
Medicine

‘How sound makes me feel’. Towards an Aural Diverse Practice of Sound Design in Museums

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Keywords:
Aural Diversity, Sonic Inclusion, Museum Auditory Environments, Human-Centered Design, Design-as-practice.

ABSTRACT:

As museums increasingly recognise the fundamental role of sound in shaping more inclusive experiences, there is a growing need for design practices that can engage with the plurality of ways people hear, perceive and respond to sound. Research on Aural Diversity highlighted the limitations of conventional sound design, which often assumes a standardised mode of listening. This article investigates how Human-Centred-Design (HCD) methods can be mobilised to capture the embodied, individual and situated nature of sonic experiences. Drawing on a participatory workshop conducted at the Science Museum in London, the article examines a sequence of activities designed to understand how existing acoustic conditions and sound installations were experienced by participants. Through soundwalking, drawing, reflective writing and collective discussion, the workshop progressively surfaced embodied sonic knowledge, revealing often-invisible sensory barriers within the galleries. Findings show how this framework can operate as an emerging design practice to explore, understand and articulate aural diversity from the earliest stages of the design process, offering museums a situated, adaptable, and reflexive method for engaging with the complexity of human hearing.

Mentre i musei riconoscono sempre più il ruolo fondamentale del suono nel plasmare esperienze più inclusive, cresce la necessità di pratiche di progettazione in grado di interagire con la pluralità di modi in cui le persone ascoltano, percepiscono e rispondono al suono. La ricerca sulla diversità uditiva ha portato all’attenzione critica i limiti della progettazione sonora convenzionale, che spesso presuppone una modalità di ascolto standardizzata. Questo articolo indaga come i metodi di progettazione di Human-Centred-Design (HCD) possano essere utilizzati per cogliere la natura corporea, individuale e situata delle esperienze sonore.Prendendo spunto da un workshop partecipativo condotto presso il Science Museum di Londra, l’articolo esamina una sequenza di attività progettate per comprendere come le condizioni acustiche esistenti e le installazioni sonore venissero percepite dai partecipanti. Attraverso passeggiate sonore, disegno, scrittura riflessiva e discussione collettiva, il workshop ha fatto progressivamente emergere la conoscenza sonora corporea dei partecipanti, rivelando barriere sensoriali spesso invisibili. I risultati mostrano come questo approccio possa funzionare come una pratica progettuale emergente per esplorare, comprendere e articolare la diversità uditiva fin dalle prime fasi del processo di progettazione, offrendo ai musei un metodo contestualizzato, adattabile e riflessivo per affrontare la complessità dell’udito umano.

Opening Picture:

Workshop participant during the soundwalk at the Medicine Galleries (Science Museum), March 2025 © Stefania Zardini Lacedelli.

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1. Introduction

Within today's multisensory, media-rich, multi-platforms environments in which museums operate, sound plays a central role: it enriches curatorial approaches,[1] deepens emotional and sensorial engagement with collections,[2] amplifies under-represented historical voices,[3] and operates as a museological object in its own right.[4] Yet, despite this expanded array of sonic practices and sonic epistemologies, museum sound design often remains shaped by the implicit assumption of an "auditory normate" – an idealised listener assumed to possess a 'good' and 'ontologically normal' hearing.[5] Such assumptions obscure the reality that hearing exists along a spectrum of differences shaped by biological, technological, cultural and lived experience dimensions.[6] Emerging scholarship on Aural Diversity calls for a shift in perspective,[7] urging the heritage sector to acknowledge and accommodate the plurality of listening experiences and diverse ways to respond to sound, rather than designing for an imagined neuro-typical ear.

Within this context, this article investigates how Human-Centred Design (HCD) methods can inform more inclusive approaches to the use of sound in museums, by meaningfully engaging with aural diversity. It asks, first, how sound design practices in museums might better respond to the plurality of hearing and sonic experiences, moving beyond the assumption of a single, idealised listener. Second, it examines how HCD methods can be mobilised to capture perceptual, emotional, and sensory dimensions of listening, as well as to identify sonic barriers that might be embedded within heritage spaces.

To explore these questions, we conducted a participatory workshop at the Medicine Galleries at the Science Museum (UK). This workshop tested a sequence of participatory sonic observation activities designed to foreground embodied and situated auditory experience. The aim of this research was primarily methodological: to explore how HCD methods, informed by principles of Aural Diversity, can operate as an emerging design practice to capture perceptual, emotional and sensory dimensions of listening within the acoustically dense environment of a gallery space.

The workshop was intentionally situated within a media-rich gallery in order to engage with the realities of a complex auditory environment.[8] In museums, and particularly in large exhibition spaces such as the Science Museum, curated sound installations coexist with visitors' voices, footsteps on hard floors, reverberant architectural surfaces, mechanical systems, and sound bleed from adjacent displays. Listening within such spaces is therefore never directed at a single, isolated source; it is shaped by overlapping acoustic fields, spatial permeability, and fluctuating levels of attention and distraction. By situating the study within this dynamic and multilayered acoustic ecology, the research seeks to understand how sound is experienced by a plurality of listeners, each bringing different lived experiences, perceptual sensitivities, bodily conditions to the museum space.

The paper is structured as follows: Section 2 outlines the growing role

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of sound in museums, introduces Aural Diversity as a key paradigm for recognising the plurality of listening experiences, and establishes the relevance of Human-Centred Design for inclusive sonic practices. Section 3 presents the case study, detailing the Medicine Galleries context, the participatory activities, and the insights generated through each tool. Section 4 discusses how these tools and activities, when orchestrated together, function as an emerging aural-diverse design practice. The paper concludes by reflecting on the methodological, theoretical and practical implications of embedding aural-diverse approaches within Human-Centred Design for museums.

2. Literature Review

2.1 From interpretative medium to inclusive design practice: Reframing Sound Design in Museums

In the past two decades, sound has gained a primary role in museums. For much of their modern history, museums privileged visual and material culture, positioning sound as a complementary medium. Within the trans-sensory logic which is permeating museum theory and practice,[9] however, sound has moved decisively to the foreground. Aligned with the broader "sonic turn" across the humanities and social sciences,[10] a growing body of works established sound as primary narrative, affective and epistemic medium capable of supporting meaning making, introducing new modes of engagement and operating as curatorial object in its own right.[11] In gaining central relevance, sound functioned as a disrupting force, prompting institutions to rethink previous exhibition vocabulary and spatial logics,[12] and introducing new sonic epistemologies for understanding audience engagement, the act of curation, and the museum architecture.[13] The publication of the first *Handbook of Sound in Museums*[14] and the convening of the first international conference dedicated to the field[15] marked this maturation. Today, museum sound design is an established domain of research and practice.

Within this extensive body of work, however, sound has been theorised predominantly through an interpretative paradigm. Drawing on its intrinsic ability to engage, immerse, connect, sound has been conceived as something to compose, curate and manage – a designed layer added to an otherwise defined environment, capable of expanding museum narratives and deepening sensorial and emotional engagement with collections. This model presumes a degree of curatorial control: sound as authored and intentionally deployed.

Within the broader transformation the sector is experiencing under what has been conceptualised as "post-digital museum,"[16] a complementary paradigm is emerging. As museums become more mediatised, participatory and relational,[17] they are reconceived not simply as sites of display but as social infrastructures. The language of exhibition increasingly makes room for co-creation,[18] social care,[19] health and wellbeing.[20] In this context, what was once imagined as a space of silent contemplation has been reconfigured as a socially animated environment, shaped by what Kelly

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terms "social sounds":[21] the unpredictable, relational and collective sonic life generated by living environments.

In such spaces, sound exceeds curatorial intention. Alongside designed audio installations and sound-based practices resonate conversations, voices, footsteps, ventilation systems, mechanical hums, café noise and reverberation across varied architectural surfaces.[22] Museums thus exemplify what auditory neuroscience describes as "auditory complex environments":[23] spaces characterised by multiple simultaneous sound sources, fluctuating signals and competing acoustic information.

It is precisely this shift – from curated sound to lived sound – that is reorienting the field towards an inclusive design paradigm.[24] When sound is understood not only as a meaning-making tool but as an environmental condition, the central question changes. The issue is no longer solely what sound can communicate, but how it enables – as well as how it hinders – participation: how it helps to navigate, orient and make people feel comfortable within heritage environments.

Within this inclusive paradigm, structural barriers embedded in the spaces become critically visible. In complex auditory environments such as heritage spaces, sound constitutes an integral component of informational and perceptual load and might contribute to experiences of sensory overload and information saturation – phenomena extensively discussed in the literature on "museum fatigue"[25] and neurodiversity research.[26] Such environments may be especially difficult to navigate by individuals who have noise sensitivities – conditions in which everyday sounds are experienced as intrusive, painful or overwhelming[27] – or neurological hearing differences that affect how auditory information is processed and filtered.[28] This is not only a matter of providing adjustments for underrepresented groups. It requires recognising that aural architecture and sound design in public spaces have historically been informed by what Renel calls the "auditory normate": an idealised, non-disabled listener whose hearing is presumed stable and consistent.[29] Grounded in the social model of disability,[30] this social relational model of sonic exclusion highlights the auditory values and norms embedded in the design that does not consider hearing differences. In other words, what is imagined, hidden and reproduced in the design of public spaces[31] is an idealised and unrealistic body and mind that fails to account for differences in how people hear and respond to sounds.

