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FOREWORD

Noise is a part of life. I love the hustle and bustle of good conversation and company, but when I was diagnosed with young onset dementia everything changed. The everyday noise of life became unbearable. For a sociable person like me this has had a profound impact on my life. This book is a perfect companion guide to my book Talking Sense: Living with Sensory Changes and Dementia, written with Dr Julie Christie. It provides a technical but accessible insight into hearing and noise. There is a helpful introduction to the subject of acoustics, and sources of noise and acoustic intrusion are discussed. Importantly, the e ects of both on people with dementia are explored and the author gives a fascinating insight into this subject. There are guidelines for managing acoustic intrusion and more detailed technical design solutions. This makes the book meaningful for carers, designers, planners and anyone with an interest in this area of work.

I have spoken to many people with sensitivity to noise and hyperacusis. Living with this sensitivity is hard as many activities such as going shopping on a busy street or meeting friends in a cafØ become impossible. People with dementia can be overcome with emotions and stress responses, and noise as the reason isn t always obvious to us or the people around us. This book provides the science behind the issue and more importantly o ers practical solutions to reduce noise intrusions in the lives of people with dementia. We need to pay attention to this important subject or, quite simply, we need to listen.

Agnes Houston MBE, Churchill Fellow

> Multiple sources of noise such as the washing machine, vacuum cleaner, radio, TV and loud conversation all at the same time will be very distressing to someone with a hearing impairment and worse still for someone with dementia.
>
> Agnes Houston

For me, living with dementia means that I can only think about one thing at a time. If I want to have a conversation and I'm also expected to perhaps eat, and/or listen to music or other background noise, I have to choose from minute to minute what I will focus on. It's so stressful, it feels like being on a noisy fairground ride that you can't get off.

Eating is no longer a social activity for me. It's either eat or listen, I can't do both, and I actually don't want to do both at the same time anymore. It's exhausting. This seems to be a very hard concept for others to understand.

All my life, sound was usually an indicator for action required – a baby crying meant I had to get up and tend to the child. Dishes clattering meant that it was time for me to wash up. So, after years of being accustomed to moving in response to certain everyday sounds, even though my circumstances have changed, my body still responds to the sounds in the same way – prompting action. When I'm prevented from fulfilling the actions that my body is trying to do, the feeling of unfinished business remains. This can be interpreted as restlessness, and will present as pacing, wandering, agitation etc. Acoustic intrusion is the most disabling factor in the external environment. Inside my brain, I can't control what my ears hear. Most people can 'filter' and 'prioritise' the sounds that they wish to listen to and fade the rest of the noise into the 'background' I can't do that anymore. I can only do one thing at a time in my brain, and if I try to focus on a voice, for example, the louder sounds will intrude and take precedence, so I have to start the whole process of choosing what sound to focus on all over again. It's frustrating, particularly when people get impatient and assume that you can't be bothered. I might look like a nice calm duck sailing across the pond and ignoring you, but underneath I'm paddling furiously just to stay afloat. The anxiety that accompanies this effort is extraordinary, and it's hard not to just give up trying.

Theresa Flavin, lived experience consultant

SOUND

Sound can be de ned as the reception of molecular vibrations that travel through the air (or another medium) and are perceived by the brain upon reaching the ear.[4] It can also be described as the sensation produced by a certain range of rapid uctuations of air pressure a ecting the ear mechanism.

Sound is propagated by means of vibrating pressure waves travelling through a medium possessing inertia and elasticity.[5] For the purposes of the book it will be assumed to be travelling through air, which is at a rate of approximately 343 metres per second at a room temperature of 20°C.

Sound dissipates over distance.

> Many of us will have experienced the curious e ect that the speed of sound has on attempts to synchronise the singing of national anthems in a large, enclosed arena. Di erent sections of the crowd end up singing out of sync with di erent periods of delay due to the range of distances from the coordinating source.

SOUND SOURCE

There are two basic sources of sound: airborne and impact.

