Aural Diversity: noise control and a sustainable future.

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ABSTRACT

The unquestioned assumption of a "normal" pair of standard healthy ears underpins most sound-related disciplines, from acoustics to engineering, from music to sound studies, from medicine to hearing science. Yet, the reality is that everybody hears differently. Our ears are uniquely shaped. We all experience temporary changes in hearing, such as during a cold. Everybody goes through presbyacusis (age-related hearing loss) at varying rates after the teenage years. More specific aural divergences are the result of an array of hearing differences or impairments which affect roughly one sixth of the world's population [1]. These include noise-related, genetic, ototoxic, traumatic, and disorder-based hearing loss, some of which may cause full or partial deafness. Moreover, "loss" is not the only form of difference: auditory perceptual disorders such as tinnitus, hyperacusis and misophonia involve an increased sensitivity to sound. This paper presents findings from the AHRC-funded Aural Diversity Network, which explores the consequences of these differences for noise-related engineering and many other fields. How may we ensure a sustainable future that acknowledges aural diversity?

1. INTRODUCTION

Let's begin with a provocative statement: *noise control that ignores aural diversity is not noise control!* Noise is defined as unwanted sound which may be hazardous to health, interfere with speech and verbal communications, or is otherwise disturbing, irritating or annoying. In other words, it is a matter of perception. What is noise to one is, by definition, not necessarily noise to all. We cannot control noise in a one-size-fits-all sort of way. The notion of Aural Diversity is essential if we are to succeed in controlling something so subjective and variable.

2. AURAL DIVERSITY

Aural Diversity is founded on the observation that everybody hears differently. This is simply a matter of fact. Naturally occurring physical differences such as the shape of the flaps, or pinna, of the outer ear, are unique to each individual. The ridges and folds of these appendages gather in sounds and convey localisation information, and other aspects, in ways that are subtly different from person to person and from situation to situation. Our age, our state of health, our social situation, the environment around us, and many other time-based factors, also affect the way we hear. If we have a cold on a given day, that can change our hearing. We are doubtless all familiar with that blocked up feeling in the Eustachian tubes, or a sudden change in hearing when a yawn changes the relative air pressure between outer and middle ear.

Every person experiences age-related hearing loss, or presbycusis, which begins in our early twenties and starts to become noticeable in middle age. Men lose their hearing this way faster than women, but everybody finds themselves sooner or later struggling with speech in crowded situations, unable to distinguish certain vocal sounds such as 's' and 'th', loss of perception of high frequencies, and an increasing tendency to ask people to repeat themselves or speak up until it sounds like shouting - a process called recruitment. Such loss is normally remedied by hearing aids, which amplify and modify aspects of the incoming signal. The hearing aid is a prosthetic machine listening device that replaces natural hearing. What sounds like noise through a hearing aid is rather different to what sounds like noise to an unmediated ear.

All of this is normal and common to every adult to some degree. But one sixth of the world's population, roughly 32 million people, possesses hearing differences that are measurable enough to be medically diagnosed [1]. These range from profound congenital deafness to heightened hearing sensitivities. These are often called impairments, but the social model of disability suggests that it is the environment that is disabling. Not every hearing difference is a problem for the individual, but they are *all* a distinct difference. For some people, the onset of this difference is experienced as a loss. Others who are born with hearing difference or acquire it at a very young age may well see it as integral to their identity as a human being, as inseparable from their essence as left or right-handedness, or the colour of their eyes.

"Aural Diversity" then, like biodiversity, simply describes this great variety of hearing. It includes the hearing of babies, whose acoustic apparatus takes six months to develop to the point that they can fully hear and understand sounds. And it goes beyond human hearing, to encompass animals, whose capabilities are vastly different to those of people. We may point to the ultrasonic emissions of bats or the infrasonic listening of pigeons and thousands of other examples, such as dolphins, elephants, owls, moths, cats, dogs, rats, and many more. Machines also hear differently to humans, if "hearing" is indeed the right word for machine handling of sound. The process of becoming familiar with cochlear implants, for example, is essentially a human-computer interface adjustment as the brain slowly makes sense of the range of strange and etiolated sounds that are received by the sensorineural system. As Meri Kytö points out, the cochlear implant is in effect a soundscape arranger, with compositional agency in the act of listening [2].