The emerging paradigm of Aural Diversity[32] contributes to dismantling these normative hearing assumptions. By acknowledging that hearing varies across biological, neurological, technological and cultural dimensions, Aural Diversity brought to the fore a multitude of auditory conditions beyond hearing loss alone, which arise from how the brain processes sound. This includes sound tolerance sensitivities such as hyperacusis,[33] misophonia[34] and tinnitus,[35] as well as Auditory Processing Disorders,[36] alongside technologically mediated listening through hearing aids and cochlear implants.[37] In the light of this activating paradigm, it becomes clear

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that sonic accessibility in public spaces such as museums and galleries cannot be reduced to accommodations framed around blindness or deafness. Rather, it concerns the multiplicity of ways each individual uses sound to navigate, localise, communicate and construct a sense of belonging within heritage environments.[38]

Accommodating the needs of an aural diverse population therefore emerges as a primary design challenge within contemporary museum practice. In recognising that hearing is highly variable across individuals and in constant flux throughout life, then the central question becomes methodological: how can the sonic perception be meaningfully captured and translated into an inclusive design practice? Sonic perception is not an isolated sensory function; neuroscience research demonstrated that hearing is deeply interwoven with memory, attention, spatial orientation, emotional processing, and imagination.[39] To design inclusively requires engaging this complexity – yet conventional acoustics research has largely prioritised quantitative metrics such as decibel levels and reverberation time, often with limited attention to the psychological and sociological repercussions of acoustic environments.[40]

Addressing this methodological gap requires moving toward design frameworks that place lived experience, perceptual knowledge and participatory processes at the centre of sonic decision-making – a shift that situates Human-Centred Design as a crucial framework for operationalising aural diversity.

2.2 Human-Centred Design (HCD) for Aural-Diverse Practices

Human-Centred Design (HCD) has become a central driver of change in contemporary museum practice[41]. Research on museum digital transformation[42] has shown that HCD contributes not merely by delivering digital products or exhibition technologies by functioning solely as a set of methods to produce specific outputs – such as digital systems or digitally embedded exhibitions[43] – but rather it is increasingly understood as a practice-based approach that reconfigures how museums frame problems, integrate visitor perspectives, and generate knowledge about visitor experience.[44] In this sense, HCD operates as an infrastructural capability, organisational mindsets and even, in some more advanced cases, organisational culture, supporting cross-departmental knowledge exchange, encouraging co-creative processes over siloed expertise, embedding empathy, experimentation, and iterative learning, and aligning visitor-centred values with strategic decision-making.[45]

Importantly, the kind of Human-Centred Design referred to in this article should not be understood as a formalised practice that is only viable within large, well-resourced institutions or museums with dedicated design teams. Instead, as discussed extensively in *Museums and Design Practices*,[46] HCD practices are already present, often implicitly and in situated forms, across a wide range of small and medium-sized museums. In these contexts, HCD does not necessarily manifest through formalised design roles or the adoption of branded

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design-thinking frameworks,[47] but through locally adapted practices of listening, collaboration, reflection, and experimentation embedded within everyday work routines, which are distributed, collective, and accessible ways of working that can be enacted by curators, educators, digital staff, front-of-house teams, and managers alike.

Framing HCD in this way is particularly relevant for aural-diverse practices. We need a brief premise to clarify this point. Indeed, from an inclusive design perspective, scholars[48] and professionals[49] have argued for *accessibility by design* emphasising that accessibility should be embedded at the earliest stages of design rather than retrofitted after solutions are developed. In other words, accessibility is not a feature to be added after design decisions have been made, but an initial, generative condition for design itself, an orientation that aligns closely with HCD's core commitment to integrating people's needs, experiences, and values at the forefront and throughout the design process. Kat Holmes' *Mismatch: How Inclusion Shapes Design*[50] reinforces this stance by arguing that exclusion does not originate in individual bodies or abilities, but in mismatches between people and the designed environments that surround them. The notion of mismatch reframes where "the problem" is located: rather than situating exclusion in individual sensory differences, Holmes shows how exclusion emerges when design decisions are guided by narrow, implicit assumptions about users, which are assumptions that often remain invisible because they reflect dominant or taken-for-granted experiences. Applied to sound in museums, this position challenges normative assumptions about hearing (see Section 2.1 above) and foregrounds aural diversity as an important aspect to consider when designing for visitor experiences. HCD provides conceptual and practical means, as well as ethical grounding, to surface ("make them visible") and interrogate these assumptions early in the design process, by prioritising lived experience, empathy, and participation over abstract standards of accessibility or compliance-driven approaches. In particular, design practices of understanding ('Discovery' in the UK Double Diamond[51], Fig. 1) – such as the workshop presented in this article – become strategically important precisely because they enable museums to recognise where mismatches occur, and to reframe sound not as a technical layer to be optimised, but as a dimension of experience that is deeply entangled with the design process (in line with organisational values).

3. Case Study: "How Sound Makes me Feel" Workshop

Embedding aural diversity into museum design practice presents a methodological challenge. Sonic perception is a complex topic to study for the multidimensionality and subjectivity of the listening experience.[52] If sound design is to move beyond normative assumptions of an 'aural typical listener', design methods must be capable of capturing, externalising, and interpreting these embodied, situated, subjective dimensions. The case study presented here responds to this challenge by shifting from theo-

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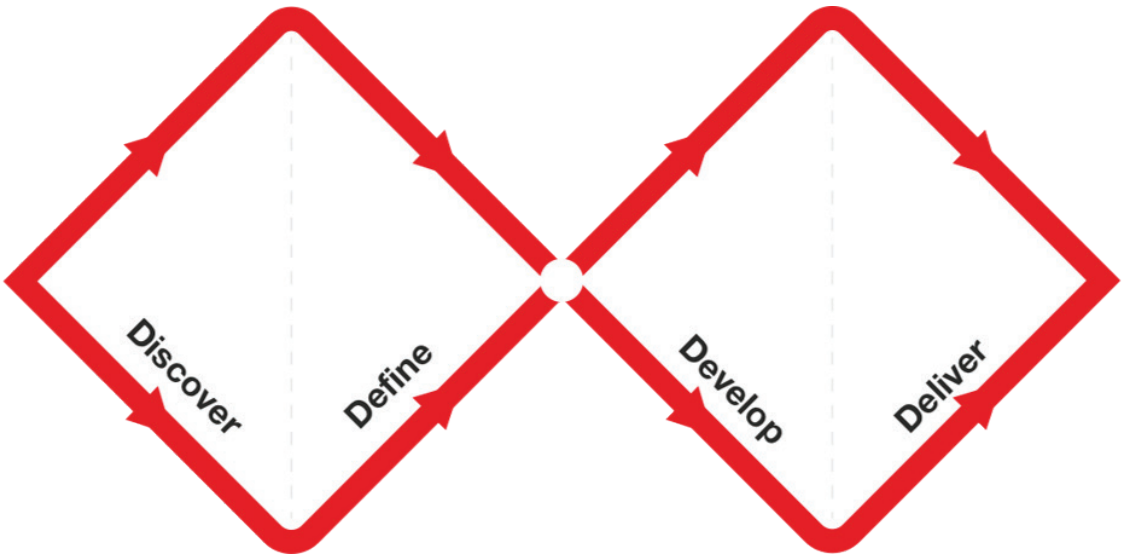

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retical reflection to methodological experimentation, using HCD design tools to capture how existing acoustic conditions and sound installations are perceived and experienced within gallery spaces.

The workshop *How Sound Makes Me Feel*, conducted by the co-author Stefania Zardini Lacedelli in March 2025 at the Medicine Galleries of the Science Museum, London, functioned as a situated case study through which principles of aural diversity were translated into design practice. The workshop experimented with a series of interrelated participatory activities to generate experiential knowledge about sonic perception.

The workshop was therefore conceived within the 'understanding/discovery phase' of the HCD process (Fig. 1 and 2): a structured sequence of participatory tools aimed at eliciting situated auditory experience, render it communicable, and translating it into design-relevant insights. The orchestration of these tools tested how aural-diverse principles might be operationalised within museum practice and inform inclusive sound design.

Participants were fifteen MA Museum Studies students. The workshop did not ask participants to disclose or identify with any form of diagnosed hearing conditions, but proceeded from the assumption that all individuals are intrinsically aurally diverse. This decision was methodologically intentional. Rather than distinguishing between "normal" and "special" hearing, the study was framed on the premise that all individuals bring different perceptual sensitivities, lived experiences, listening behaviours, and emotional responses to sound. Participants were guided through a structured sequence of participatory activities including an auditory self-assessment tool, a soundwalking and sound-drawing exercise, reflective writing on an Aural Empathy Canvas, and a final collective discussion.

