

Acoustics & Inclusive Design for Aural Diversity

An industry perspective

Chris Watkins | Jemma Jones

27 May 2022

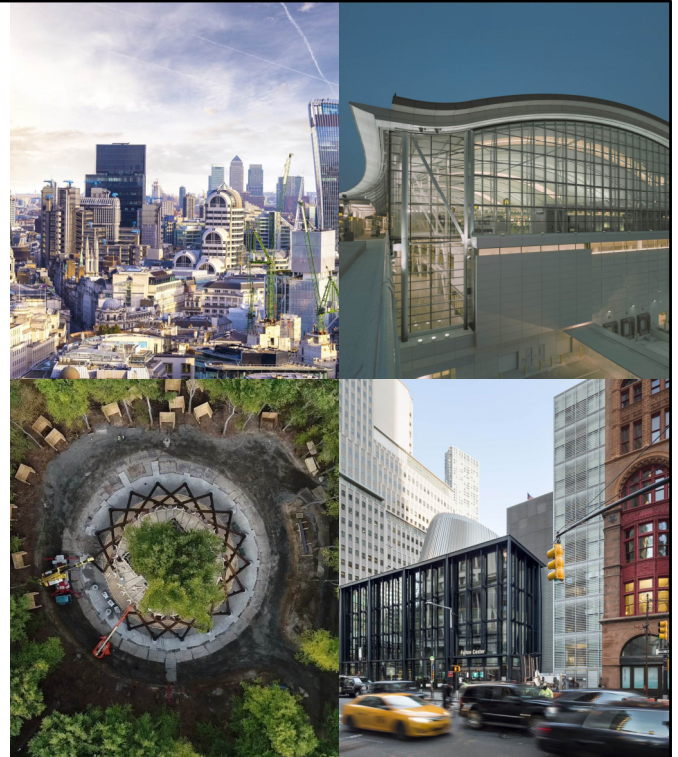
General introductions

Introduction

Who we are

- Designers, advisors & experts
 - Shape a better world
- Industry perspective
 - Acoustics
 - Inclusive Design

ARUP



We are Arup, a design firm with projects and people around the Globe. We work with clients and collaborators using imagination, technology and rigour to shape a better world.

We are fortunate to have both acoustics and inclusive design specialists in-house. This project is a collaboration of our Acoustics and Inclusive Design teams and we are here to provide an Industry perspective.

Specifically here – we are talking about buildings and about acoustics

Project aim

Acoustics & Inclusive Design for Aural Diversity

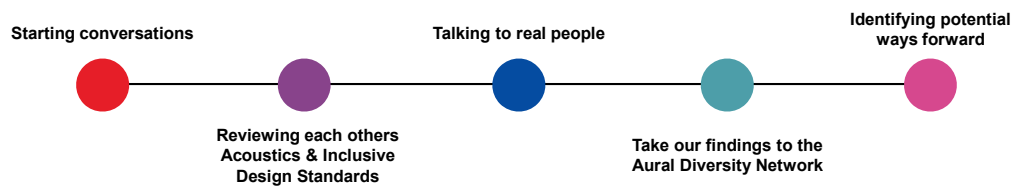
 Aim: To review the current state of acoustic design and inclusive design **standards** to consider how acoustic design can be **improved** for those with atypical hearing (e.g. hard of hearing, noise sensitivity etc.) to make spaces/environments more suitable for an **aurally diverse population**.



The aim of this project is to review the current state of acoustic design and inclusive design standards to consider how acoustic design can be improved for those with atypical hearing (e.g. hard of hearing, noise sensitivity etc.) to make spaces/environments more suitable for an aurally diverse population.

Project overview

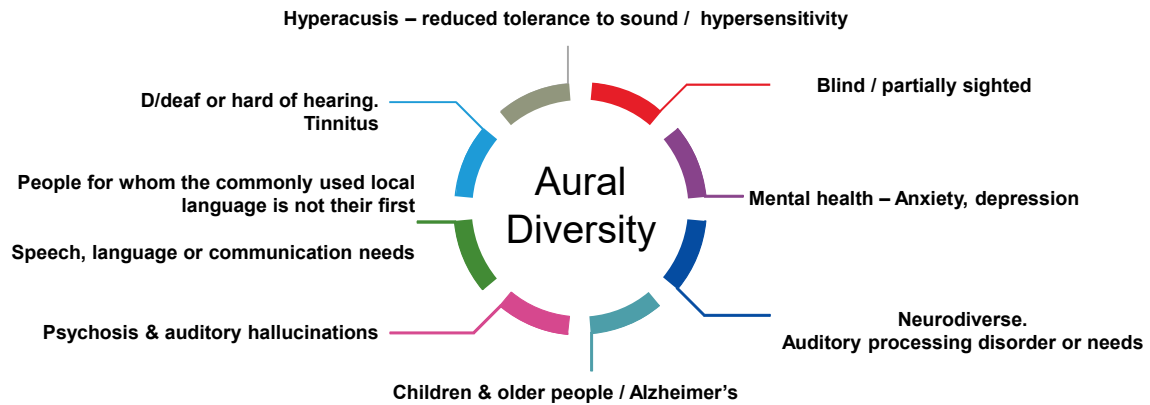
Acoustics & Inclusive Design for Aural Diversity



This is the process we are following reach our aim

Aural Diversity

What does it mean?



