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Do You Hear What I Hear? Some creative approaches to sharing and simulating diverse hearing

John D'Arcy

Introduction

In its early stages, the *Do You Hear What I Hear* project explores how aural diversity might be shared with the broader public through technology-assisted interactive experiences. The project aims to incorporate augmented-reality audio within participatory performance in an exploration of a spectrum of aurality. It is hoped that these performances might help audiences better understand diverse sensory experiences and come to question preconceptions of normalcy in hearing.

This chapter documents the development of *Do You Hear What I Hear* through three initial pilot activities carried out at public events and conferences between 2018-20 and the audio processing software used in these. Some participant feedback is shared, along with ideas for development of future activities.

Context

Jonathan Sterne points to the otological ‘normalism’ pervasive throughout societal discourse on human hearing that reaches across various fields in science and technology (Sterne 2015). Addressing the interdisciplinary field in which he situates himself, Sterne proposes that “sound studies—but also many forms of politics—begins with hearing the hearing of others” (Sterne 2015, 66). I find this phrase to be a valuable provocation for the activities of *Do You Hear What I Hear*, to find ways of better understanding diverse modes of hearing through the act of listening.

Aural representations of sensory difference are commonplace in media and arts where sound design interprets a specific character’s hearing perspective. Altman (1992) terms this technique ‘point-of-audition’ sound (POA). Audiences are accustomed to the sonic tropes of ‘shellshock silence’ and ‘cinematic tinnitus’ often associated with negative experiences of pain and trauma. However, a recent episode of the BBC’s hospital drama *Casualty*, ‘Jade’s World’, attempts to present a more rounded representation of sensory difference. This production involved Deaf representation in the writing and direction team and carefully designed POA sound based on recurring deaf character Jade’s sensory experience (Ward et al. 2020).

Elsewhere, audio processing for hearing loss simulation (HLS) and cochlear implant (CI) simulation is deployed in audiological research in trials amongst a broad base of participants. Simulations are also used in the design of hearing aid and CI products (to broaden participant testing pools) and in the marketing of these products (typically to illustrate the ‘need’ for a device).

HLS is also adopted in sensory awareness training in the realm of healthcare and education. While these activities aim to improve positive attitudes towards sensory difference, some forms of ‘simulation’ training have come under criticism. French (2013) proposes that simulation exercises may create a sense of individualisation and medicalisation, which may ultimately convey misleading information and cultivate negative attitudes towards disability. French calls for ‘disability equality training’ approaches based on dialogue around broader societal issues of inclusion and representation.

My first work with the sounds of sensory diversity was as the sound designer for the theatre piece *The Unheard* (2017). I consulted with the playwright Vanessa Haynes to accompany her autobiographical narrative about hearing loss, tinnitus and hearing aid usage with aural representations using audio signal processing and sound synthesis. The audience heard these aural representations via manipulation of both pre-recorded sounds and the performer’s voice live on stage. At different times these were heard via surrounding loudspeakers and individually assigned headphones.

In a survey conducted with the audience of *The Unheard*, some listeners drew links between the experience and experiences in their own lives (“my father wears a hearing aid and I found it very useful and effective to have a first-person experience”). Others investigated their preconceptions (“I reflected on the assumptions I make about other people’s sensory abilities”). Some felt prompted to address their everyday recognition of sensory diversity (“be more patient”, “more aware”, “show empathy”, “be more tolerant and understanding”).

Perhaps the most exciting responses (1) alluded to assumptions of the ‘normal hearing’ community: “I assumed I knew what hearing impairment was... I was wrong”; and (2) considered how technologically-mediated listening experiences might challenge these assumptions and understandings: “I feel like I have learned more from this immersive theatre experience than I have from written and verbal communication alone”. Responses like these helped encourage me to develop *Do You Hear What I Hear* to explore how aural diversity might be shared through mediated listening experiences.

The initial activities of Do You Hear What I Hear

Do You Hear What I Hear would adopt two key considerations of *The Unheard*: (1) real-time manipulation of audio to convey varying modes of hearing; and (2) the use of individual headphones for audience members. *Do You Hear What I Hear* would introduce additional considerations: (3) audience mobility; (4) dialogue with the audience; (5) mediation of audience voices; (6) audience control of audio settings. It is hoped that through these strategies, the project might create affective experiences and stimulate meaningful conversation around aural diversity whilst avoiding the pitfalls of simulation discussed earlier.