The workshop took place in the Science Museum's Medicine Galleries, a section of the museum which undertook a major redisplay in 2020. These five interconnected galler-

Fig. 1: The Double Diamond by the Design Council. CC BY 4.0 license

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ies foreground personal stories of medicine through digital media, interactive displays, and dedicated sound installations. Sound plays a key curatorial role, contributing to foregrounding personal, intimate and patient-centred perspectives.[53] At the same time, these galleries are characterised by high-visitor density – reaching up to 12,000 visitors on peak days (figure provided by the museum's curatorial team), multiple concurrent audio sources, reverberant architectural conditions, and overlapping acoustic zones. These environmental features made the site particularly suitable for examining how sound contributes – or hinders – cognitive, sensory and emotional engagement.

The following sections describe each activity in detail, beginning with the preliminary sonic mapping conducted in preparation for the workshop. A detailed account of each tool is then presented followed by the results generated through their application. As will be shown, each tool elicited a distinct yet complementary layer of insight: from participants' pre-existing attitudes toward acoustic environments, to their embodied and spatial perceptions of the gallery soundscape, and finally to the emotional, cognitive, and physical dimensions of engaging with specific sound installations.

3.1 Human-Centred Sonic Mapping of the Medicine Galleries

Prior to the workshop, co-author Zardini Lacedelli conducted a preliminary sonic mapping of the Medicine Galleries (Fig. 1). Documented through photographs, short videos and audio recordings, this mapping aimed to identify the defining acoustic characteristics of the space and chart the distribution of sound-based installations across its five interconnected galleries. The acoustic mapping was informed by the human-centred principles of the APEAL method,[54] developed by Apex Acoustics. APEAL centres auditory perception and listening methods in the acoustic assessment, enabling non-specialists to participate meaningfully in evaluating acoustic conditions of an occupied place. In contrast to purely quantitative measurements conducted in unoccupied spaces, this method adopts soundwalking[55] as a way to engage with inhabited environments and capture the dynamic, subjective dimension of the sonic experience. Inspired by the principles of this method, a selection of photo, video and audio recordings were collected while walking in each gallery, attending to how sound was encountered in motion and in context. As part of this process, co-author Zardini Lacedelli also experienced five sound-based installations to include in the workshop (listed in Table 1). The selection was guided by the intention to expose participants to diverse sound technologies, modes of sound engagement, and degrees of acoustic containment.

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Gallery	Sound installation / Audio Exhibit selected	Sound Technologies used in the installation
Medicine and Bodies	When Medicine Defines Normality	Single-cup earphone (mono handset).
Medicine and Treatments	Therapist's Room	Headphones.
Medicine and Treatments	John Gibson & Son pharmacy	Directional speakers, triggered on entrance. Induction loop provided for users of hearing devices.
Faith, Hope and Fear	Faith, Hope and Fear	Sound Showers/overhead speakers triggered upon entrance in the alcove.
Medicine and Communities	Padded Cell	Directional speakers.

Table 1: List of the sound installations selected for the workshop.

The galleries are organised into five interconnected sections: three "narrative" galleries – *Medicine and Bodies, Medicine and Treatments,* and *Medicine and Communities* – and two "spotlight" galleries – *Exploring Medicine* and *Faith, Hope and Fear*. Together, these spaces form a continuous exhibition environment in which visitors move fluidly between thematic areas. The sonic mapping made explicit how each gallery sustains a distinct acoustic atmosphere while remaining permeable to neighbouring sounds.

The first gallery after the entrance is *Medicine and Bodies*, which explores how medicine has shaped the way bodies are observed, measured, and categorised. The displays combine objects, photographs, and personal accounts to challenge fixed notions of the "normal" body. For this section, the installation *When Medicine Defines Normality* (Fig. 3) was selected to be included in the workshop. In this installation, large photographic portraits by Siân Davey are paired with audio interviews in which patients reflect on living with sensory or physical impairments, chronic illness, or men-

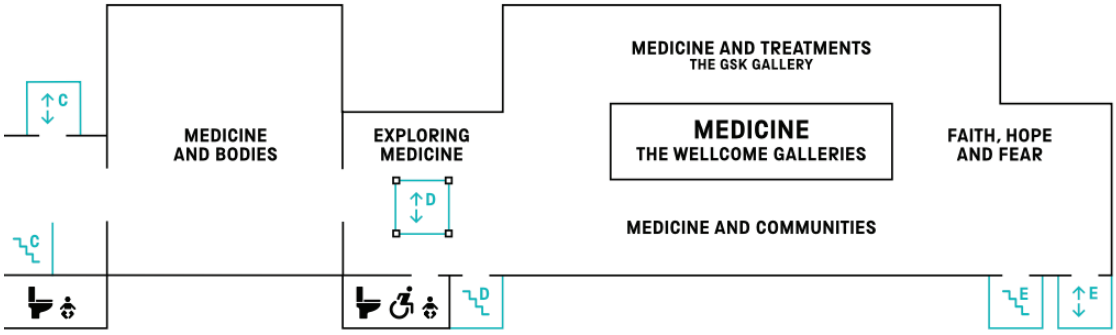

Fig. 2: Map of the Medicine Galleries, Science Museum.

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3

tal-health conditions. The juxtaposition of image and voice constructs a deeply personal encounter that questions how medicine has historically defined – and constrained – ideas of normality. This installation uses a single-cup earphone (mono handset) to deliver the audio from video recorded testimonies, offering a semi-contained listening zone embedded in a visually as well as sonically dense environment.

The second gallery – *Exploring Medicine* – is a largely silent installation bringing together around one thousand objects from diverse medical traditions to challenge preconceptions of what "medicine" looks like. With no recorded audio or sound technology to support the experience, the gallery relies on visual density and minimal labelling encouraging observational and self-directed engagement. The gallery was included in the workshop as a space to listen during the soundwalk, but no audio exhibit was selected for further analysis.

Personal stories are again at the centre of the third gallery, *Medicine and Treatments*, which is focused on individual experiences of medical treatments. For this environment, two sonic installations were selected. The first, the *Therapist's Room* (Fig. 4), is a headphones-based installation which invites visitors to sit into chairs and listen to audio recordings of therapists and patients. While patients speak about their mental-health experiences and how therapy helped them articulate difficult emotions and confront internal struggles, the therapists reflect on their own perspective, describing their role in creating a safe listening space and acknowledging the emotional labour their work entails. The use of headphones encourages a self-contained, intimate listening experience, partially isolating the visitor from the surrounding gallery soundscape.

A further installation selected for the workshop was the *John Gibson & Son pharmacy* (Fig. 5). In this re-

Fig. 3: *When Medicine defines Normality* exhibit, Medicine Galleries, Science Museum © Stefania Zardini Lacedelli.

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4

constructed Victorian-era pharmacy, actors voice the pharmacist, his apprentice Alice, and customers, re-enacting everyday interactions, while ambient noises – street sounds, footsteps, a chiming clock, a doorbell – reinforce the sense of stepping into a functioning historical environment. Here, directional speakers triggered upon entrance distribute spatialised audio across the room, creating a shared sonic environment that can be experienced collectively, while an induction loop ensures accessibility for users of hearing devices.

Further on, *Faith, Hope and Fear* explores the emotional and spiritual dimensions of illness and healing. The section brings together objects associated with belief, ritual, and care, alongside contemporary testimonies on highly emotive and ethically complex topics such as IVF, pilgrimage, oncology and neonatology. By entering six dedicated alcoves, visitors are presented with a single poignant object, and as they step over the threshold, a voice recording of the donor introduces their own story. The alcoves are equipped with directional speakers embedded in the walls and on the ceiling, producing a localised listening field which contains the sound within each architectural niche.

Finally, the galleries conclude with *Medicine and Communities*, which foregrounds public health, lived experience, and the impact of social systems on wellbeing. For this section, the *Padded Cell* installation was selected, where visitors can hear the recorded voices of former patients of psychiatric hospitals who experienced confinement (Fig. 6). Designed to mimic the dimensions and spatial arrangement of a real psychiatric "padded cell" displayed directly alongside it, the installation employs directional speakers within an enclosed architectural space, offering a powerful, immersive aural encounter with the realities of psychiatric hospitals.

Fig. 4: The *Therapist's Room* installation, Medicine Galleries, Science Museum © Stefania Zardini Lacedelli.

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5

6

Fig. 5:
The *John Gibson & Son pharmacy*, Medicine Galleries, Science Museum. © The Board of Trustees of the Science Museum.

Fig. 6:
The *Padded Cell*, Medicine Galleries, Science Museum © Stefania Zardini Lacedelli.

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3.2. Tuning Acoustic Perception: Auditory Self-Assessment

3.2.1 Description of the activity

On the day of the workshop, participants completed an auditory self-assessment prior to entering the galleries. Conceived as a preparatory reflective tool rather than a data-collection instrument alone, this activity was designed to attune participants to their own auditory perception and to foreground sound as a critical dimension of heritage experience. It functioned as a "tuning" device: orienting attention toward specific acoustic phenomena while prompting reflection on individual listening preferences and auditory sensitivities before undertaking the sonic observation.

