Improving Sound Absorption in the Home: Part 1

11 April 2018

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Foreword

This two-part article is about *sound absorption*, not *soundproofing*. Soundproofing is designed to keep noise out whereas sound absorption is designed to absorb internal ambient noise. Some soundproofing products both block and absorb sound but our primary interest in the home is absorption.

Introduction

Like most hard-of-hearing people, I have difficulty distinguishing foreground noise from background noise and, as a result, I shun noisy public places such as restaurants and pubs, and social gatherings with more than four people present (my *Rule of Four*). But, in my own home, all is peace and tranquillity and I hear family and visitors clearly, right? Wrong. Many of the floors in my home are made of squeaky hardwood boards, the walls are painted plasterboard, and the ceilings similarly with recessed lights. In the kitchen, we have an inherited marble table, a large metallic fridge-freezer, and the storage cabinets and wall cupboards are made from veneer-covered fibreboard. All these kinds of surfaces reflect rather than absorb sound and, for me, represent bad news. If there are more than four people sitting around the table in the kitchen, I'm lost. If the television is on in the background in the living room, I struggle to follow a live conversation.

So, what's the solution? First, let's understand the problem.

Sound differentiation and reflection

There are two factors that contribute to our inability to hear properly in confined spaces where other people are both present and talking. One is we are often not able to differentiate foreground noise from background noise (aggravated by the Lombard Effect[1]), and the other is that sound reflects off flat hard surfaces. Foreground/background differentiation is something both normal and hearing-impaired people suffer from but it does seem to be exacerbated if we wear hearing aids. Maybe it's because we tend to pay more attention to what's being said and this may affect the ability of the brain to filter the received sounds? I am not an audiologist, nor a neuroscientist, and so cannot comment more on how the brain

[1] The Lombard Effect is the tendency to increase the volume of your voice when speaking to someone close by in the presence of many other people all trying to have a conversation with their neighbour e.g. at a party. The effect is cumulative. As each speaker in the room raises his or her voice, so the noise level in the room continuously increases until, finally, nobody can hear anybody!

processes the sounds it receives through the ears but, as I said, it affects us all and there doesn't seem to be much that hearing-aid users can do about it other than reduce constant ambient noise (the whirring of a fan, for example), using aids with active noise cancelling.

But, what of the second problem - sound reflection? Sound energy travels from a source to our ears by vibrations through a medium: gas (the air that surrounds us), solids (remember the two-tin-cans-and-piece-of-string communicator?), or liquids (listening to the songs of whales transmitted through water to a hydrophone). If we are in a kitchen, say, and somebody speaks to us, we hear via the direct path through the air that separates us. But that same sound travels elsewhere in the kitchen and if it finds a sound-reflective surface such as a cupboard door or the ceiling, it's reflected back and, again, enters the ear but at different times. Thus, the sound starts to become fuzzy. As a result, if there are more than two people talking at the same time in this type of environment, all we will hear is an indistinct noise and it becomes virtually impossible to make out what was said.

We can't do much in the home to solve the sound differentiation problem - inductive T-loops and television/radio assistive listening devices all help - but we can reduce the amount of sound reflection by covering major reflective surfaces with materials that either absorb or diffuse (scatter) the sound rather than unidirectionally reflect it back into the room - that is, by improving sound absorption in the home. Here's how…

Sound absorption in the home

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The two most important social rooms in a home are the kitchen and the living room. Ideally, we would like these rooms to have thick carpeting and sound-absorbing acoustic panels on the walls and ceiling, similar to those in an audiometric test room, but already I hear the protests - "It's a home, not a laboratory!" and, "At what cost?" Fortunately, there are a number of simple things, and not-so-simple things, we can do to increase sound absorption and thus reduce sound reflection in the home:

- Install wall-to-wall floor carpeting ideally, or place a profusion of rugs on hard wooden floors.
- Fill bookcases with books and remove glass cover panels.
- Distribute indoor plants in nooks and crannies.
- Buy a rough-wood coffee table rather than one topped with smooth glass.
- Drape thick curtains around windows and hang wall rugs (I like Navajo!) or tapestries on the walls.
- Replace sound-reflective window blinds with soft-furnishing nicely-wrinkled curtains.
- Apply a textured coating such as Artex, or similar, on ceilings (modern Artex does not contain asbestos).
- Paint walls with sound-absorbing paint (yes, such paint exists - see later).
- Use sound-absorbing acoustic-laminated glass, not ordinary glass, to protect photographs and pictures.