This diagram shows our interpretation of what aural diversity means

Focus

Acoustics & Inclusive Design for Aural Diversity

Acoustic comfort & communication



The focus of our study is **acoustic comfort and communication**

At this stage we are primarily considering internal commercial or public spaces rather than people's homes.

By acoustic comfort we mean how comfortable does a person feel in an acoustic environment or space

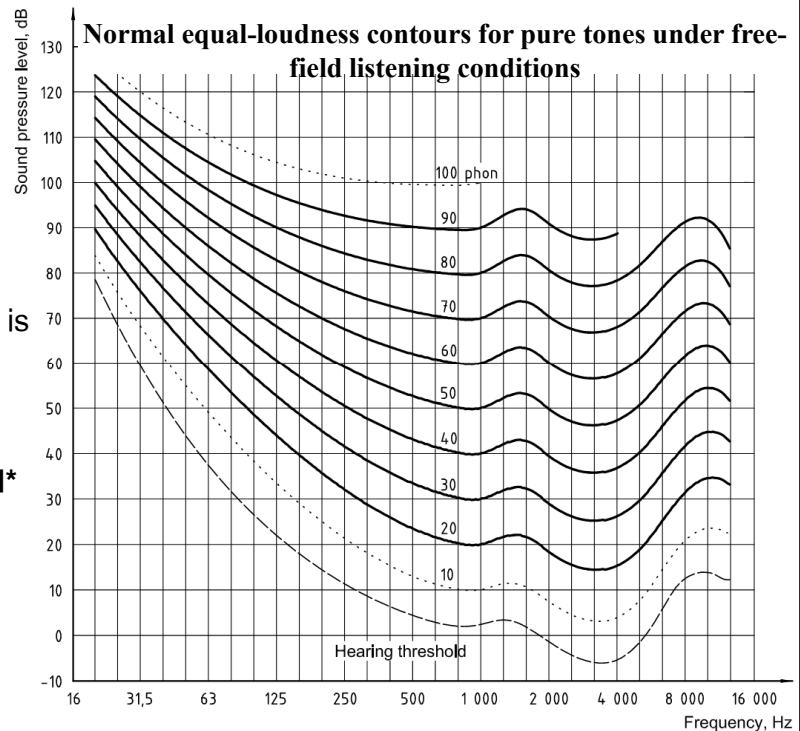
By communication we mean the ability to understand and be understood.

Background

Hearing

- Sound is measured in decibels
- To account for the human ear being less sensitive to low frequency sounds - A-weighting is used (dBA)
 - based on equal-loudness curves derived from listening tests on **otologically normal*** persons aged 18-25 year old using pure tones

*meaning without ear disease or hearing loss.



We measure sound in decibels

A-weighting is used to account for the human ear being less sensitive at certain frequencies. Acoustic criteria is commonly set using this A-weighting often referred to as “dBA”

The A-weighting is based on equal-loudness curves which are the black ones shown in the graph to the right.

The equal loudness curve represents the level at which the tone needs to be at per frequency in order to be judged to be equally loud.

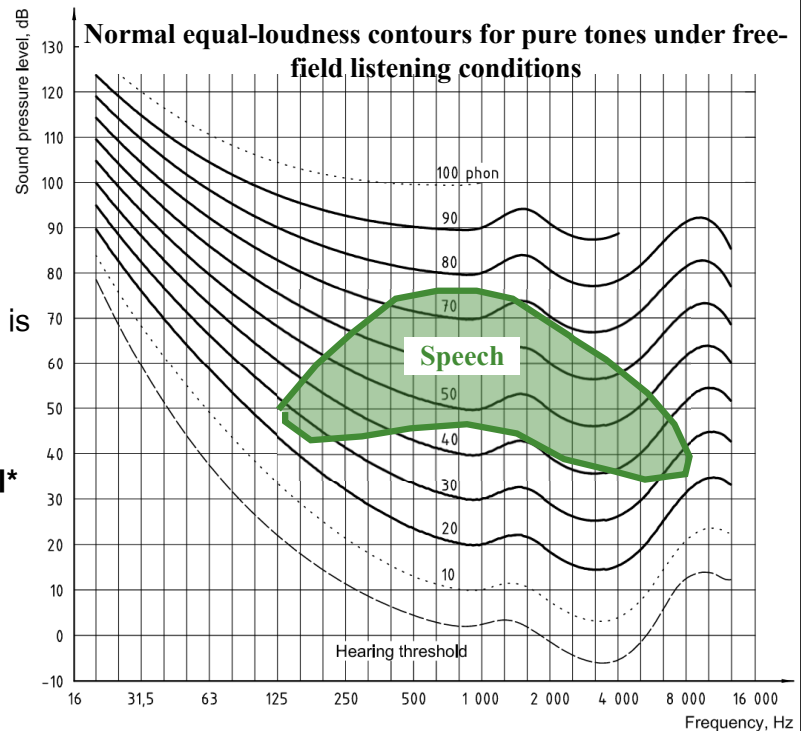
These curves are derived from listening tests on otologically normal persons aged 18 to 25 years. So it was derived from tests made in the 1980s through to the early 2000s on people with near perfect hearing.