The self-assessment tool was informed by the principles of the Aural Diversity Toolkit,[56] a design resource intended to support architects, curators, and spatial designers in recognising aural diversity as a spectrum of listening experiences. Drawing upon the empirical research with aurally divergent participants,[57] the activity adapted the toolkit's principles to the specific context of museums and heritage spaces. Structured around four interconnected prompts, it invited participants to reflect on the importance of the acoustic environment in their decisions to enter public spaces, to assess their sense of acoustic comfort across different spatial typologies (including museums), to consider the role sound plays in shaping their museum experience, and to identify the types of sounds they find most challenging in exhibition settings.

The first two questions introduced the concept of *acoustic comfort* as a factor shaping how individuals choose, navigate, and experience public spaces. By situating museums alongside other environments – such as restaurants, theatres, supermarkets, parks, railways, airports, or libraries – these questions highlighted both the variability of acoustic conditions across spatial typologies and the diversity of individual responses to them.

The third question translated the toolkit's identified sound stressors (loud sounds, background noise, high-pitched sounds, reverberant or "echoey" spaces) into heritage environments. Its purpose was to sensitise participants to potential acoustic challenges of museum spaces, preparing them to identify these phenomena during the soundwalk. The fourth question extended the toolkit framework by moving beyond comfort and difficulty toward a more holistic reflection on sound as an interpretative and curatorial agent within museums.

Together, these four prompts tuned participants' attention to their own sonic perception and provided conceptual anchors that could be recalled while experiencing the space and the installations. In doing so, the self-assessment tool positioned participants as active listeners, each carrying distinct auditory profiles and sonic preferences into their engagement with the Medicine Galleries.

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3.2.2. Results

All twelve participants completed the self-assessment (Fig. 7), which was conducted live via Menti.com, allowing responses to be displayed in real time. When asked to consider visiting a public space more generally, ten participants indicated that acoustic conditions play a significant role in their decision-making: four described them as *very important* and six as *quite important*. Only two participants attributed limited importance to sound. These responses suggest a high level of pre-existing sonic awareness within the cohort and confirm that acoustic comfort is a meaningful factor in spatial choice.

In relation to different types of environments, the library emerged as the most comfortable acoustic space among those listed, followed by parks or natural environments, with museums ranked third. At the opposite end of the spectrum, railway stations received the lowest comfort ratings by a substantial margin, followed by airports and restaurants/pubs. These results point to a clear preference for environments characterised by lower noise levels, reduced unpredictability, and greater perceived control over auditory input.

When focusing specifically on museums, participants identified sound as a powerful emotional and sensorial trigger. The highest-rated functions of sound were its capacity to raise feelings and emotions, enhance sensorial involvement, and create a sense of intimacy. In contrast, the lowest score was attributed to the ability of sound to foster a feeling of inclusion. This suggests an awareness – later reinforced in the workshop activities – that while sound can deepen engagement, it may simultaneously create barriers, whether due to audibility challenges, sensory overload, or limited accessibility options.

Regarding the most challenging sounds in museum environments, participants consistently identified loud and unexpected sounds, peo-

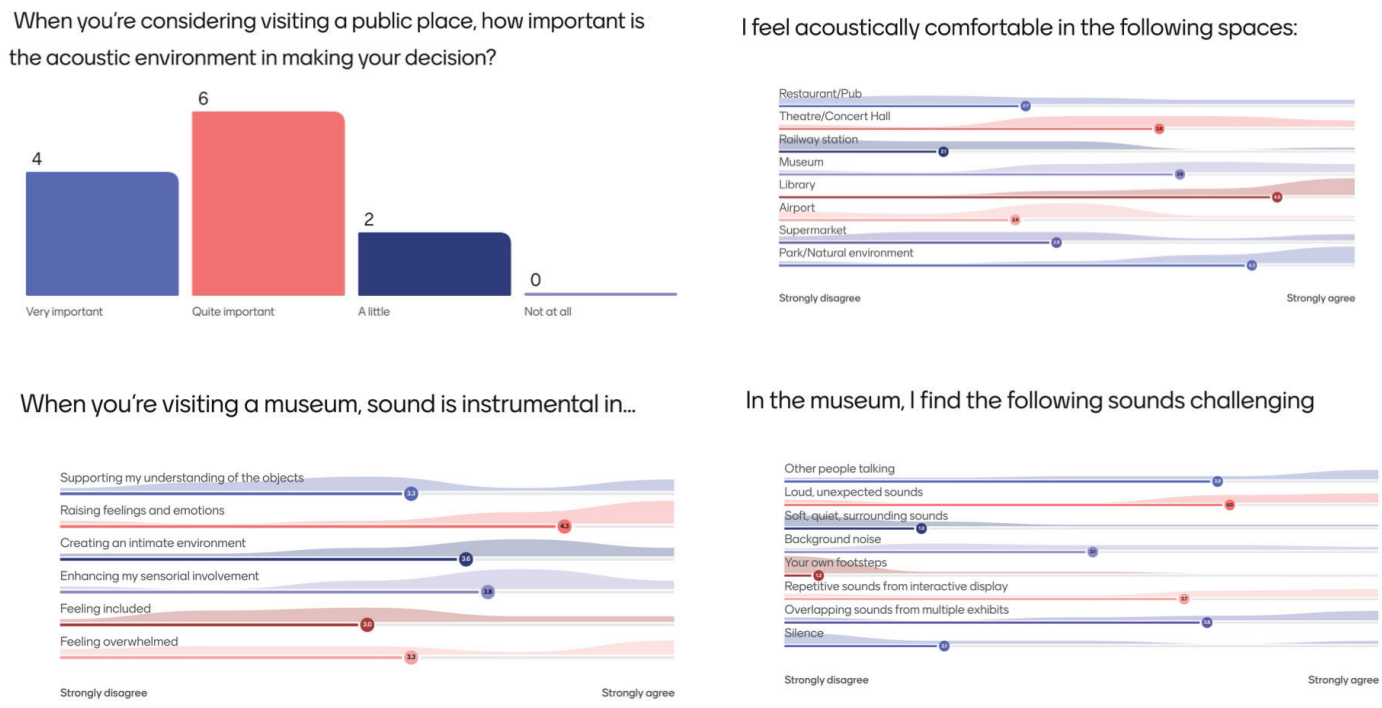

Fig. 7: Results of the self-assessment tool informed by the Aural Diversity Toolkit.

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ple talking, overlapping audio from multiple exhibits, and repetitive sounds from interactive displays. These concerns were later corroborated through the sound-drawing and empathy canvas exercises (see sections 3.3 and 3.4). By contrast, footsteps, soft ambient sounds, quiet background noise, and silence were generally described as the least challenging.

Overall, the survey results established a shared sensitivity to acoustic conditions and anticipated many of the themes – emotional resonance, cognitive load, and sensorial accessibility – that emerged more fully in the *in situ* observation activities.

3.3 Sonic Observation in situ: Walking, Listening and Drawing

3.3.1 Description of the activity

Once on site, the workshop shifted into a structured sonic observation activity combining soundwalking and sound drawing. Before entering the galleries, participants listened to five short audio recordings – each captured in a different section of the Medicine Galleries – and were invited to select the sound they found most interesting. Based on their choice, they were directed to a specific gallery and its associated sound installation, which then became the focus of their *in situ* activity.

At the Medicine Galleries' entrance, each participant began by slowly walking through their assigned section, taking time to attune to its acoustic characteristics (Fig. 8). This activity was informed by soundwalking and deep listening methods, which foreground listening as the primary sense through which the environment is perceived. A soundwalk invites place discovery through focused auditory attention, encouraging participants to give attention to sounds both acoustically and psychologically.[58] Pauline Oliveros describes "deep listening" as an expansion of perception towards "the vastness and complexity" of sound – an attunement that heightens awareness of one's connection to the surrounding environment.[59] Walking is integral to this practice. Since the 1960s, walking methods have become a tool to question institutional limits, reimpose spatial order, and explore the world in affective, embodied and multimodal way.[60] In museum contexts, movement is inseparable from experience: exhibitions unfold through wandering, pausing, and transitioning between rooms.[61] Drawing on these principles, the soundwalk sought to foreground the dynamic and transitional nature of gallery

Fig. 8: Workshop participant during the soundwalk at the Medicine Galleries (Science Museum), March 2025 © Stefania Zardini Lacedelli.

Stefania Zardini Lacedelli, Marco Mason
'How sound makes me feel'. Towards an Aural Diverse Practice of Sound Design in Museums
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experience, inviting participants to engage in attentive listening while in motion across their assigned section.

As part of the soundwalk, participants were invited to engage in a sound-drawing exercise, producing a personal visual representation of their sonic perception. This activity was informed by sound-mapping approaches which use graphic notation to represent the acoustic properties of places.[62] In particular, the exercise drew on creative approaches developed within the Arts and Humanities Research Council project *Tinnitus, Auditory Knowledge and the Arts*, which used drawing and other artistic practices to explore subjective experiences of tinnitus.[63]

Inspired by these approaches, this activity explored the use of drawing to externalise inner auditory perception, making perceptible experiences that are otherwise invisible and difficult to verbalise. Through drawing and visual representation, participants were encouraged to translate sonic qualities such as volume, rhythm, repetition, directionality, proximity, and reverberation into lines, marks, densities, symbols, or abstract forms, making them discussable within the group.