- Place soft placemats, tabletop runners or permanent tablecloths on hard-surface kitchen and dining room tables.
- Favour fabric (rather than leather) armchairs and settees, and populate with scatter cushions.
- House full-length wall-mounted mirrors in cupboards with closing doors or close off with curtains.
- Install kitchen cabinets with non-sound-reflective cupboard doors and surrounds, if you can find them!
- Keep a large worn wooden chopping board out on a smooth kitchen work surface rather than put it away.
- And so on…

A recent online search for sound absorbing products revealed many suppliers of acoustic panels for public places - offices, schools, restaurants, theatres… - but very few suppliers of what I call *cosmetic panelling* for the home - panels that look good in the kitchen or living room and, most importantly, are acceptable to the nest builder, in my case, my wife! One supplier that caught my eye offered a variety of different-sized wall panels on which can be printed a digital photograph - a family member, a landscape or portrait of choice, even a favourite pop star or film star. The same company also supplies a range of suspended cloud-shaped acoustic ceiling panels to help reduce reverberation from a smooth ceiling. All that's missing is the sun, moon and stars!

I'm sure there are other ways we can reduce the sound reflections in our home and readers are encouraged to submit their own tips. Let's hear it from the home sound absorbers!

Useful websites

Acoustic products for the home:
http://www.soundsorba.com/
https://www.ourproperty.co.uk/guides/how_to_soundproof_your_house/
https://www.soundproofcow.com/soundproofing-101/how-to-soundproof-a-home-2/
https://www.elledecor.com/design-decorate/trends/g2926/soundproofing-a-room/
http://www.soundproofing.org/infopages/liquid.htm
https://www.pilkington.com/en-gb/uk/products/product-categories/noise-control
https://www.acousticalsurfaces.com/blog/soundproofing/blog-soundproofing-blogsoundproofingsound-proofing-vs-sound-absorbing-the-difference-between-blocking-and-absorbing/

Sound transmission and reverberation
https://tellmewhyfacts.com/2007/09/how-does-sound-travel.html
https://science.howstuffworks.com/humans-hear-in-space1.htm
http://www.betterhearing.org/hearingpedia/counseling-articles-tips/tips-hearing-noise

Foreground/background differentiation:
http://www.ldonline.org/article/5919/
https://www.healthyhearing.com/report/41066-Hearing-aids-background-noise
https://mysoundtherapy.com/what-is-sound-therapy/tinnitus-hearing/background-noise-discrimination/
https://en.wikipedia.org/wiki/Lombard_effect

Improving Sound Absorption in the Home: Part 2
5 October 2018

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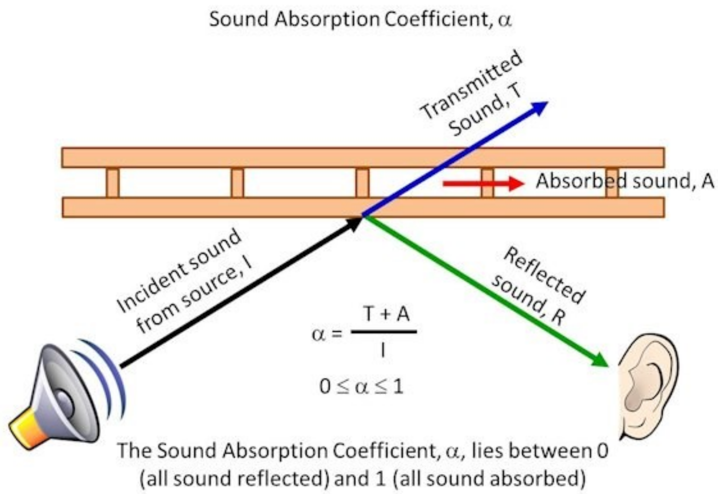
In Part 1 of this article, I wrote about the need to reduce the amount of sound that reverberates around the social rooms in our home - the kitchen and dining rooms particularly. I described how sound, such as the human voice, bounces off shiny surfaces and returns to our ears by an indirect route causing fuzziness and ambiguity in what we hear compared to what was said. I, like many other hard-of-hearing people, have great difficulty making out what other people say in a kitchen or dining room and I put forward a number of tips on how to improve the sound absorption in a room thereby reducing the sound bounce back - simple things like more carpets and curtains, rugs on the walls, and placemats, runners and tablecloths on the tables. Note: I am not trying to keep sound out of these rooms. That's called soundproofing. What I'm trying to do is improve the sound absorption properties of the surfaces within the room to stop sound, particularly voices, reflecting back into the room. That's called sound absorption and that's what carpets, curtains, etc. do.