1. Airborne examples are speech, music, loudspeakers, birdsong and alarm tones.
2. Impact examples are footsteps, moving furniture, and slamming shut doors and bin lids.

Sources can often be visible (vibrating tuning fork) as well as felt.

Credit: Mary Marshall

MEASURING SOUND

Sound wave vibrations have two characteristics that can be measured: intensity and frequency.

1. **Intensity** – This is described in terms of decibels (dB), a logarithmic scale used to measure the volume of the sound. Because the sensitivity of the human ear is not consistent over the whole of the hearing range, a slightly modified weighted scale (dB[A]) is often used.

Some examples of sound levels of normal activities in dB(A)	
Threshold of human hearing	0 dB(A)
Sound of breathing @ 1 m	20 dB(A)
Noise of normal living	45 dB(A)
Bird twitter outside @ 15 m	45 dB(A)
Noisy vacuum cleaner @ 10 m	55 dB(A)
Passing car @ 7.5 m	75 dB(A)
Loud WC flush @ 1 m	85 dB(A)
Food processor	85 dB(A)
Electric drill	93 dB(A)
Airplane take-off @ 100 m	115 dB(A)
Loud hand clapping @ 1 m	130 dB(A)

Since the Decibel scale is logarithmic, it should be noted that every increase of 3 dB (or dB[A]) in sound intensity equates to a doubling of the volume.

There is a huge range of scale of the ear's pressure sensitivity, from the threshold of human Hearing at 0 dB to the threshold of pain at around 120 dB. There is a higher risk of heart disease with long term exposure to noise levels above 65 dB and permanent damage to hearing with levels above 85 dB.

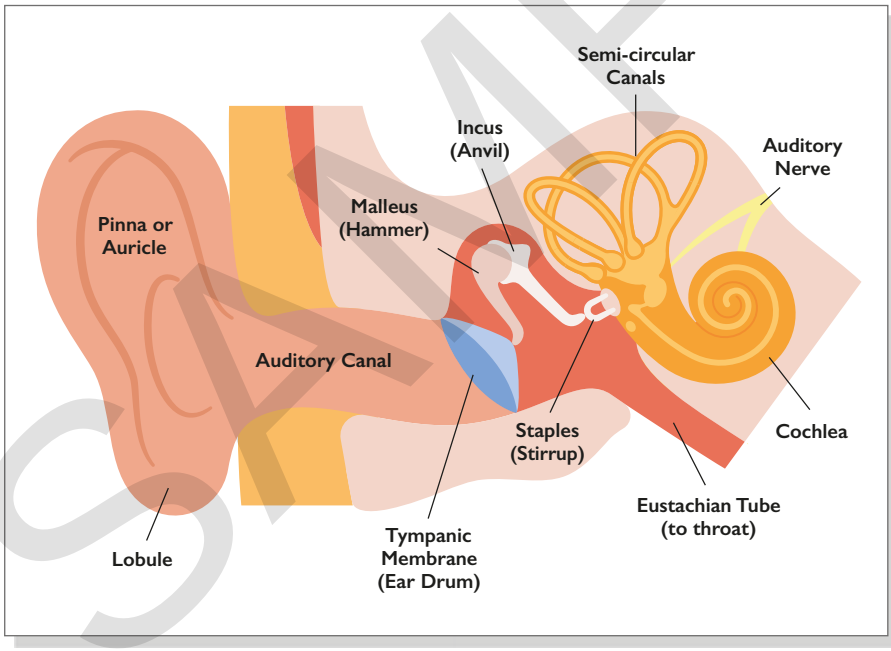
Unless a person is in an anechoic chamber (an echo-free room), there is always background or ambient sound of around 10 dB.

HEARING

THE HUMAN EAR

There are three parts to the human ear: the outer ear, the middle ear and the inner ear. The outer ear has the pinna, which operates as a funnel to direct the sound vibrations through the auditory canal towards the ear drum. The middle ear consists of three small bones or ossicles: the hammer (malleus), the anvil (incus) and the stirrup (stapes). These further transmit the sound vibrations to the oval window of the inner ear. The oval window is much smaller than the ear drum, so this mechanism serves to amplify the pressure of the vibrations and transfers the sound to the liquid content of the inner ear.