The infographic in Figure 1 attempts to summarise all this in a single diagram. It is of course very high level and probably fairly incomplete, but it does manage to convey something of the extent of aural diversity.

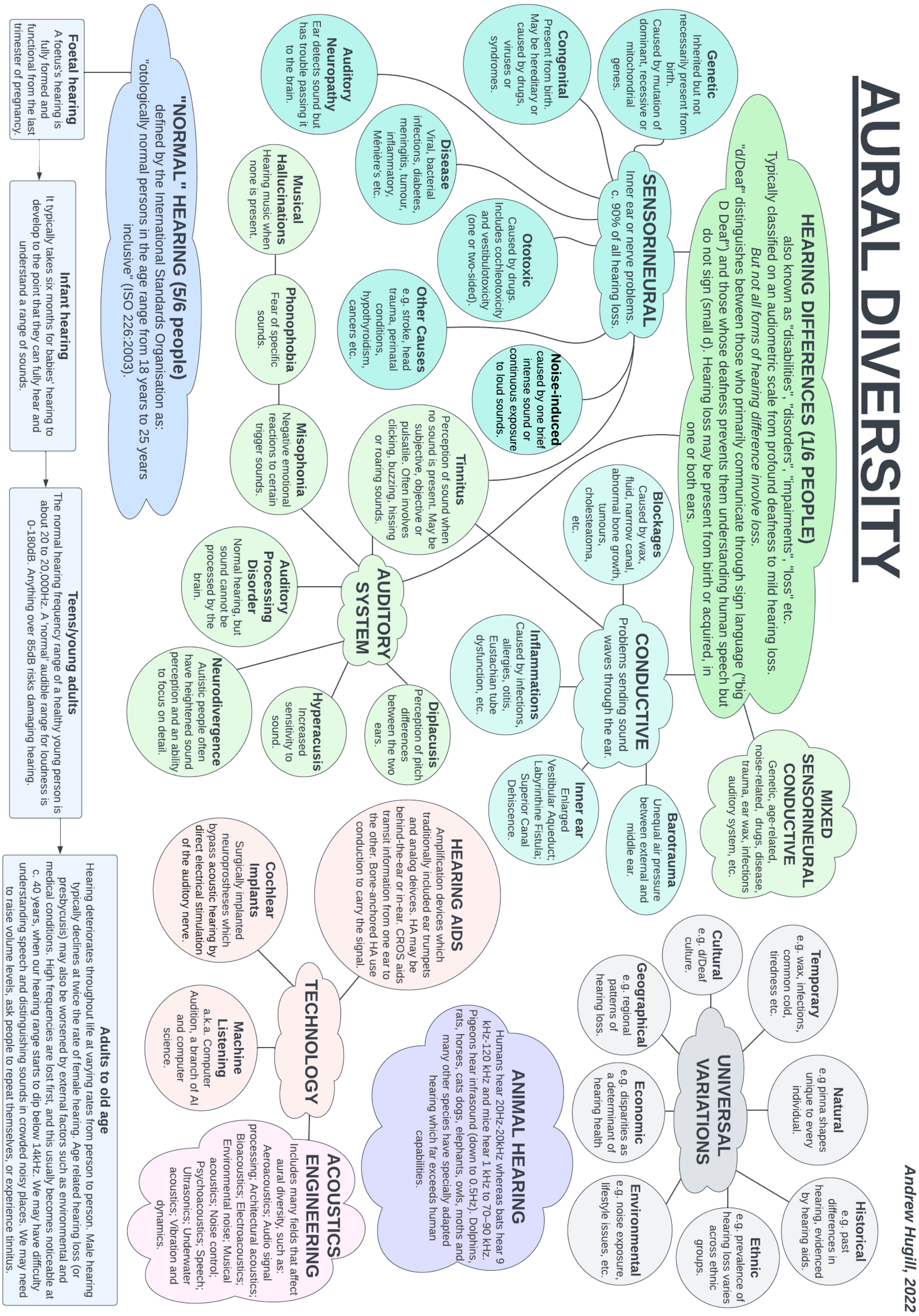

Figure 1: Aural Diversity infographic

3. SCIENTIFIC CONSEQUENCES

Given the vastness of aural diversity, it might be expected that sound-related disciplines such as acoustics and engineering, music and sound studies, audiology and hearing science, would always take into account the variations in hearing that characterize sound perception and response. Yet even the most cursory review of the standard literature in these disciplines reveals a tacit acceptance of a standardized set of norms that systematically ignore this reality. The general assumption is that everyone is in possession of an equally balanced pair of ears, defined by the International Standards Organization as those of "otologically normal persons in the age range from 18 years to 25 years inclusive" [3] This assumption is so unremarkable as to go unacknowledged in all but the most specialised literature. But it is a dangerous generalisation that excludes large numbers of people and from a whole range of environments and technologies, designs and artworks, processes and situations.