3.3.2 Results

The sound-drawing exercise revealed rich multilayered insights conveying the embodied, spatial, and affective dimensions of listening that were otherwise difficult to articulate. Participants employed a highly diverse visual vocabulary to express not only individual sounds, but also their position within the acoustic environment, the simultaneity of sound sources, the dynamic interplay between sound installations and living sounds, and their emotional responses. Across the cohort, modes of representation ranged from waveforms to figurative sketches, symbolic notation, onomatopoeic text, colour coding, layered textures, and spatial zoning. Many drawings combined multiple strategies within a single page, producing hybrid forms that mirrored the complexity of the sonic environments they sought to render.

Some participants adopted soundwave motifs to capture distinct acoustic qualities. The drawing pictured in Fig. 9, for example, displays lines of varying amplitude and rhythm – jagged, spiked forms to suggest abrupt or high-pitched sounds; undulating curves to evoke softer and more continuous sounds. Differences in shape and density transformed pitch, intensity and rhythm into graphic form.

Others participants relied on symbols and figurative elements. The drawing in Fig. 10 depicts human presence profiles – two silhouettes, a pair of feet, footprint – alongside icons representing specific sound sources, such as speakers and conversational “vignettes.” Exclamation and question marks signal abrupt or intrusive sounds, while a large zone marked “ALERT” visually dominates the drawing, expressing the unpredictability of intermittent noises more forcefully than the participant verbalised during discussion.

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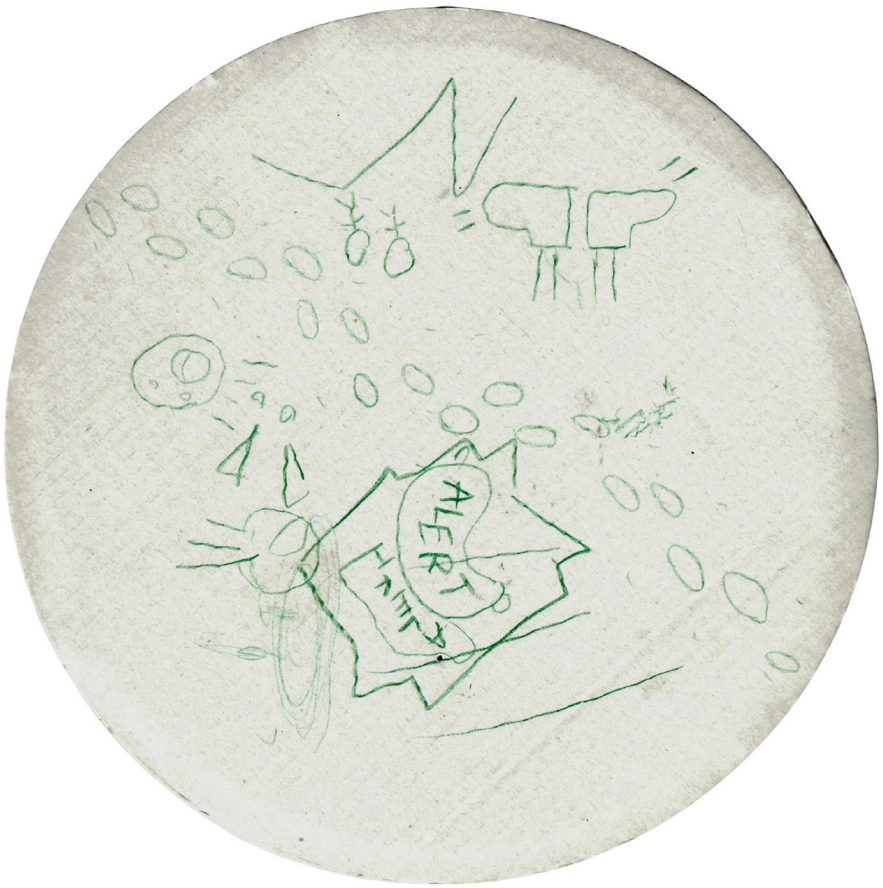

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Fig. 9:
Sound drawing n°2.

Fig. 10:
Sound drawing n°3.

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Particularly striking is the drawing in Fig. 11, which captures the difficulty of focusing on a single sound source by representing the gallery as an acoustic mesh or tangle. Dense clusters of marks, contrasting textures, and variations in colour differentiate between roughness, softness, direction, and intensity. At the centre, the participant positions herself as the listening node – the perceptual anchor – surrounded by figures of a staff member, a baby, and a visitor wearing headphones. Onomatopoeic words such as "stomp," "boop!", and "beep beep!" appear at varying sizes to indicate repetition and volume. Textual annotations further layer subjective evaluation of the sonic experience: next to a densely populated sound zone appears the phrase "silence would be preferred"; beside the image of headphones, "library-owned, don't like sharing"; near an indistinct block of overlapping text, "can't reach", suggesting difficulty in discerning speech. Here, auditory perception, personal preference, and accessibility concerns converge in a single multimodal composition.

Several drawings foregrounded the liveliness of the museum environment, emphasising the centrality of human voice. The example in Fig. 12 focuses almost exclusively on speech sounds, with a silhouetted face positioned at the centre to represent the listener. A concentric wave radiates outward, carrying fragments of overheard dialogue: "Alright, this way class", "Hey, come look at this, wow!", "Mum, over here!" – alongside the repeated "mutter, mutter, mutter" of indistinct conversation. Near the listener figure, overlapping words become illegible, visually conveying the cognitive strain of processing multiple conversations simultaneously. The drawing thus captures not only the presence of speech, but its density, directionality, and interpretive load.

Taken together, the drawings demonstrate how participants perceived the galleries as layered and negotiated acoustic environments filled with overlapping voices, curated installations, mechanical noises, and fluctuating intensities. Most importantly, they make visible the situated nature of listening: each drawing centres a perceiver, explicitly or implicitly, and constructs the environment from that subjective point. The use of this tool surfaced a plurality of auditory experiences, highlighting how the same acoustic conditions can be experienced differently across listeners.

3.4 Aural Empathy Canvas

3.4.1 Description of the activity

After being immersed into the gallery soundscape, participants were invited to engage with the specific sound-based installation associated with their section. They were invited to listen, observe the technological set-up, and examine how the installation operated within its surrounding acoustic environment. Their reflections were guided by a set of prompts designed to capture multiple layers of the listening experience.

This tool was informed by empathy mapping, a HCD tool widely used in design practice[64] to articulate users' thoughts, feelings, pains, and gains in relation to a product or environment. Traditionally, empathy maps help designers move beyond func-

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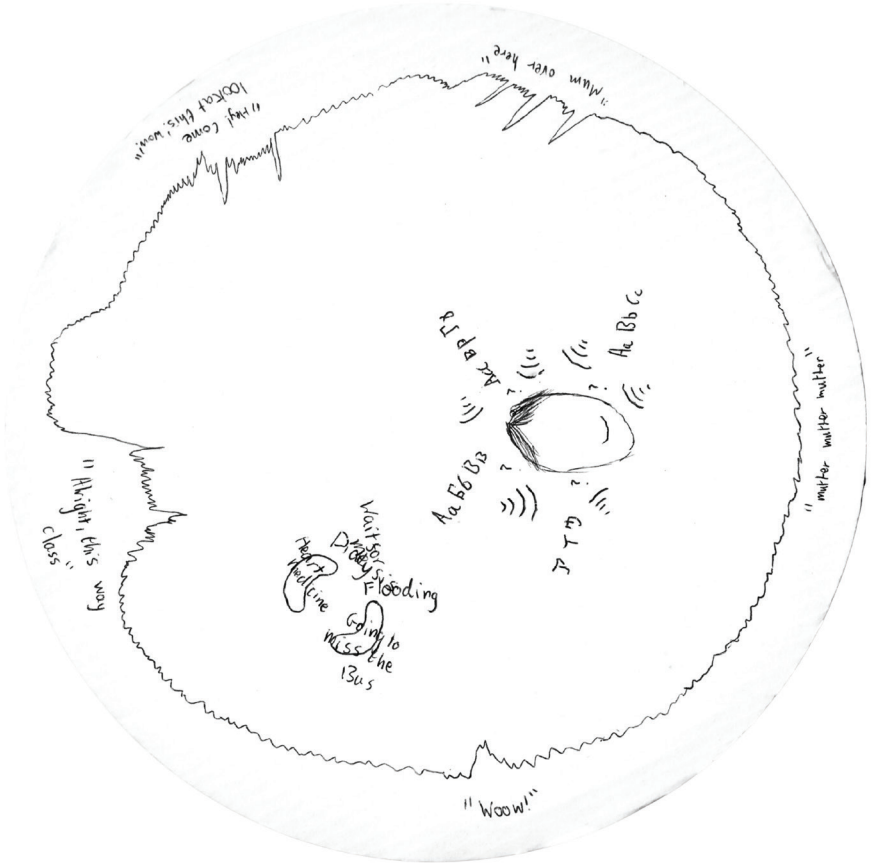

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Fig. 11:
Sound drawing n°6.

Fig. 12:
Sound drawing n°10.

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tional assessment and engage with lived experience, offering "perceptual lenses" to focus on specific dimensions such as emotional responses, bodily sensations, cognitive load. In the workshop, the tool was adapted into an auditory-centred empathy map that reoriented the attention towards listening as a situated, subjective and embodied experience (Fig. 13).