Figure 3

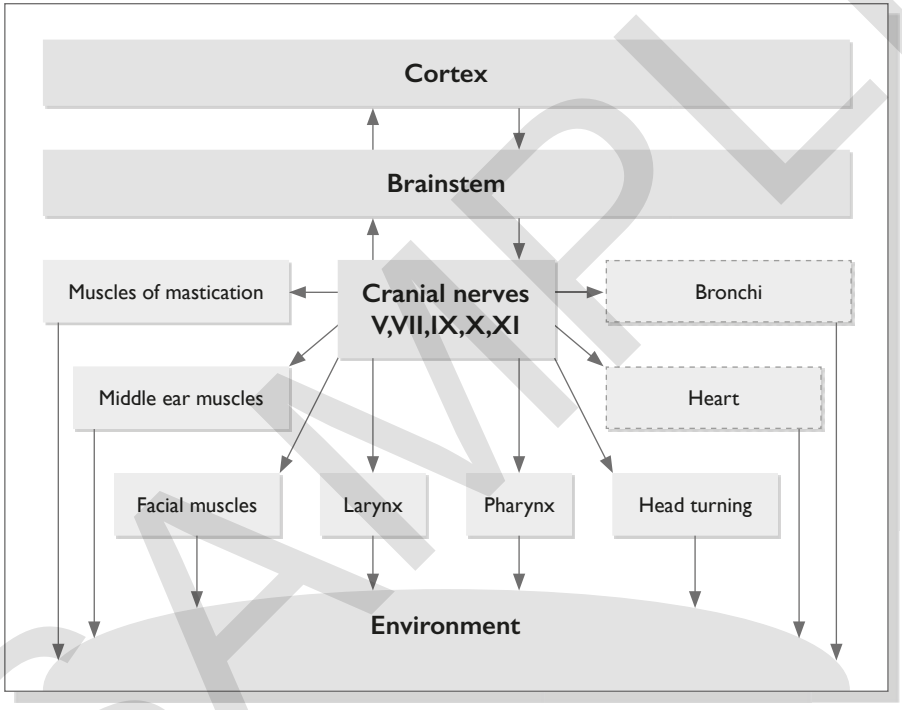


The inner ear serves two purposes; firstly, to control the body's sense of balance and secondly, to convey the perception of sound through the cochlea with its tiny, delicate hair-like receptors to the auditory nerve. The auditory or cochlea nerve carries auditory sensory information to the auditory cortex in the brain.

For a person with dementia with normally functioning hearing, damage to the part of the brain that receives and interprets the nerve signals can make their hearing unintelligible or lead to auditory hallucinations.[8]

According to research (Porges and Lewis 2010), when people feel uncertain or over-stressed, muscles in the inner ear are affected in a way that makes them unable to hear calming, considerate voices. Conversely, when people feel cherished and safe, these same muscles respond by shutting out background sound and enabling them to focus better on the frequencies of normal human speech.

Figure 4



The basic mechanism is shown in the following diagram taken from the research paper by Porges and Lewis.[9]

There are three stages of hearing:[10]

1. **Detection** – this first stage concerns the actual detection of sound. Can a sound be heard?
2. **Resolution –** secondly, can we identify the source or origin of the sound?
3. **Identification –** the last stage of the process is the ability to understand and name the sound.

Despite the wonders of the brain and what we may think, we cannot process two separate sounds simultaneously. We have to focus on one.

GUIDELINES FOR MANAGING ACOUSTIC INTRUSION

The following are suggested guidelines for effectively controlling and managing acoustic intrusion for people living with dementia. These guidelines have been written specifically for use in residential aged care homes. However, a number of these suggestions are applicable to homes, hospitals and public spaces too.

1. SITE AND BUILDING LAYOUT CONSIDERATIONS

A site assessment, whether for a new build or for a refurbishment, is essential to shape the best way a building is laid out.