The presence of noise is a major factor in this systematic exclusion of aurally divergent persons. Consider, for example, hyperacusis, in which there is an increased sensitivity to sounds, especially everyday sounds that most people would find tolerable [4]; or misophonia, in which certain sounds trigger an unwanted and powerfully negative emotional reaction [5]. The prevalence of hyperacusis is estimated at up to 17% of the population and misophonia at a surprising 15%. In other words, one billion people around the world experience one or both of these: roughly the same number as those who are reckoned to have disabilities overall. This is a significant group whose perception of what constitutes noise is greatly different to those deemed "otologically normal". Any standardised solution to noise is unlikely or unable to take account of such variations. We need a more granular approach in which the needs of individuals and groups are taken into account. In other words, the science of noise control needs to be more inclusive and accepting of aural diversity.

3. The AURAL DIVERSITY Project http://auraldiversity.org

I started the Aural Diversity Project in 2018, following my own experience of severe unbalanced hearing loss due to Ménière's Disease, diagnosed in 2009. This compounded some peculiar aspects of my listening that I had possessed since birth, thanks to autism. As a Professor of Music and a composer I had always worked with my special hearing, unaware of just how unusual it was until Ménière's forced me to reconsider my professional involvement and make a sideways move into Creative Computing. I still compose and perform, but now in ways that are compatible with my hearing requirements and often with those as the subject-matter of my works.

The Aural Diversity project quickly grew, attracting funding and support from: GNResound Ltd, the hearing aid company; Arts Council England; the Attenborough Arts Centre; and the Arts & Humanities Research Council. The AHRC are funding the currently running network that has held three workshops so far. The first covered Hearing Care and Hearing Technologies, and was led by Dr Alinka Greasley at the University of Leeds. The second concerned Hearing Sciences and the Arts and Humanities, and was led by Professor David Baguley and hosted by the University of Nottingham. The third was on Acoustics and Psychoacoustics, led by Professor Bill Davies and hosted by University of Salford. Next month will see the fourth workshop, on Soundscape and Sound Studies, led by Professor John Levack Drever and Professor Joshua Reiss, and hosted by Goldsmiths College and Queen Mary University of London respectively. The final workshop will take place in January 2023, led by myself and hosted at the University of Leicester and the Attenborough Arts Centre. The theme will be Music and Performance. This will include several new commissions of works by and for aurally divergent persons. One feature of the Aural Diversity project has been a series of concerts that adopt a unique listening format designed to accommodate as many hearing types as possible and including multiple ways to listen, from tactile interfaces and vibrating floors, to British Sign Language and video interpretations, to direct streaming to headphones and hearing aids. The concert programme gives advance warnings of the acoustic characteristics of each work and suggests ideal listening strategies for each set of hearing needs.

The term "auraldiversity" was coined by John Levack Drever in 2018, to echo 'neurodiversity' as a way of distinguishing between 'normal' and atypical hearing [6]. The Aural Diversity project explores the consequences of these differences. It will be noted that the project generally avoids the term "disability". This is not to deny the disabling effects of hearing loss, but rather to focus on the potential in the concept of diversity. A multi-authored book with the title ‘Aural Diversity’ and edited by Drever and myself will be published by Routledge in 2022. Today's panel will summarise several of the findings of the network so far.

4. CONCLUSION

What could the future hold? We may dare to imagine a world in which noise controls better reflect individual needs. Why should we have to adapt to noise controls? Why can they not adapt to us? This is also the key to sustainability, because only noise controls that take account of individual differences stand a chance of being adopted by all. I would love to be able to enter a space or a situation in the knowledge that all my hearing needs were met in advance.

5. REFERENCES

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