In particular, the prompts extended the core dimensions of empathy mapping to auditory perception, as shown in Table 2.

By integrating these dimensions, the exercise moved beyond a purely descriptive account of the installation as an isolated exhibit. Instead, it framed the sonic encounter as a situated, personalised and mediated experience, one produced through the interaction between curatorial interventions, architectural acoustics, living soundscape, and the embodied listener. Participants were encouraged to make explicit their tacit sonic impressions: to identify how headphones or directional speakers shaped speech intelligibility, how sound bleed affected meaning, how design decisions could enable, constrain, or complicate accessibility. Through the canvas, the installation was understood as a sonic interface structured by inclusionary and exclusionary dynamics, within a living museum environment.

At the conclusion of the activities, participants reconvened at the gallery entrance and placed their sound drawings and completed Aural Empathy Canvases on the floor (Fig. 14). This collective moment was structured as an opportunity for externalising, articulating and comparing individual experiences. Each participant described

Question	Objective	Empathy Canvas Area
How does the sound installation make me feel?	To explore the affective and emotional impact of the installation.	Feelings
What I found powerful was …	To identify what aspects of the installations participants found meaningful, powerful, or conceptually effective.	Gains
I find it hard to…	To capture perceptual (audibility, clarity), cognitive (interpretive load), and emotional (discomfort, intimacy, distress) difficulties.	Pains
What technologies and devices are used to bring sound into this space?	To understand how the technologies deployed affected auditory accessibility and sonic perception.	See
Additional sounds I heard that were not part of the exhibit	To consider how ambient noise, reverberation, or sound bleed affected the experience.	Hear

Table 2: List of the questions from the Auditory Empathy Canvas and their relation to Empathy Mapping.

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13

Fig. 13: Aural Empathy Canvas for the 'How Sound makes me feel' workshop.

their work, explaining how specific graphic choices corresponded to perceived sonic elements, as well as highlighting key reflections from their installation experience. This exchange enabled them to verbally express emotional responses, perceived challenges, and observations about the use of sound technologies. The exchange made perceptual differences explicit: the same acoustic feature might have been experienced differently, while certain sounds identified by one participant had gone unnoticed by others. Participants also reflected on installations or sections they had not personally encountered, listening to peers' accounts and comparing how similar technologies or spatial configurations were perceived across the group.

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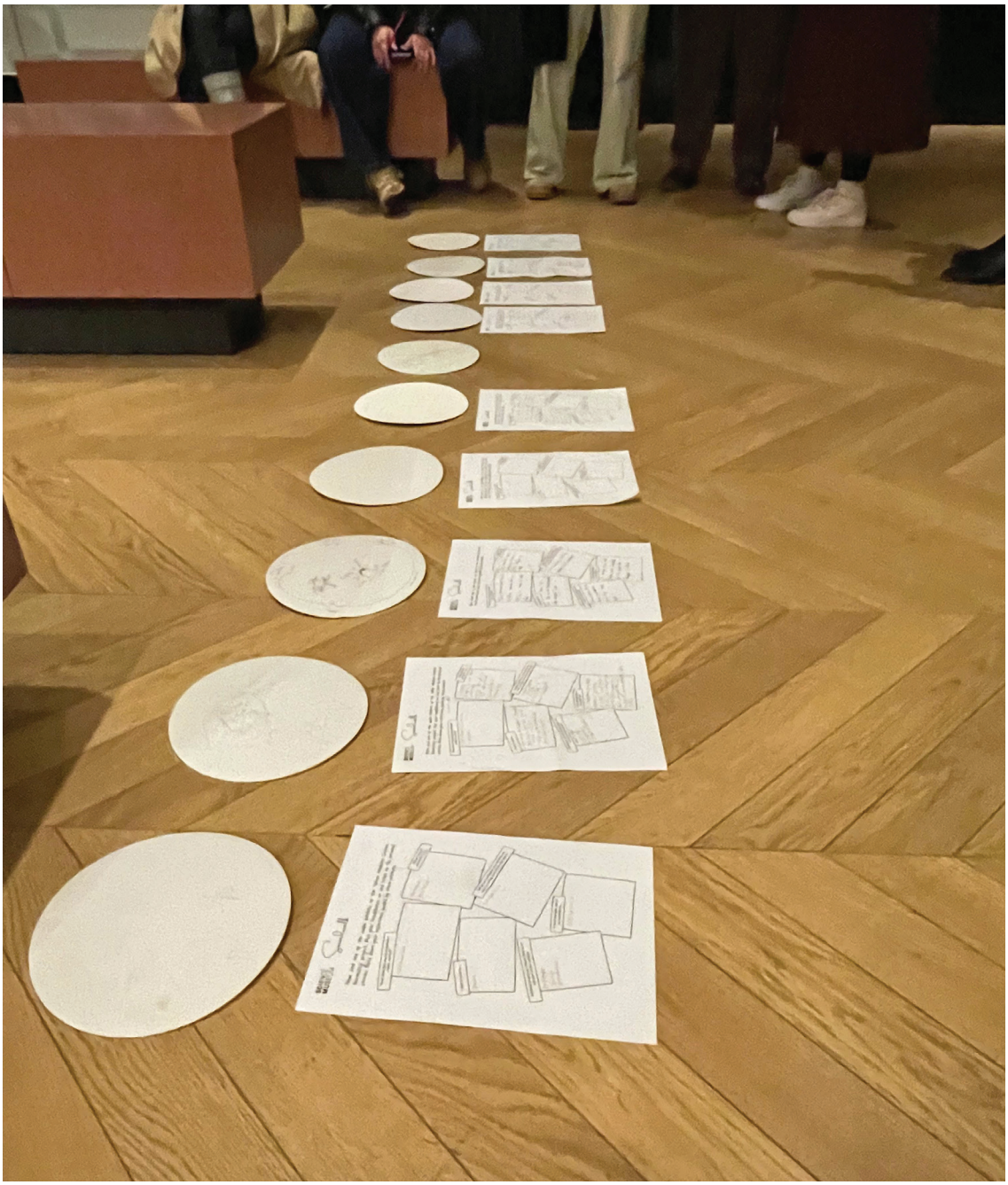

14

3.4.2 Results

The Aural Empathy Canvas provided particularly effective in capturing emotional, sensorial, cognitive and physical dimensions of engaging with sound within a curated setting. Whereas the sound-drawing exercise externalised perceptual impressions of the broader acoustic environment, the canvas directed attention to a specific, intentionally designed listening experience. It structured participants' reflections across multiple layers: what they felt at sensory and emotional levels, how they cognitively processed the content, how their bodies responded (e.g., fatigue, comfort, posture), and how both sound technologies and surrounding acoustic conditions shaped or mediated their engagement. Overall, 11 completed canvases were collected across the selected installations, distributed as shown in Table 3.

Fig. 14: Discussion of the drawings and canvas at the end of the 'How Sound makes me feel' workshop © Stefania Zardini Lacedelli.

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Gallery	Installation/Exhibit	Respondents
Medicine and Bodies	When Medicine Defines Normality	5
Medicine and Treatments	Therapist's Room	1
Medicine and Treatments	John Gibson & Son pharmacy	1
Faith, Hope and Fear	Faith, Hope and Fear	4
Medicine and Communities	Padded Cell	0

Table 3: Number of Aural Empathy Canvas collected per installation.

Intimacy and closeness emerged as strong themes, particularly among participants who experienced *When Medicine Defines Normality* and *Faith, Hope and Fear*. Many described their listening experience using affective descriptors such as "empathetic," "concerned," "worried," and "hopeful", with one participant explicitly referring to it as an "emotional experience" (AC9). Personal stories were consistently identified as one the most powerful dimensions of the installations. Participants valued hearing individuals "tell their own stories" (AC4), noting how this promoted a sense of "closeness and connection with the people behind the audio" (AC10).

At the same time, the canvas revealed the diversity and subjectivity of affective response. The same installation that fostered empathy and intimacy for some provoked discomfort for others. One participant explicitly referenced misophonia, explaining: "I found it hard to listen. Certain voices and audio peaks trigger misophonia. I would rather read the subtitles" (AC5). This response highlights how vocal timbre, amplitude peaks, or acoustic sharpness can generate distress, underscoring the importance of considering neurodivergent and sensory-sensitive listening profiles in exhibition design.

A recurring theme across eight canvases was the difficulty of sustaining focus on a single audio source. Participants reported they "struggled to remember", "stay concentrated", or found it "hard to focus". The canvas structure helped disentangle these cognitive challenges from purely individual reactions, making visible how attentional fatigue intersected with design and environmental factors. Overlapping and competing sounds were frequently identified as primary sources of distraction: voices and footsteps of other visitors, intermittent audio from nearby displays, noise from other gallery levels, and mechanical hums. One participant captured the cumulative cognitive load very effectively: "I think I prefer silent installations. Sounds make me tired. There is always a chance I will be distracted or surprised and I struggle to remember information" (AC5).