Similarly, the placement and juxtaposition of rooms and spaces within a building can have a significant influence on the quality of the acoustic environment. The following bullet points cover the general considerations and more technical solutions are covered in the section on 'Technical Design Solutions'.

Some common sounds and their decibel ratings at source	
Unsilenced pneumatic drill (at 7 m distance)	95 dB(A)
Heavy diesel lorry (40 km/h at 7 m distance)	83 dB(A)
Modern twin-engine jet (at take-off at 152 m distance)	81 dB(A)
Passenger car (60 km/h at 7 m distance)	70 db(A)
Office environment	60 dB(A)
Ordinary conversation	50 dB(A)
Quiet bedroom	35 dB(A)

- **Proximity to noise**. The proposed site/building should not be located near external sources of noise which cannot be avoided (e.g. busy roads, flight paths). *(Refer to Design features – acoustic windows/glazing in technical section.)*
- **Planning**. Arrange the layout of the rooms in a building so that quiet areas, bedrooms, quiet lounges, small wards or sitting areas are located well away from plant rooms, stairs, lifts, sluices, laundries etc.
- **Structural noise insulation**. The form of construction should be designed to facilitate effective noise insulation, e.g. through discontinuous construction and appropriate window positioning. *(Refer to sample details in technical section.)*

- **Size of residential units**. It has been found that residents in small-scale and home-like environments experience fewer changes in behaviour[46] as small generally means quieter. Residents should also have a choice of small rooms for quiet conversation or reflection.
- **Reverberation levels**. Different spaces and room shapes have different reverberation level requirements and should be assessed for appropriateness.
- **Access to outdoors**. Residents should have easy access to visible outside spaces. These are often quieter and more calming than public indoor areas.
- **Landscaping**. Planting beds and other soft landscaping located close to windows will help to absorb external noise which would otherwise be reflected off hard surfaces into the building.

As she got older, Mrs Suarez began to trouble the neighbours in her block of flats increasingly. She was a widow who had lived in the small block of flats for a long time. She did not trouble them at night but during the day they were aware that she was agitated and constantly going in and out of the flat – often heading for the small garden at the back whatever the weather. A careful assessment revealed that it was the noise of the increasingly busy road (a new distribution depot had been built nearby) outside her flat that was distressing her. Double glazing solved the problem.

UNDERSTANDING BASIC ACOUSTICS

As has been mentioned, the normal process of ageing leads to a natural deterioration in human hearing ability. To compensate for this and the additional complications resulting from having dementia, it is necessary to gain an understanding of the basic principles of acoustic design.

TRANSMISSION

Transmission occurs when sound is carried from one space to another directly through the materials of construction that enclose the spaces. A sound source in one room or area sets up vibrations in the air around it and these vibrations are transferred to the separating construction materials, which, in turn, set up sound vibrations in the receiving room or space.

Transmission can result in sound, for example from a plant room, lift or stairway, being heard in nearby rooms if the form of construction of the separating wall does not include adequate sound insulation. If the next-door room is a quiet room such as a bedroom, this could be very disturbing to sleep and rest.

Materials with higher mass such as dense blockwork are more effective in reducing sound transmission. Discontinuous methods of detailing, as shown in the technical section, are also an effective means of preventing or significantly reducing sound transmission through a building structure.

From *The Guinness Book of Records*

Highest absorption/insulation

A specially constructed anechoic chamber is hidden in the depths of Building 87 at Microsoft's headquarters in Redmond, Washington, where the firm's hardware laboratories are based. In 2015, it set the official world record for silence when the background noise level inside was measured at an ear-straining -20.6 decibels.

Longest echo

In 2014, acoustics expert Trevor Cox crawled through a narrow pipe into a subterranean wartime emergency oil tank in Inchindown, Scotland. One gunshot and 75 seconds later, he had set a new world record for the longest echo in a man-made structure – 112 seconds.

Both of these extreme acoustic conditions have proven to be a highly unpleasant experience for the majority of people who have experienced the sensations!

Visit Building 87 at: https://news.microsoft.com/stories/building87/