While I was researching this article, I came across two commercial sound absorption techniques I hadn't really thought of in any detail. They were acoustic panels for walls and ceilings, the sort of thing you would have seen in your audiologist's test room, and sound absorbing paint. That got me thinking. Could these techniques be of value in the home? Or are they more suited to large open public areas such as offices, theatres, concert halls, and lecture rooms? Relative to simple remedies such as buying a heavy tablecloth or replacing a window blind with a curtain, are these techniques of similar cost or considerably more expensive? And, most importantly, what are their sound absorption properties and are these values quoted by those who sell the products so that we can judge their potential impact on home kitchens and dining rooms?

These questions led me into understanding how sound absorption is measured and what parameters we should look for i.e. the science of sound absorption.

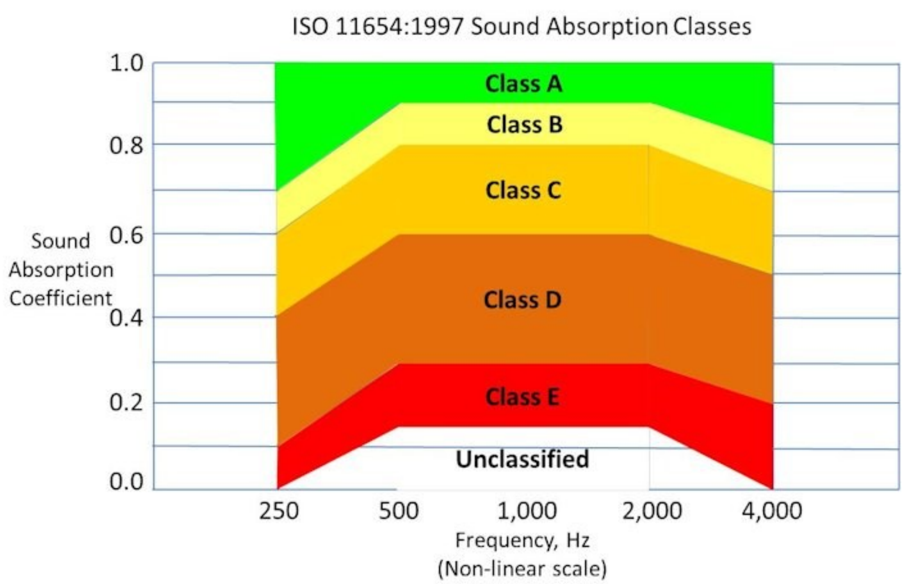
Given that we are trying to improve our ability to hear others speak, either in the kitchen or around a dining table in a dining room, we are primarily interested in wall and ceiling materials that absorb rather than reflect sound at the frequencies of the human voice. To get a little bit technical, a male human voice is centred around somewhere between 85 Hz and 185 Hz (roughly an octave below middle C, 261.6 Hz, on a piano), and a female human voice is centred more between 165 Hz to 225 Hz i.e. closer to middle C. But, as we know, the voice has many harmonics - sounds which are both higher and lower than the mid-band frequencies - and telephone engineers realised a long time ago that voice transmission over what we would now call an analogue transmission path, such as a telephone line, should be capable of transmitting voice frequencies considerably above the mid-band range and they extended the range up to 3,100 Hz. This enabled a listener to recognise particular higher-frequency sounds, such as fricative alveolar sounds (T and D, for example) and fricative sibilant sounds (S and F, for example). So, next time you pick up the phone and someone says, "It's me", your ability to recognise the caller instantly is because the telephone engineers of days of yore increased the bandwidth of a telephone transmission to accommodate these higher frequencies!