Below, these six key considerations of the project are discussed concerning the three initial activities involving three versions of a bespoke smartphone application:

- i. *Ways of Hearing* app developed for a workshop at the Sonic Arts Research Centre, Belfast.

- ii. *Do You Hear What I Hear v1* app update for exhibition activities at Belfast City Council's Summer of Music programme 2018, various conferences in 2019 (TaPRA, Irish Sound Science & Technology Association and Aural Diversity) and NI Science Festival in 2020.
- iii. *Do You Hear What I Hear v2* app update for remote facilitation at Urban-Related Sensorium 2020.

1. Real-time manipulation of audio to convey varying ways of hearing

Developing from the aural representation of Hayne's hearing loss and tinnitus in *The Unheard*, it was hoped that the activities of *Do You Hear What I Hear* might convey a larger palette of aural diversity, including hyperacusis, CI listening and others. The aural representations or simulations of hearing adopted in audiology research, sensory awareness training and media demonstrate various approaches. Some aim for physiological or phenomenological realism. Others adopt artistic impressions or interpretations. The initial activities of *Do You Hear What I Hear* would adopt an approach broadly based on physiological or technological aspects of specific ways of hearing but not modelled on specific individuals (e.g. audiograms, CI settings). This approach would involve audio processing to interpret some aspects of a particular sensory difference rather than claiming a 'realistic' simulation to avoid the feeling of individualisation and medicalisation sometimes critiqued in simulation experiences.

The first app, *Ways of Hearing*, featured two modes: a multiband compressor conveying age-related hearing loss and a noise vocoder interpreting the audio processing of a CI. A variety

of techniques are commonly deployed in HLS (Mourgela 2019 provides a useful summary of these). Due to the audio processing capabilities of the smartphone application, it was decided that the multiband compressor would serve as a good impression of commonplace differences in dynamic range and spectrum filtering (EQ). The noise vocoder employed to mimic the filterbank stage of a CI's audio processing. Since this implementation, a recent study suggests that the traditional noise vocoder approach to CI hearing simulation may be significantly improved by combining various spectral filtering methods (Dorman et al. 2020). Similar techniques may improve future iterations of *Do You Hear What I Hear* if deemed most appropriate to represent CI hearing realistically.

The subsequent app update *Do You Hear What I Hear v1* added additional audio settings aiming to decentralise further the assumed normalcy of the listener's own hearing. One of these was influenced by Matt Green's animal hearing exploration project *Ears of Others* (2015). This used an amplified notch in high frequency sounds to create an interpretation of animal hearing and start a conversation around high-frequency sensitivity among humans with conditions such as hyperacusis. Another two additional audio settings, 'hypothetical ears', hinted at future technological hearing augmentations. One of these tuned a resonant filter bank into bell-like musical chords, while the other used a modulating stereo delay creating pitch-shifting echoes across two ears.

The third app, *Do You Hear What I Hear v2*, added a 'drone selector' that allowed one of four additional signals to be added to the audio mix. These additional signals were a selection of sine wave tones and filter noise based on varying descriptions of tinnitus (Kaltenbach 2011).

Listener responses, both verbally during the activities and in feedback surveys completed afterwards, demonstrated a keen interest and curiosity in the variety of audio settings. Whilst listening, audiences showed signs of concentration and contemplation, often articulating their interpretations of sonic characteristics. While many listeners made aesthetic judgements of individual audio settings, the broad reaction to the variety of settings was promising:

“I guess I assumed my hearing was ‘normal’, but I now appreciate that there are many different ways of hearing.”

“What a variety of different ways of hearing there exists and how difficult it is to imagine another person’s aural perspective.”

2. Individual headphones for audience members

In *The Unheard*, individual headphones gave listeners a close-up experience of the live audio processes conveying Hayne’s hearing loss and tinnitus. Headphones have been used extensively in theatre and audio art to explore embodiment, immersion and intersensory perception (Klich 2017). Particularly influential on *The Unheard* were the intimate sound stage of *Reassembled Slightly Askew* (2015) and the sharing of another’s perspective in *The Encounter* (2015).