This is a problem as most acoustic design criteria is based upon this dataset of essentially “perfect hearing” so by default is not inclusive

Background

Hearing

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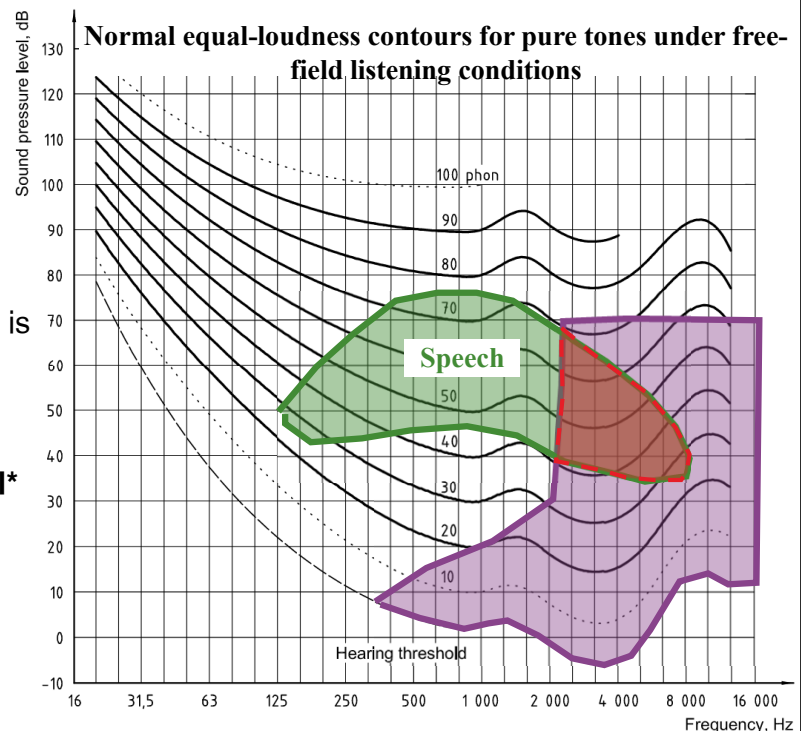


Speech is typically between bass to treble frequencies i.e. from below 125kHz to above 8kHz as shown in the green banana shape

Background

Hearing

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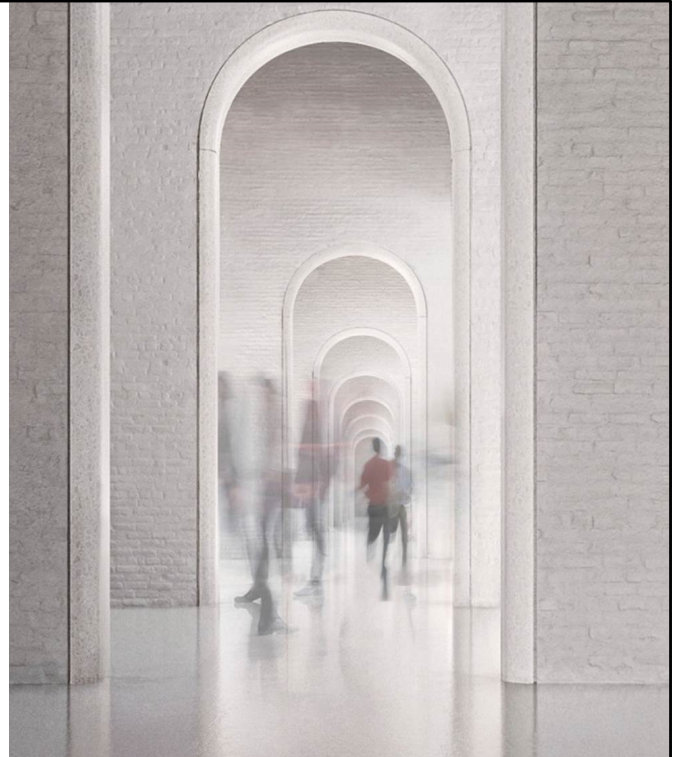


The red area shows an example of how a portion of the speech frequencies can be lost when hearing is reduced in the higher frequency range, for example as people age

Background

Standards

- Inclusive design standards & regulations give a nod to aural diversity
- Acoustic standards / guidance
 - set acoustic criteria however few and far between mention aural diversity



The **inclusive design standards** & regulations give a nod to acoustic diversity however there is a lack of technical knowledge and detail.

The **acoustic design standards** mostly provide criteria in dBA, which does not account for the fact that individuals hear differently and have differing hearing abilities



ANC

ACOUSTICS & NOISE CONSULTANTS

ARUP

Acoustics for inclusion

Arup Access & Inclusive Environments team

Nuala O'Sullivan

Ed Elbourne

RESEARCH AT ARUP

Acoustics in the workplace

– are we focusing on the actual elements that make the most difference to people?