Another basic fact about sound absorption is that the amount of sound that is absorbed by anything is a function of the frequency of the sound. For example, if junior is upstairs playing the latest heavy metal creation on his music system, you will hear the boom-boom-boom of the bass but not so much of the higher frequency guitar riffs. That's because the higher frequency notes are absorbed by the bed, books and piles of dirty washing in junior's room whereas the lower bass frequencies are not. They will travel through the floor and interrupt your enjoyment of Chopin's Nocturne in E-flat major, Op. 9 No. 2.



So, how well do acoustic panels and sound-absorbing paint succeed in absorbing sound within a room? To answer this, we need to know what is called the *Sound Absorption Coefficient*, SAC, of a surface material. When a sound hits the surface of anything, some sound passes through (transmitted), some is absorbed (and converted to heat within the material), and some is reflected (either directly or scattered). The *Sound Absorption Coefficient* is the ratio of the transmitted plus absorbed sound over the total amount of incoming sound energy. In simple terms, an SAC defines what percent of an incident sound is absorbed with values ranging from 0% (no sound absorbed) to 100% (all sound absorbed). For example, heavy folded draped curtains have an SAC of 0.56 at a frequency of 2,000 Hz i.e. 56% of the sound hitting the curtain is absorbed by the curtain material; 44% is reflected.

Now, putting these basic scientific facts together, we are interested in knowing how well a sound-absorbing surface, such as an acoustic panel or sound-absorbing paint, will absorb sound in the range of frequencies produced by the human voice. As it turns out, the International Standards Organisation (ISO) has produced a standard for defining this property and which goes by the grand name of *ISO 11654:1997 Acoustics: Sound absorbers for use in buildings: Rating of sound absorption*. Basically, there are six classes of sound absorption over a frequency range of 250 Hz to 4,000 Hz: see diagram.



Absorption Class	Sound Absorption Coefficient within the mid-band frequencies, 500 - 2,000 Hz
A	0.9 - 1.0
B	0.8 - 0.9
C	0.6 - 0.8
D	0.3 - 0.6
E	0.15 - 0.3
Not classified	Below 0.15

The vertical axis on the graph shows the *Sound Absorption Coefficient* ranging from 0.0 to 1.0. The higher the coefficient, the better the sound absorption. Hence, an open window has an SAC of 1.0 - all incident sound is transmitted through the open window and none returns. That same window, when closed but not curtained, will return most of the incident sound back into the room and will, consequently, have a coefficient close to 0.0. (One source I read suggested a closed window would have an SAC value of somewhere between 0.1 and 0.2. One way to think of this is that somewhere between 10% and 20% of the sound is absorbed by the glass and, thus, 90% to 80% of the sound is bounced back into the room.)

The horizontal axis shows how the classes of sound absorption vary as the frequency moves from the lower value of 250 Hz to the upper value of 4,000 Hz with concentration on the mid-band zone of 500 Hz to 2,000 Hz.

In simple terms, a Class A material, such as a top-end acoustic panel, is excellent at absorbing sound within the range of the human voice whereas a Class E material, such as a tiled floor, is extremely poor at absorbing sound. The other three classes are somewhere in-between.

One other comment. You will sometimes see the sound absorption quoted as a *Noise Reduction Coefficient*, NRC. This is the average *Sound Absorption Coefficient* over the frequency range of 250 Hz to 2,000 Hz i.e. a mid-band value suited to most of the frequencies in the human voice. The table below lists some typical NRCs for common household items and materials.

Material	Sound Absorption Coefficients at specific frequencies and average SAC between 250 Hz and 2,000 Hz (NRC)				
	250 Hz	500 Hz	1,000 Hz	2,000 Hz	NRC
40 mm acoustic panel	0.60	1.00	1.00	1.00	0.90
9 mm pile carpet with underlay	0.08	0.30	0.60	0.75	0.43
Seated adult, seated	0.40	0.44	0.45	0.45	0.38
10 mm plasterboard ceiling backed with 25 mm bitumen	0.20	0.15	0.05	0.05	0.11
Heavy folded draped curtains	0.45	0.65	0.56	0.59	0.56
Wooden floor on joists	0.11	0.10	0.07	0.06	0.85
Tiled floor, plastic or linoleum	0.00	0.03	0.00	0.05	0.02
6mm glazing glass	0.06	0.04	0.03	0.02	0.37
Painted plaster on masonry wall	0.02	0.02	0.02	0.02	0.02
Smooth brickwork, painted	0.01	0.02	0.02	0.02	0.02

Source: http://www.acoustic.ua/st/web_absorption_data_eng.pdf

With this as background, here is what I found out about acoustic panels and sound-absorbing paint.