Two participants connected concentration difficulties to physical fatigue – particularly when required to hold a device to the ear (AC4) or stand for prolonged periods (AC11). In contrast, the presence of seating was mentioned as enabling more focused attention. One participant sitting in the *Therapist Room* appreciated having "a relatively quiet and suitable space for thinking", suggesting that spatial layout, bodily

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comfort, and acoustic containment play a decisive role in modulating both cognitive processing and emotional engagement.

Participants appreciated moments of sonic restraint. The installation *John Gibson & Son Pharmacy* was particularly appreciated for its immersive, calm and comfortable characteristics. Here, reduced auditory density was valued as a space for reflection: "I like there's not always someone talking, it gives you time to think/rest" (AC7) (Fig. 15). However, even in this case, acoustic permeability limited immersion. Voices of audiences both inside and outside the installation space were reported as intrusive, diminishing the installation's immersive potential. The canvas responses thus revealed how immersion is not a fixed quality of the installation itself but a dynamic condition co-produced by architectural acoustics, technological mediation, and individual sensorial sensitivity.

4. Findings and Discussion: Towards a Participatory Aural-Diverse Design Practice

The findings discussed in this section demonstrate how understanding of aural diversity can emerge through the situated interplay of multiple elements of practice, including activities, mediating artefacts, embodied engagement, shared reflection, and forms of knowledge mobilisation. This perspective aligns with the practice-theoretical approach adopted in this study, drawing on the broader "practice turn" in social theory,[65] which has subsequently informed organisational and workplace studies,[66] design research,[67] and, more recently, digital cultural heritage design research.[68] From this perspective, understanding within an aural diverse practice of sound design in museums emerges not from isolated methods, individual cognition, or discrete evaluative tools considered independently, but through the relational and processual enactment of practice itself. Importantly, our study should not be interpreted as a comparative claim between practice-based approaches and individual tools or techniques, since the latter were not examined independently within this study and their relative effectiveness therefore remains outside its scope.

4.1. From discrete tools to situated design practice

The first finding concerns how the workshop operated as a situated Human-Centred Design practice – constituted through the interplay of activities, tools, different actors, forms of knowledge, and situated modes of coordination – rather than a collection of separate methods, and how this configuration enabled understandings of aural diversity to emerge. This finding synthesises the relational and processual logic underpinning the other findings discussed in the following sections.

The workshop materialised this perspective through a structured sequence of activities designed to elicit and mobilise understandings of aural diversity in situ. Participants were guided through preparatory reflective questions, an *in-situ* soundwalk, individual sound-drawing activity, Aural Empathy Canvas and collective discussion. Each activity was designed as an interdependent progression towards an

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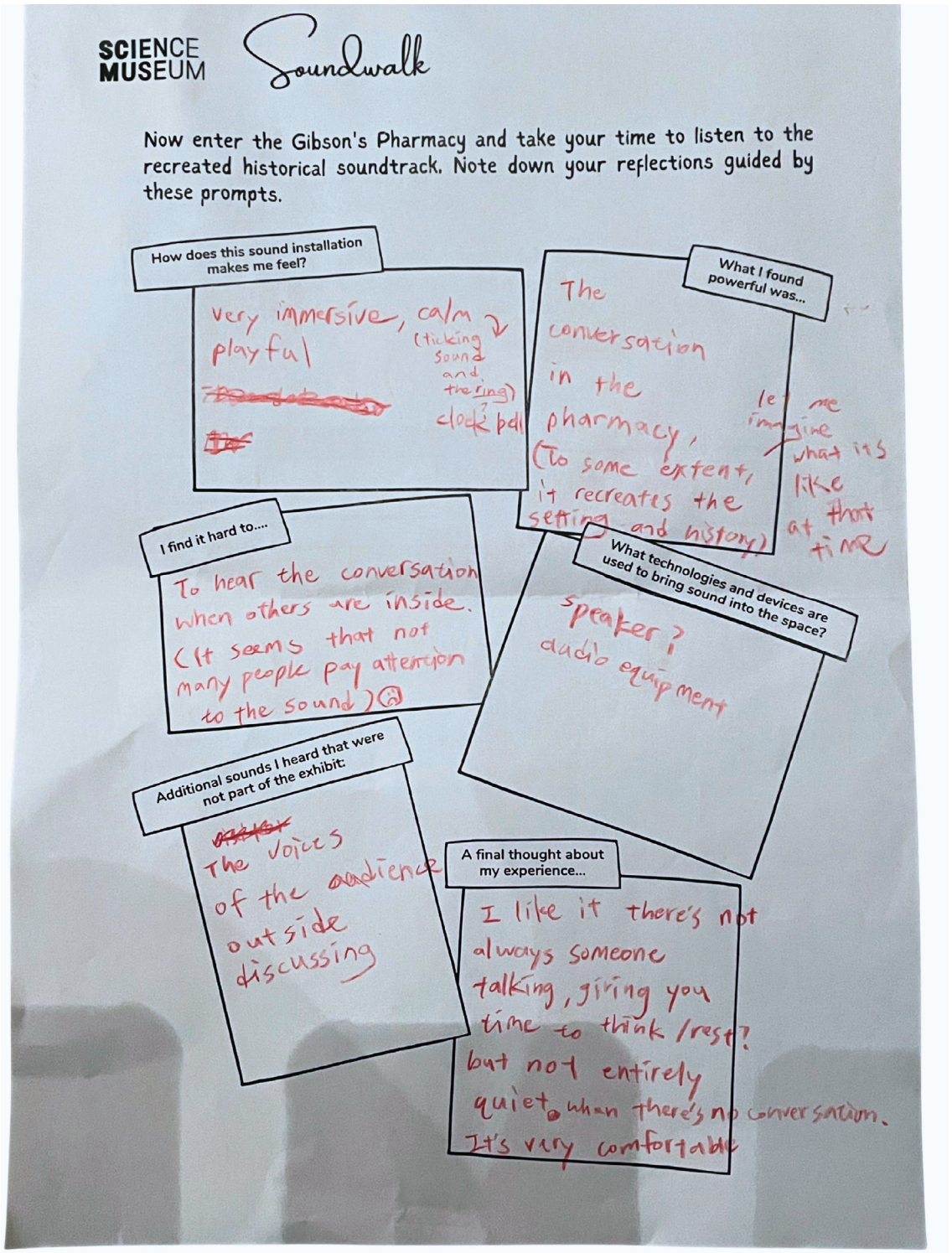

15

Fig. 15: Aural Empathy Canvas of Gibson's Pharmacy, Medicine Galleries - Science Museum.

in-depth understanding of sonic experience: preparatory questions oriented attention and expectations; the soundwalk activated listening as a situated and embodied act; drawing slowed perception and enabled externalisation of experience; and the collective discussion transformed individual reflections into shared knowledge.

As argued in Mason and Vavoula's conceptual framework for digital cultural heritage design practice,[69] design work becomes meaningful and transferable when activities, mediating tools, and forms of

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knowledge production align into a recognisable pattern of practice. In this sense, the workshop should not be interpreted as a mere application of a toolkit, but as an emergent practice in which each tool gains meaning through their relationship. Mason and Dziekan[70] further emphasise that such a practice-based approach is essential for addressing complex, embodied, and subjective phenomena such as aural diversity. The workshop's results showed how this configuration enabled the surfacing of patterns, tensions, and situated conditions of experience that remain difficult to access through metric or standalone evaluative approaches.

This emerging practice can be meaningfully situated within the Discovery/Understanding and Define phases of established HCD frameworks (e.g. UK Double Diamond, see Fig. 1). Its key contribution lies not in replicable sequencing of activities, but in the underlying logic of practice through which sonic experience becomes observable, discussable, and actionable. Understanding its internal mechanisms – as elaborated in the findings below, together with the detailed description of the workshop above – opens up the possibility for other museums to adopt and adapt this approach within their own situated contexts. While the workshop should not be reproduced as a fixed model – given the specific organisational, spatial, and infrastructural conditions of each museum context and the specific participant profiles involved – its practice logic and mechanisms can be reconfigured and adapted to different situated settings.

4.2 The preparatory auditory self-assessment as cognitive scaffold

This finding concerns the role of the preparatory auditory self-assessment used at the beginning of the workshop as design canvas and cognitive scaffold. While it might superficially resemble a data-gathering instrument, its function within the design practice was fundamentally different. Rather than operating as a survey intended to collect responses for later analysis, the self-assessment enabled shaping participants' attentional stance and orienting how they engaged with subsequent activities. The questions were deliberately open-ended and experiential, prompting participants to reflect on their own relationship with sound and listening sensitivities. Significantly, these questions acted as framing devices, comparable to empathy-oriented tools within Human-Centred Design, guiding what participants would attend to, how they would listen, and which aspects of experience might become salient during the following workshop activities.

From a practice-based perspective, this preparatory activity can also be understood as a situated form of orientation and gradual embeddedness within the understanding context of the workshop, as it progressively situated participants within the sensory, reflective, and interpretative conditions of the practice itself, preparing them to engage more attentively with the situated nature of auditory practice.