SUMMARY

Noise levels in open plan offices have a big effect on people's ability to focus. However, relatively little research has been conducted into how different kinds of office noise affect different people's experience. To address this topic, acoustic engineers at Arup are

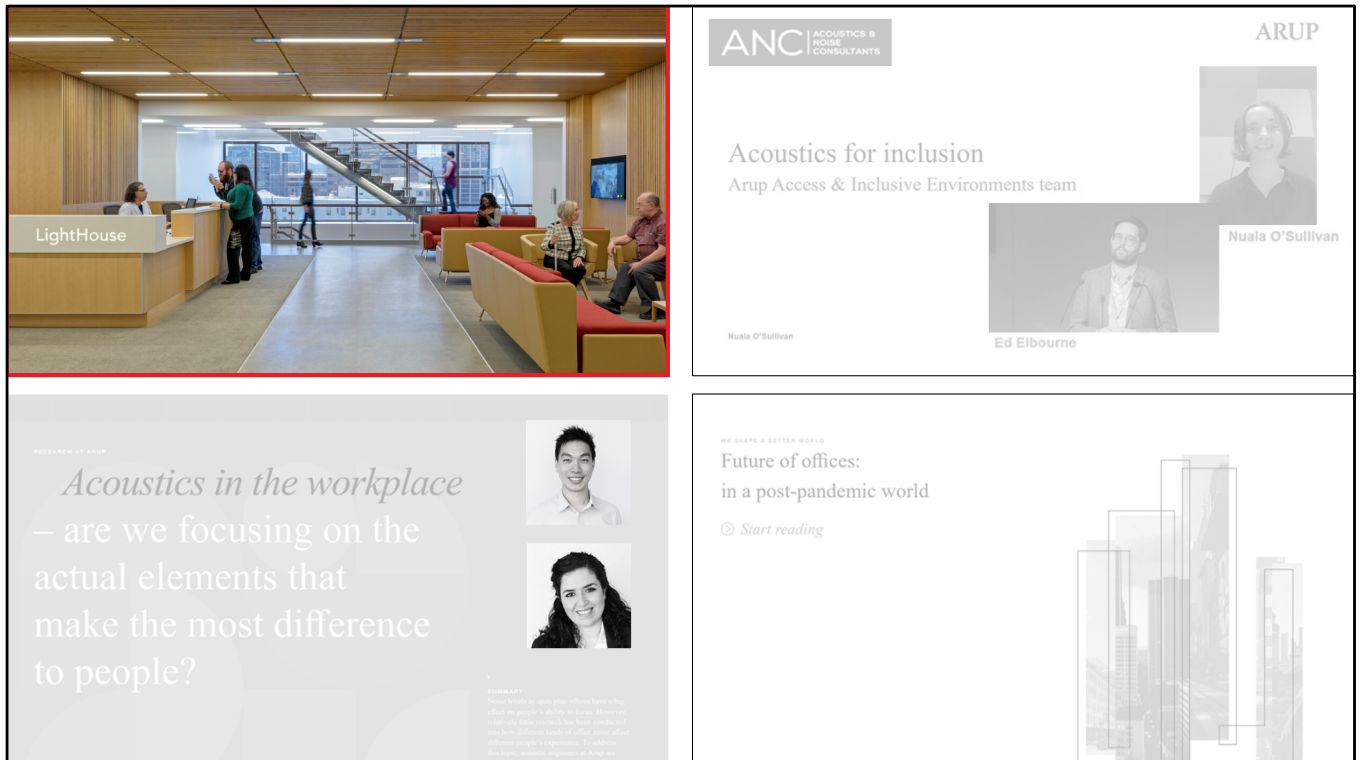
WE SHAPE A BETTER WORLD

Future of offices:

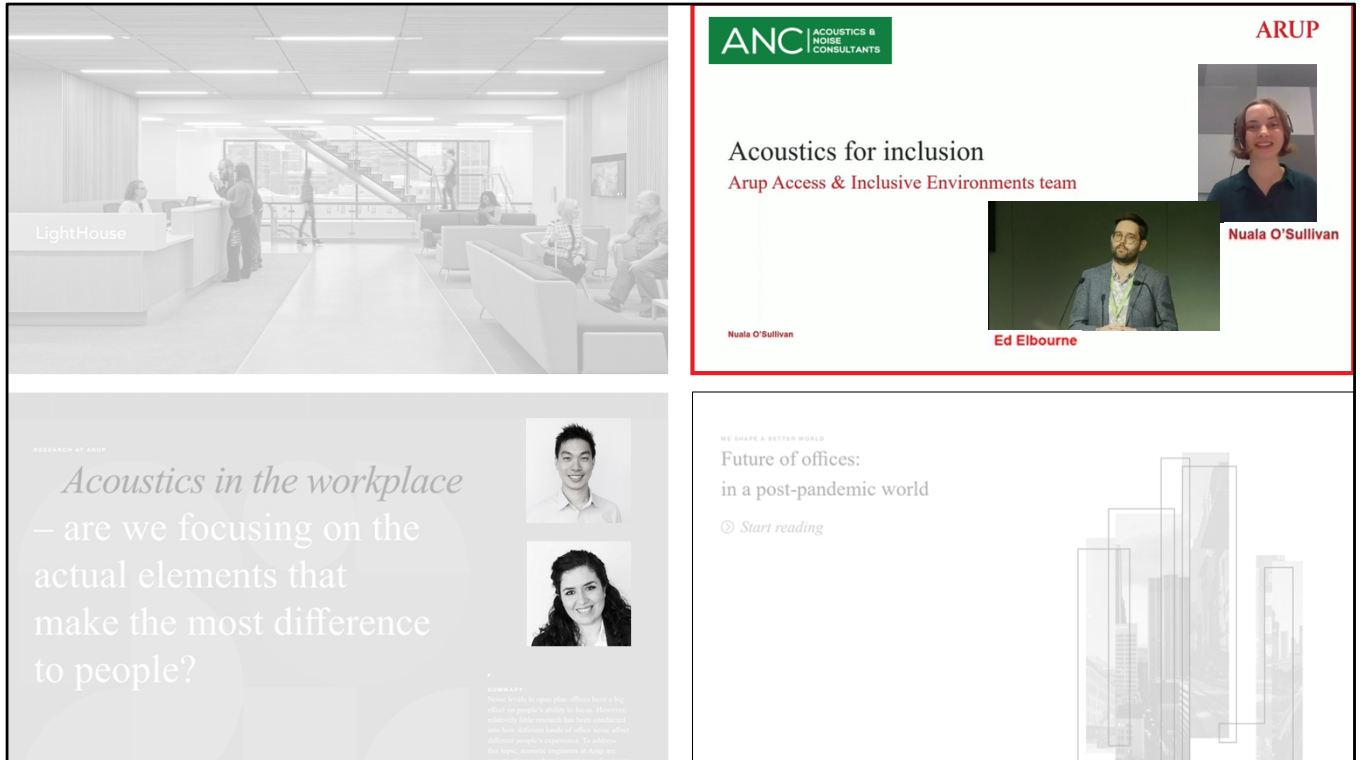
in a post-pandemic world

🕒 Start reading

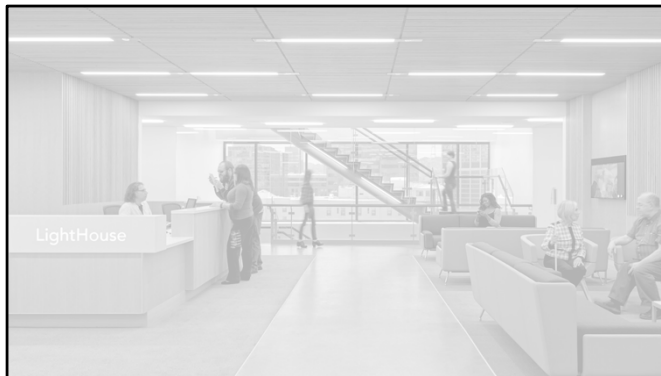
Here are some examples of existing work at Arup in this field



To the top left is the Lighthouse for the Blind and Visually Impaired. This is a building in San Francisco which is designed to promote the equality and independence of people who are blind or have low vision. The material selections were considered for acoustic feedback, for example what particular flooring would sound and feel like when someone travels with their cane.



On the top right Arup's contribution to the ANC Conference in 2021 on Acoustics for Inclusion. Our colleagues Ed and Nuala spoke about good practice principles of acoustics for inclusive design as well as particular examples of inclusive design in venues. The recording of the session is available online.



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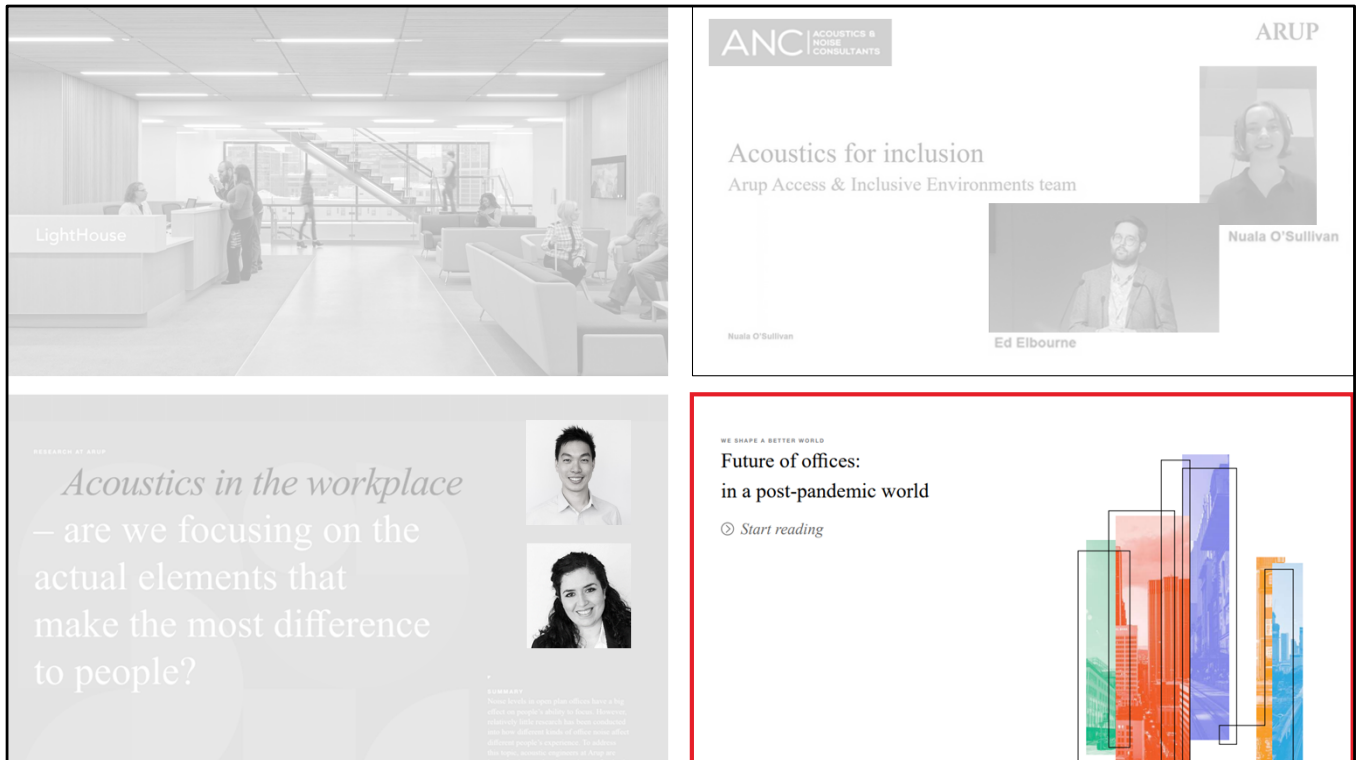
WE SHAPE A BETTER WORLD