Acoustic panels are made from various materials - recycled cotton, glass wool (recycled glass), cellulose fibres, and so on - and hence will have a range of absorption classes but their absorption capabilities are excellent with manufacturers quoting a *Noise Reduction Coefficient* of anywhere between 0.85 (Class B) to 1.0 (Class A). Sound-absorbing paint is an emulsion paint (water-based) containing styrenated buradiene rubber (a synthetic rubber that forms a membrane as it dries) plus ceramic microspheres and sound-absorbing fillers. NRC data is hard to obtain but one figure I've seen is 0.3 meaning that, in general, sound-absorbing paint does not perform as well as acoustic panels: only 30% absorption compared to 85% and higher for acoustic panels.

(One leading manufacturer of sound-absorbing paint targets the paint more as a soundproofing paint than a sound absorbing paint, and quotes ratings in terms of its noise blocking properties - sound attenuation in terms of dB loss through the material. I have asked for SAC and NRC figures. They were promised but never arrived!)

Which brings me to my final point; cost. Rather than quote absolute prices, I have looked at the per-square-metre cost of acoustic panels and sound-absorbing paint and compared the two. Roughly speaking, the per-square-metre cost of covering a wall with high-class acoustic panels is anywhere between twelve to twenty times the cost of applying at least two coats of the paint depending on how much surface you want to cover and how much product you buy. But, sound-absorbing paint is easier to apply to a large surface, such as a wall or ceiling, and less obtrusive to the eye whereas acoustic panels can be imprinted with JPEG images, such as family portraits, and thus made to look very decorative.

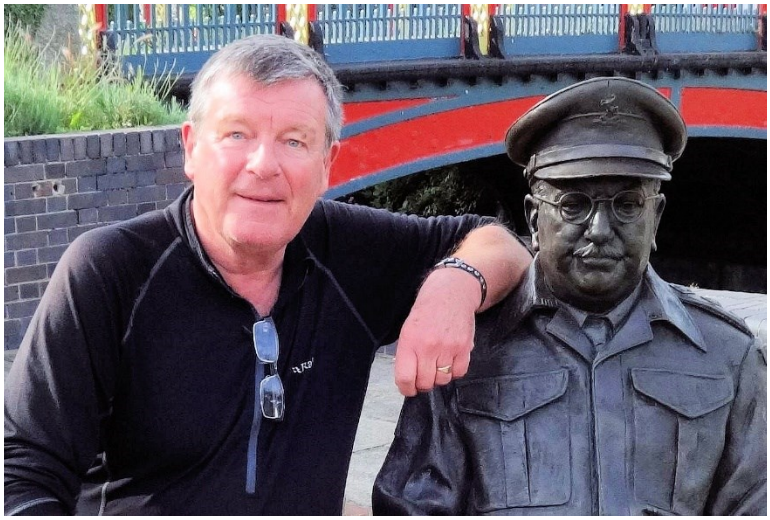
You pays your money and takes your choice!

Acknowledgement.

I am indebted to Ben Newington of Soundsorba Limited for providing data on both acoustic panels and sound-absorbing paint.

(^_^)

About the Author



With Capt. Mainwaring, Thetford, Peddars Way, 2014

After retiring in 2007 from a busy career as a consultant electronics engineer, I took up walking long-distance trails both in my home country (UK) and in other places such the Himalaya in Nepal and India, the Sierra Nevada in Spain, and the *levadas* in Madeira. These activities kept me physically fit. To stay mentally fit, I took to blogging and writing books. To date, I've published sixteen books on topics as diverse as religion, current affairs, a storybook for children, an autobiography, idiosyncrasies of the English language, long-distance walking, and keeping fit as we age.

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