The initial activities of *Do You Hear What I Hear* rather more closely echo Peter Ablinger’s headphone-based interactive sound artwork *Kopfhörer* (1999), where listeners hear their surroundings through microphones mounted on their headphones. The individual link between the headphones and live microphone feed would be central in heightening

embodiment and immersion whilst exploring the audio settings of the *Do You Hear What I Hear* apps.

The headphones used in initial activities were chosen for their balance of cost, audio quality and relatively strong noise isolation (-35dB) to help block out external sounds blending with the audio received from the app. Nevertheless, loud sounds would still cause a noticeable bleed through the headphones, reducing the intended clarity of the app audio.

An important observation during testing was the potential for audio feedback caused by the proximity of the microphone to the headphones when headphone speakers were exposed (i.e. not worn on the head). This was prevented by keeping volume levels low during setup and including an introductory warning about high volume levels.

3. Audience mobility

A key consideration of *Do You Hear What I Hear* was audience mobility. Mobile works as a subset of headphone theatre and sound art raise the same questions around immersion and embodiment whilst inviting a physical exploration of an environment. In site-specific/promenade theatre, elements of narrative and soundtrack augment everyday spaces, asking us to experience these environments in new ways (Barton 2012). Whilst prominent artists such as Janet Cardiff and Lundhal & Seidl use pre-recorded narrative and soundscapes, the initial activities *Do You Hear What I Hear* would aim to incorporate the live audio feed of the in situ aural surroundings.

Smartphones with inbuilt microphones were used, affording portability and ease of app prototyping. MobMuPlat was chosen as a wrapper for the PureData audio programming platform, allowing distribution to Android and iOS devices. The portable smartphone set up in the initial activities of *Do You Hear What I Hear* allowed the audience to hear the sounds of their surrounding environment through the varying audio settings of the app, helping frame the discussion around aural diversity within everyday environmental listening.

4. Dialogue with the audience

The initial activities of *Do You Hear What I Hear* were centred around a dialogue between the audience and a facilitator so that the different audio settings could be given context within a discussion of aural diversity. It was hoped that this interaction would encourage critical engagement with one's own hearing and consideration of broader implications such as equality and inclusion.

During the initial activities, the discussion and listening process was preceded by some questions on the audience survey sheet, hoping to prime the audience for a critical reflection on sound and hearing. Questions included:

- “What are your favourite sounds?” (most respondents chose music, water and birds)
- “What are your least favourite sounds?” (most respondents chose loud, high-frequency sounds, or a particular instance of voice or speech)
- “What would you change about your hearing” had a wide variety of answers, including ‘nothing’, ‘better’, ‘clearer’, ‘sensitivity’, ‘less chaos’ ‘less background’,

‘less crowds’, ‘hear distance’, ‘less damage’, ‘remove tinnitus’, ‘turn on/off’,
‘echolocation, and ‘would have mood music in the background all the time’.

The first workshop, *Ways of Hearing* (2018), was held as a one-hour group session for 15 participants in a three-part structure:

1. Introduction (including overviews of hearing loss and CI hearing, a guide to the mobile listening activity, the functionality of the *Ways of Hearing* app)
2. Mobile listening activity (vocalisation and listening using the *Ways of Hearing* app, carried out in the building’s auditorium, hallways/staircases and outdoors)
3. Reflective conversation amongst the participants

Following the *Ways of Hearing* workshop, a shorter 20-minute activity was designed with the aim of embedding reflective conversation into the listening activity, and working with smaller groups of five to allow more one to one engagement with the facilitator. Here, the *Do You Hear What I Hear v1* app was used, with listeners gathered around a table (indoor or outdoor depending on venue) and carried out listening activities while conversing with the facilitator. The activity was structured to demonstrate the different audio settings of the app one by one. A narrative device (‘trying on someone else’s ears’) was used, with a name given to each audio setting: *Jean* (HLS); *Charlie* (boosted high frequencies); *Rory* (noise vocoder); *Elliot* (harmonious filterbank); and *Morgan* (stereo echoes). The introduction made clear that these ‘ears’ were not realistic simulations or replications but rather creative interpretations and impressions of aural diversity.