Future of offices:

in a post-pandemic world

Start reading

The sound of collaboration - Acoustics in the workplace – is a research study focussed on user experience and particularly on staff wellbeing in offices considering collaboration noise in open plan offices. You can search for the publication online.



This is a study on future of offices: in a post-pandemic world looking at how COVID 19 has shifted the priorities towards Health, Wellbeing and Safety in the built environment.

Design Standards

Inclusive Design



The design of buildings and spaces is driven by technical standards.

Here are the Inclusive design standards we looked at.

Design Standards

Acoustics



Here are some of the acoustic standards we have looked at

These are used for the design of various buildings such as hospitals, offices, schools.

Design Standards

Acoustics



Acoustics & Inclusive Design Standards

Evaluation

What they **do** well:



- Schools guidance includes enhanced acoustic criteria
- Inclusive design guide for Neurodiversity includes particular acoustic criteria
- Inclusive design standards include lots of awareness level notes on what the challenges might be

What they **don't** do well:



- Very few acoustic standards mention differing hearing needs and very few reference Inclusive Design Standards
- Criteria typically based on dBA
- Inclusive design standards lack technical knowledge and level of detail on acoustics

We have taken a joined up approach on the Acoustics & Inclusive Design standards to evaluate what they do well and what they don't do well

There are some good example for the design of schools and for designing for neurodiversity

There is a risk that people's differing need could be overlooked as the criteria are generally based on near perfect hearing

Acoustics & Inclusive Design Standards

Evaluation

Good example:



- Network Rail Inclusive Design Manual
- Standalone section on acoustic design within stations/platforms
- Consideration of different auditory environments for people with reduced vision



One good example is the Network Rail Inclusive Design Manual which includes a standalone section on acoustics.

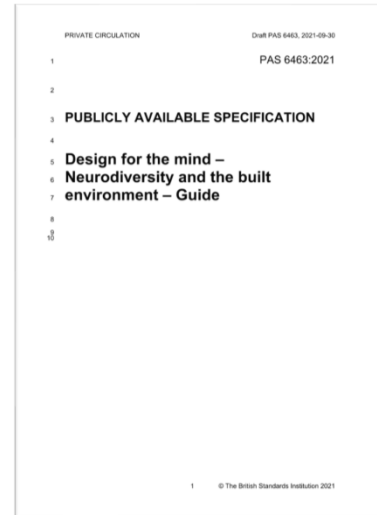
Acoustics & Inclusive Design Standards

Evaluation

Good example:



- PAS: Design for the Mind
- Brand new and currently in draft
- Only one of the inclusive design standards to include specific, measurable metrics
- Specifically addressing neurodiversity



Another good example is the PAS: Design for the Mind. It actually includes specific measurable criteria which is something we would like to see more of.

Acoustics & Inclusive Design Standards

Evaluation

Good example: Schools guidance



- Enhanced acoustic criteria for children with special hearing or communication needs:
 - speech, language and communication difficulties
 - visual impairments
 - fluctuating hearing impairments caused by conductive hearing loss
 - attention deficit hyperactivity disorders (ADHD)
 - an auditory processing disorder or difficulty
 - being on the autistic spectrum
- In-depth design guide providing more detail

Department for Education
Education Funding Agency

Acoustic design schools: performance standards

Building bulletin 93

February 2015

Acoustics of Schools: a design guide



November 2015

In terms of acoustic standards, the acoustics of schools guidance is an example of good practice in that it includes enhanced acoustic criteria for rooms designed for children with special hearing or communication needs.

It also includes an accompanying design guide which provides more detail and has a chapter on Acoustic design for pupils with special hearing requirements

Acoustics & Inclusive Design Standards

Evaluation

- Enhanced acoustic criteria:
 - Shorter reverberation time (0.4s), with lower frequency criteria
 - Higher sound insulation between spaces
 - Lower indoor ambient noise levels
- However these enhanced criteria are not necessarily applied in all learning spaces, rather for a...
 - *“Teaching space intended specifically for students with special hearing and communication needs”*

Department
for Education

Acoustic design
schools: perform
standards

Building bulletin 93

February 2015

Acoustics of Schools:
a design guide



November 2015

The enhanced acoustic criteria has been informed by the recommendations of the British Association of Teachers of the Deaf and the American Speech-Language-Hearing Association.

In essence the criteria sets better control of the reverberation in the space, higher control of sound between spaces and lower background ambient noise levels in classrooms.

The enhanced criteria is usually applied in specific learning spaces.

