sustained management over a long period to make a lasting difference. It was also clear that sharing solutions would bring wider benefits.

Paul Greeves, head of BBC Safety and Chris Burns, Audio & Music, agreed to take the work forward, as the BBC was an early signatory to the HSE's 'pledge' to 'be part of the Health and Safety solution'. Steve Gregory, BBC's Head of Production Safety, saw the scope for cross-sector working and a seminar was organised in July 2010 bringing together musicians, ensemble managers, acousticians, occupational health colleagues and safety practitioners and others. Out of that came a working group which acted as an editorial group for this guide.

Working group membership was as follows: Leo Beirne, Colin Chatten and Anne Wright (Noise & Vibration Unit, HSE), Phil Boughton (Welsh National Opera), Roanna Chandler (London Philharmonic Orchestra), Sally Mitchell (Royal Opera House), Keith Moston (ABO), Nicola Mutton (Royal Academy of Music), Simon Webb (CBSO), Helen Wilson (Opera North), Euan Turner (Federation of Scottish Theatres) and Bill Kerr, Morris Stemp and Diane Widdison (Musicians' Union). From the BBC Performing Groups: Susanna Simmons (BBC Symphony Orchestra) and Richard Wigley (BBC Philharmonic). From BBC Safety: Laura Baker, Louise Bisdee and Wendy Pelaez.

Many others have had a hand in this guide and their ideas and contributions have been incorporated in some form or another: acousticians Steve Dance and Georgia Zepidou (London South Bank University) and Richard Cole (BBC) and many engineers including Ian Astbury, Andy Leslie and Dougal Proudlock (BBC), Brad Backus (UCL Ear Institute). Medical colleagues whose contribution is in here include Paul Checkley (Musicians' Hearing Services), audiologist and epidemiologist Dr Christian Meyer-Bisch, Chris Rhodes (Capita Health Solutions), Dr Martin Rosenberg and Dr Colin Thomas (BBC's Chief Medical Officer). Dom Stiles of the RNID Library provided access to the literature. Countless musicians have helped to influence what has gone into the guide (and what's been left out) and particular thanks go to Andy Cresci and Jamie Pullman (Bournemouth SO), Sarah Freestone and David McCallum (BBC Concert Orchestra) and Chris Bowen (BBC Singers). Jayne Bailey, Chris McNally and Nick Walker are among the many BBC Safety colleagues who have provided help. Philip Burwell of BBC Radio 3 prepared the Brahms sound clips. Photos are mostly by Euan Turner; percussionist Alasdair Malloy (BBC CO) took the photo of Sir Henry Wood. Violinist Julian Gregory of the BBC Philharmonic has captured in his cartoons of the kind of scenarios we hope will become a thing of the past.

# THE 2005 NOISE REGULATIONS: PLAYING YOUR PART

Time -line	Musicians	Managers (coloured text refers to a duty under the Noise Regs)	Venues
General activity	<ul style="list-style-type: none"> <li>Minimise extra-curricular noise exposure.</li> <li>Get used to wearing earplugs.</li> <li>Have hearing tests.</li> </ul>	<ul style="list-style-type: none"> <li>Provide audiometry to in-scope musicians.</li> <li>Go on noise awareness training to understand duties under CNAW.</li> <li>Information provision to musicians.</li> </ul>	<ul style="list-style-type: none"> <li>Put documentation together and make it available.</li> </ul>
Artistic planning	<ul style="list-style-type: none"> <li>Contribute to Risk Assessment.</li> </ul>	<ul style="list-style-type: none"> <li>What are the noise implications of this project? (rep+venue).</li> <li>Risk assessment.</li> <li>Measuring if no figures exist.</li> </ul>	<ul style="list-style-type: none"> <li>Can the venue accommodate this project? (stage? acoustic treatments?)</li> </ul>
Sched-uling	<ul style="list-style-type: none"> <li>Inform management of potential noise risks.</li> </ul>	<ul style="list-style-type: none"> <li>Ensure there are adequate rest periods in the schedule</li> </ul>	
Rehearsal	<ul style="list-style-type: none"> <li>Mark up score.</li> <li>Ask for screen if necessary.</li> <li>Discuss noise problems with colleagues.</li> <li>Wear hearing protection</li> <li>Rest ears during breaks.</li> </ul>	<ul style="list-style-type: none"> <li>Adjust staging</li> <li>Provide screens and check they are positioned correctly</li> <li>Encourage musicians to leave the stage when not required</li> <li>Remind re: hearing protection</li> </ul>	<ul style="list-style-type: none"> <li>Adjust staging and acoustic (treatments) of room if possible.</li> </ul>
Before the show	<ul style="list-style-type: none"> <li>Ask again: do I need this screen?</li> <li>Give your ears a rest.</li> </ul>	<ul style="list-style-type: none"> <li>Check position of screens.</li> <li>Reminder re: hearing protection.</li> <li>Dynamic risk assessment.</li> </ul>	
Show	<ul style="list-style-type: none"> <li>Earplugs.</li> </ul>	<ul style="list-style-type: none"> <li>Stage mgt to add or remove screens according to the repertoire.</li> </ul>	
After the event	<ul style="list-style-type: none"> <li>Feed back to management and each other.</li> <li>Don't add to your noise exposure.</li> </ul>	<ul style="list-style-type: none"> <li>Feed back experiences to venues.</li> <li>Revisit risk assessment: what can we learn?</li> </ul>	<ul style="list-style-type: none"> <li>Listen to the feedback; use it for business case for improvements.</li> </ul>