Each audio setting presented an opportunity to discuss a different aspect of hearing and sound while allowing individuals to share relevant anecdotes about their hearing and that of friends and family. Whilst exploring the HLS (*Jean*), the audience was introduced to the frequency spectrum, dynamic range and how sensitivity typically changes with age. The noise vocoder (*Rory*) was an opportunity to discuss the technologies of CI and introduce the cultural debates around it. This setting also impeded speech recognition for some listeners, introducing a consideration of how some ways of hearing may impact the cognitive load of everyday verbal communication. The final two ‘hypothetical ears’ *Elliot* and *Morgan* started a speculative conversation about how we might use technology to change our hearing for aesthetic or functional reasons. Hopefully, these conversations reposition hearing technologies not just as ‘cures’ or ‘treatments’ but rather, as Park (2014) suggests, signposts on a continuum of individual differences.

The *Do You Hear What I Hear v2* app update was developed specifically for remote facilitation at the online conference Urban-Related Sensorium (2020). This version of the activity incorporated the information and questions previously delivered by the facilitator as onscreen instructions in a step-by-step guide through audio settings and a series of listening and sound-making activities. Creating this app helped refine the core components of the dialogue with the audience as a concise text, and positive audience feedback was encouraging for further development of a downloadable interactive app. However, it is hard to gauge how listeners interpret the audio settings and information around sensory differences without in-person dialogue.

5. Mediation of audience voices

The activities of *Do You Hear What I Hear* invite listeners to speak, sing and produce a variety of noises into the microphone and hear these directly through the app's audio processing. Many representations of hearing in media and HLS are heard on pre-recorded audio. However, some projects such as Ablinger's *Kopfhörer* (1999), with live sound mediated through microphones mounted on headphones, allow the listener to join the sound scene and interact with the system. In *Do You Hear What I Hear*, it is hoped that the listener hearing their vocalisations through the audio settings will create more significant engagement with the sonic experience and ultimately the discussion around aural diversity.

The audience was invited at various points during the activity to speak directly into their smartphone microphone. Typically, audiences showed some initial trepidation around vocalising aloud. Many individuals whispered, spoke quietly, or mumbled at first. In these instances, the facilitator actively encouraged louder vocalisation, and as the activity progressed, most individuals confidently spoke into the microphone. In audience feedback, some respondents indicated their favourite part of the activity was "hearing my own voice".

The use of smartphones allowed audience members to quickly move their handsets to angle the inbuilt microphone towards their mouth or the other group members. This was particularly popular for audience members participating in the activity as a pair or a group. In audience feedback, some respondents indicated this was their favourite part of the activity ("laughing with my mum and brother").

Perhaps the most interesting audio settings for users to explore with their voices were the 'hypothetical ears'. Whilst listening through *Elliot*, individuals made percussive noises such as clapping and tapping to hear the musical response of the resonant filterbank.

The *Morgan* settings seemed to inspire extended use of one's voice in two ways. Firstly, the echo of the voice heard whilst trying to continue speaking prompted a sense of self-talk monologue, with moments of confusion and weighty cognitive load (a phenomenon demonstrated beautifully in Nancy Holt and Richard Serra's video *Boomerang* (1974)). Secondly, the changing vocal pitch caused by the modulating echo time created a sense of wonder, curiosity and alienation as listeners conversed with their own low and high echoes. Several individuals alluded to gender stereotypes, raising conversations around the physiology of the voice and one's perception of their own voice.

6. Audience control of audio settings

It is hoped that the ability to control audio settings within the *Do You Hear What I Hear* apps will help listeners better understand the underlying audio processing effects and ultimately engage more deeply with the conversations around diverse ways of hearing. Some HLS demonstrate one or two pre-set audio settings. However, others like 3D Tune-in's *Online Toolkit* web app offer many adjustments to explore sonic effects (e.g. 'level of hearing loss', 'frequency smearing' and 'temporal distortion').

Looking to the realm of augmented-reality audio apps, many give the user intricate control over settings that manipulate the processing of the live microphone signal. Reality Jockey's *RJDJ* (2008) used the smartphone's touchscreen, gyroscope and GPS as input controls for audio effects parameters such as delay and filtering to alter the listener's soundscape in what they called 'reactive music'. The app's successor *Hear – Advanced Listening* (2016) took some of the live audio processing ideas of *RJDJ* but presented these as a set of 'filters' with specific functional or aesthetic effects designed for specified listening

scenarios: ‘Talk’, ‘Sleep’, ‘Office’, ‘Relax’, ‘Happy’, ‘Super Hearing’. The Hear One earbuds (2017) led a wave of wireless earbuds with built-in controllable audio effects such as noise and hum reduction, speech enhancement, and reverb. Other manufacturers followed suit with features such as hearing profile EQ matching and increasingly intelligent background noise control, potentially turning many mobile devices into DIY hearing aids.