Acoustics & Inclusive Design Standards

Evaluation

Good example: Speech intelligibility



- Includes age-related hard of hearing intelligibility qualifications

Table 1.1 – Adjusted intelligibility qualification tables for normal listeners and people over 60 years old with hearing loss

STI label category	Normal listeners (Standard STI)	Older listeners PTA=15 dB	Older listeners PTA=20 dB	Older listeners PTA=30 dB
bad – poor	0,30	0,42	0,47	0,51
poor – fair	0,45	0,57	0,62	0,66
fair – good	0,60	0,72	cannot be achieved	cannot be achieved
good – excellent	0,75	cannot be achieved	cannot be achieved	cannot be achieved

To achieve an intelligibility equivalent to an STI of 0,45 for an older listener with PTA=15 dB, the transmission system needs to achieve an STI of 0,57.

NOTE 1 For details on categories, refer to ISO 9921.

NOTE 2 Typical normal listeners have a PTA of between 0 dB and 5 dB



Another area relates to the speech intelligibility of systems.

This particular sound system equipment standard does provide advice on criteria that is suitable for age-related hard of hearing.

But, in practice we know loudspeaker systems are rarely designed to achieve these values.

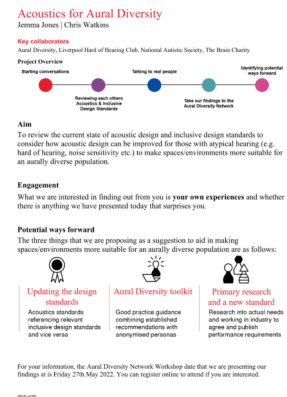
Community Engagement

We are currently engaging with various groups:

- Liverpool Hard of Hearing Club 
- The Brain Charity 
- The National Autistic Society 

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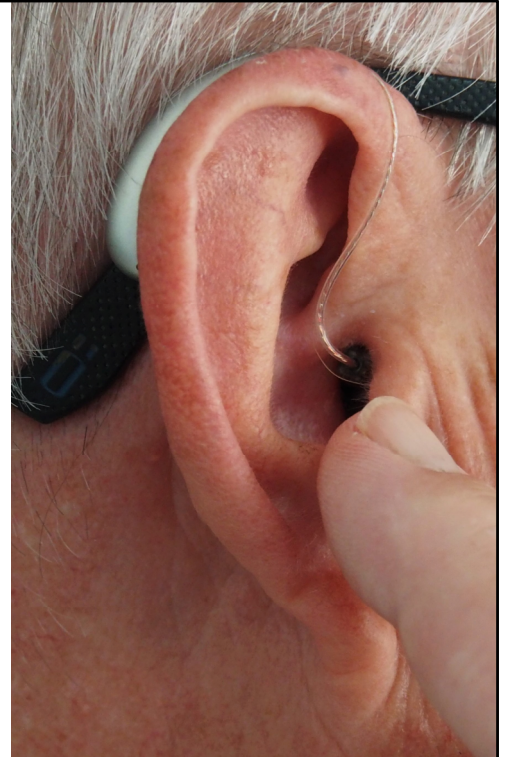


We are currently engaging with various building users to gain perspective.

Community Engagement

Liverpool Hard of Hearing Club 

- Some members wear hearing aids, some sign
- Breadth of experience within the group covering the following themes:
 - Hearing loop
 - Communication - in person / on the phone
 - Announcements & Alarms
 - Background noise
 - Disturbance from neighbours - noise and/or vibration



The Liverpool Hard of Hearing Club have a breadth of experience within their group. Some members wear hearing aids and some sign. The themes which came up in our engagement session included hearing loops, communication, announcements / alarms, background noise and disturbance from neighbours due to noise and/or vibration

Community Engagement

Liverpool Hard of Hearing Club 

Particular examples:

- Hearing loops being switched off or the staff are not trained on how to work them
- Call centre noise when on the phone to someone who is in a busy open office environment making it difficult to understand
- Reverberation and hard shiny surfaces causing problems
- Visual “noise” being distracting e.g. busy pattern on a curtain



We talked a lot about hearing loops and there were the usual issues of them being switched off or the staff of the building not being trained in how to work them.

There was an example of struggling to understand someone on the phone particularly because the person on the other side was in a busy open plan office environment

There was a sense that hard and shiny surfaces that are included in buildings these days can cause issues with reverberation if there are not enough soft furnishings or finishes

Visual “noise” was mentioned as being distracting e.g. if a person is trying to sign and lip read a busy pattern can be a hindrance.

Proposals for key improvements

Proposals for key improvements



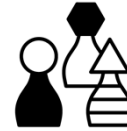
Updating the design standards

Acoustics standards referencing relevant inclusive design standards and vice versa



Aural Diversity toolkit

Good practice guidance combining established recommendations with anonymised personas



Primary research to inform industry

Research into actual needs and working in industry to agree and publish performance requirements

- We want to see updated design standards that reference both acoustics and inclusive design together.
- We are proposing to develop an aural diversity toolkit
- Research into actual needs to provide to provide an evidence basis for change

Updating the design standards



ARUP

- What is it? Acoustics standards referencing relevant inclusive design standards and vice versa
- Why? Bring about a greater awareness of inclusive design and aural diversity to design teams
- Who would use it? For use by building designers

Why are we proposing this?...to bring about a greater awareness of inclusive design and aural diversity to design teams

Aural Diversity toolkit

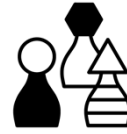


ARUP

- What is it? Good practice guidance combining established recommendations with anonymised personas
- Why? Bring about a greater awareness of differing needs and good practice design
- Who would use it? For use by building designers

The proposal is to create an Aural Diversity toolkit including good practice guidance combining established recommendations with anonymised personas
We propose to do this to bring about a greater awareness of differing needs and to implement good practice
It would be for use by building designers

Primary research to inform industry



ARUP

- Seek to define the following for various users in various spaces:
 - Acceptable levels of noise
 - Desirable reverberation times
 - Suitable sound insulation between spaces
 - Appropriate signal to noise levels
 - Vibration limits
- Acknowledging that all users are unique and so some may require a bespoke design not captured by standard enhanced criteria

As part of the primary research we are proposing, we seek to define the following for various users in various spaces for example:

Acceptable levels of noise

Desirable reverberation times

Suitable sound insulation between spaces

We acknowledge that all users are unique and so some may require a bespoke design not captured by any standard enhanced criteria that could be defined.

Summary

Acoustics & Inclusive Design for Aural Diversity

- There is lots of work still to do in this area



There is lots of work to do in this area and we would like your input

Team

Acoustics & Inclusive Design for Aural Diversity



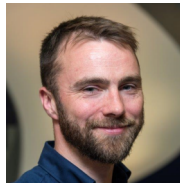
Mei-Yee Man Oram

Associate
Director
Access and
Inclusive
Environments



Chris Watkins

Senior Consultant
Access and
Inclusive
Environments



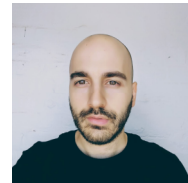
Adam Thomas

Senior Consultant
Acoustics



Jemma Jones

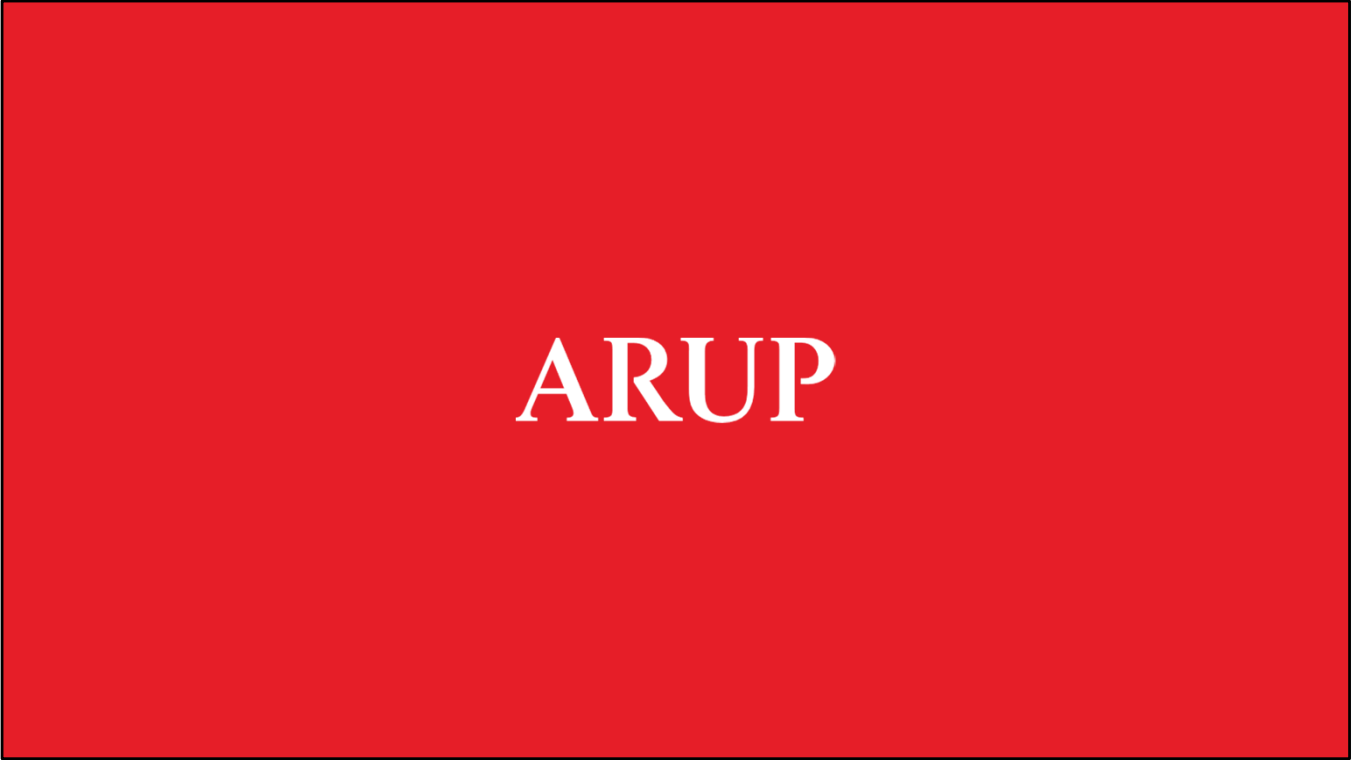
Consultant
Acoustics



Marios Filippoupolitis

Graduate Consultant
Acoustics

We will now open out to take any questions

The ARUP logo consists of the word "ARUP" in a white, serif, all-caps font, centered within a solid red rectangular background.

ARUP