The initial *Ways of Hearing* app had two core settings (HLS and noise vocoder). However, the individual parameters of these were pre-set. The *Do You Hear What I Hear v1* app introduced a rectangular draw pad in the centre of the screen that allowed users to control some audio settings, tapping and dragging along an up-down, left-right XY axis.

During the activities, listeners were invited to adjust the controls and describe how the sounds were changing. Following these responses, the facilitator would explain the key aspects of audio manipulation and how they might relate to the listener’s perception. In the *Hear – Advanced Listening* app, the controls for audio processing often have abstract names (e.g. ‘Time Scramble’ and ‘Unhumanize’) and affect multiple parameters with one control slider, concealing the underlying audio effects from the listener. While this might be beneficial to the simplistic user experience of this app, *Do You Hear What I Hear* aims to share an understanding of sound, so audio effects are explained in detail where possible. The exploration of control seems to be an engaging aspect of the activity for some listeners (“I liked to switch between the ears and play around with different sounds”).

Potential developments for Do You Hear What I Hear

Overall, the initial activities of *Do You Hear What I Hear* received an enthusiastic response from audiences. Comments in feedback surveys used descriptors “fun”, “great”, “different”, “weird”, “scary”, “cool”, and “important”. Some responses indicated evocative experiences; for example, “it made me much more aware and observant of how sound can change how you feel things, even how you see or concentrate”. Some critical areas for potential developments have been identified based on audience feedback and reflection on the initial activities.

Diverse collaborators and audiences

Acknowledging my position as hearing ‘normally’ within mainstream hearing culture, the strength of *Do You Hear What I Hear* will depend on quality collaboration with diverse ears (artists, researchers, technologists and facilitators) who may inform and participate in future activities. The initial activities of *Do You Hear What I Hear* were designed for delivery via verbal communication, and only three of over two hundred total audience members wore hearing modifying technologies. Future iterations should consider how the activities might reach and be accessible for broader audiences of diverse hearing.

Hardware and software

The initial apps have audio latency longer than the 5-6ms tolerated in hearing aids (Stone et al. 2008). Future iterations should consider alternatives to the smartphone to optimise low latency mobile audio processing. The attenuation of exterior sound offered by the headphones currently used could also be improved with more substantial physical sound isolation and noise-cancellation software. There is potential to create a binaural experience with

headphone-mounted microphones and consideration of spatial audio perception. The audio settings of the app may also be refined to convey additional aspects of sensory difference.

Interaction and engagement

Thus far, activities have used dialogue with a facilitator to guide listening and interaction.

Some responses to audience surveys suggested the app be released for public download.

However, there are currently concerns that the app's audio controls might simply be used as audio effects or be misinterpreted without facilitation and dialogue.

Future developments could introduce new engagement strategies such as narrative storytelling or game-like scenarios to guide the audience through their experience: interaction with other audience members, exploration of space, critical listening strategies, and audio device control. There may also be opportunities for improvised vocalisation, linking to my ongoing participative performance practice as the director of Belfast City Choir and HIVE Choir. This may allow for more diverse, non-semantic ways of giving voice. Narrative, gameplay, and increased vocalisation adopted in future activities might help encourage more individual reflection on aural diversity and foster personal advocacy for inclusion and equality amidst prevalent hearing normalcy.

Summary

Let us return to Sterne's proposal that the field of sound studies "begins with hearing the hearing of others" (Sterne 2015, 66). The core premise of *Do You Hear What I Hear* is that

strategies are drawn from the diverse disciplines of sound art, theatre, HLS and disability studies to create interactive performances that share the hearing experiences of diverse listeners. The activities of *Do You Hear What I Hear* aim to create thought-provoking and memorable moments, hopefully giving rise to broader conversations and critique around dominant societal structures that frame some ways of hearing as ‘normal’. Moreover, perhaps in hearing ‘through someone else’s ears’, we might learn more about our own.

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