Seen in this way, the preparatory self-assessment operated as an enabling device that prepared participants for embodied engagement,

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playing a strategic role within the HCD understanding phase. This can be compared to what, in educational theory, is referred to as "scaffolding": a provisional structure that supports learners as they engage with complex tasks, gradually enabling them to act with greater autonomy.[71] In the case of aural-diverse practice, scaffolding becomes essential and part of the design practice together with other activities, tools, and knowledge mobilised, becoming a recurring "orientation device" that helps team members to better and more deeply engage with a plural, embedded, and experiential phenomena such as aural-diversity.

4.3 Activities externalising tacit and embodied sonic knowledge as epistemic mediators

A third finding concerns how tacit and embodied knowledge related to sound and listening can be externalised and shared through multiple embodied, performative and reflective actions and their interplay. The emphasis here is placed less on the resulting artefacts themselves (whose role will be discussed in 4.4) – and more on the mediated dimensions of these activities as part of a wider sequence of participatory design actions. The diversity of activities mobilised throughout the workshop – from the preparatory auditory self-assessment, to the soundwalk and sound-drawing exercise, to the verbal articulation prompted by the Aural Empathy Canvas – elicited complementary dimensions of the auditory experience, contributing to a more nuanced understanding of how sound is perceived, interpreted, remembered, and negotiated. Importantly, this understanding did not emerge through verbal communication alone, but through the interplay of multimodal and embodied forms of expression: walking, listening, drawing, writing, and discussing. This suggests how the complexity of auditory and sensory perception often exceeds the limits of language, requiring visual, spatial, and performative forms of articulation to become perceptible and communicable.

In particular, the combined activity of walking, listening and drawing – during which participants were prompted to translate their sonic impressions into visual form – proved to be a particularly effective method for externalising forms of knowledge that typically remain implicit, embodied, and difficult to articulate. While participants moved through the same environment and were exposed to similar sonic conditions, the visual artefacts they produced differed. These differences revealed distinct, situated ways of perceiving, attending to, and interpreting sonic experience. For instance, in several cases, participants captured sonic elements that went unnoticed by others, surfacing aspects that would likely remain invisible within verbal reporting alone. In this sense, the action of drawing functioned not simply as a representational technique, but as a mode of inquiry and sense-making that enabled participants to reflect upon, interpret, and communicate embodied and difficult-to-articulate perceptions.

From a design perspective, this finding exemplifies a tacit-to-explicit knowledge transformation enacted through design activity. Following

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Polanyi,[72] tacit knowledge is not simply extracted through reflection, but becomes expressible through mediated action (i.e. drawing). In this case, drawing functioned as an epistemic action that is a way of "thinking through making." The sound-drawing disks were not intended to represent sound accurately or objectively, but to support sense-making by inviting participants to externalise embodied listening experiences in a form that could be revisited and discussed.

However, making individual perceptions visible is only a first step; for these insights to inform design, they must be shared, compared, and negotiated across different listening perspectives.

4.4 Boundary objects as mediators of plural listening

A further finding concerns the role of the workshop artefacts (e.g. the sound-drawing disks and the Aural Empathy Canvas) in bringing the plurality of listening experiences into relation. When the artifacts were shared and discussed collectively, they enabled participants to compare experiences, recognise contrasts, and identify patterns without requiring agreement on a single interpretation. This dynamic can be seen through the concept of "boundary objects",[73] which are artefacts that are "plastic enough" to accommodate different interpretations while remaining "robust enough" to sustain shared work across diverse social worlds. Their function is not to eliminate differences, but to make collaboration possible in the presence of differences as boundary objects are not simply communication tools – they occupy an "in-between position" – enabling coordination without requiring full alignment of understanding amongst team members with different backgrounds.

In the workshop, each participant interpreted and produced their drawing through a personal, embodied listening experience, yet once placed side by side, they became shared reference points. The differences between them – and, crucially, the reflections on those differences – proved essential, as divergent listening perspectives became productive resources for exploring the problem space (see Section 4.6). This is particularly significant for engaging with aural diversity, as it allows differences in sonic perception to become productive resources for exploring the acoustic environment.

4.5 From Boundary Objects to Intermediary Design Deliverables

A further finding concerns the potential for the workshop artefacts to function not only as mediators of plural listening perspectives, but also as evolving carriers of aural-diverse knowledge across subsequent phases of Human-Centred Design. The emphasis here shifts towards the processual and evolutionary nature of design practice: specifically, how these insights can become progressively stabilised and translated into forms that inform future design action. Rather than generating isolated reflections about sound, the workshop produced artefacts capable of carrying insights about auditory experience beyond the immediate activities and into later stages of the design process.

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This resonates with Vavoula and Mason's concept of "Intermediary Design Deliverables" (IDDs),[74] which materialise the progressive stabilisation of understanding within a design process. IDDs are artefacts that embody the evolving progression of design, from initial understanding and exploratory phases toward more structured forms of definition and intervention. In this sense, they mark key moments where collective insights, interpretations, and partial agreements become objectified in forms that guide and inform "what happens next", functioning as "connective tissue" across the design lifecycle. They create what Vavoula and Mason describe as moments of provisional consent, whereby certain tensions or insights become recognised as legitimate points of action and, once materialised, enter the process memory of the project, shaping what can subsequently be proposed, revisited, ignored, or reworked.

Within the context of this study, the workshop itself remained confined to the Understanding/Discovery phase of Human-Centred Design (see Fig. 1) and, therefore, our study could not empirically examine how these artefacts would concretely evolve, circulate, or operate across later design phases. However, the findings suggest that, if an aural-diverse design practice were integrated within broader Human-Centred Design processes, the artefacts generated through the workshop could function as Intermediary Design Deliverables, capable of informing subsequent phases of definition, ideation, development, and even testing. In the case of the Science Museum, for example, insights related to cognitive fatigue, sound overlap, or the need for quieter reflective spaces can inform future design interventions aimed at improving sonic accessibility of the galleries.

From a Human-Centred Design perspective, this highlights how understanding of sound and auditory experience can be progressively integrated from the earliest stages of design, rather than addressed retrospectively as an accessibility adjustment. In this sense, the workshop artefacts do not simply preserve reflections generated during the activities, but participate in the progressive framing and reframing of the design problem itself, supporting the transition from exploratory understanding toward more structured forms of problem definition discussed in the following section.

4.6 Problem framing as an aural-diverse design practice

The final finding concerns the relationship between understanding sonic experience – as enacted through the workshop – and problem framing in HCD practice. Problem framing refers to the process through which designers and non-designers (e.g. museum practitioners) co-define what is considered relevant, problematic, actionable, and meaningful within a design situation. Rather than assuming that problems pre-exist and simply need to be solved, problem framing recognises that design challenges are progressively constructed, interpreted, and negotiated through inquiry, interaction, and exploration[75].

Within this perspective, the work-

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shop operated within the problem framing space. Rather than aiming at delivering a formal problem statement (or a design brief), it configured the problem space itself, enabled participants to articulate and negotiate what aspects of auditory experience might become relevant, actionable, or meaningful for future design intervention. Positioned between the Discover and Define phases, the workshop operated as a formative and situated process through which the design problem progressively began to take shape, laying the groundwork for subsequent framing during the Development and Ideation phases.

This understanding of "problem framing" aligns with foundational research in design. Dorst[76] argues that problem framing is a strategic design capability: it reshapes how situations are understood and what becomes actionable. Earlier, Dorst and Cross[77] demonstrated that problems and solutions co-evolve in design activity: designers and non-designers iteratively structure and restructure the problem space while simultaneously exploring possible solutions.

Within this perspective, the way in which problem framing was enacted in the workshop can be understood not as a separate or preliminary activity, but as an integral and foundational component of the design process itself, allowing to continuously refine, clarify and articulate the set of conditions, tensions and experiences through which aural diversity become understood, negotiated and addressed.

5. Conclusion

This article set out to investigate how Human-Centred Design (HCD) can meaningfully engage with aural diversity within contemporary museum environments. Rather than treating sound solely as a curatorial medium or an environmental condition to be managed, the study reframed it as a complex, embodied and situated dimension of experience – one that requires design approaches capable of capturing plurality, tacit knowledge, and sensory difference. Through the workshop *How Sound Makes Me Feel*, the article examined how an emerging design practice can be developed to understand and work with aural diversity from the earliest stages of the design process.

A central contribution of the study lies in demonstrating that design value did not emerge from single/isolated tools, but from the structured sequencing of activities – preparatory reflection, soundwalking, drawing, focused analysis through the Aural Empathy Canvas, and collective discussion. Together, these activities created a scaffold that enabled participants to attune to their listening experiences, surface embodied perceptions, and recognise the multiplicity of ways sound is perceived, processed, and emotionally experienced. Understanding developed gradually, through immersion, externalisation, and comparison – a progression integral to HCD's commitment to empathy, participation, and critical reflection.

The use of creative methods and visualisations – particularly sound walking and sound drawings – proved essential. These artefacts enabled tacit and embodied listening knowledge to become visible and

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discussable, functioning as *boundary objects* that supported meaning making across diverse experiences. As participants identified recurring tensions – fatigue, difficulty focusing, cognitive overload, or the benefits of sonic restraint – these artefacts became *Intermediary Design Deliverables*, stabilising key insights and carrying them forward into the design process as legitimate considerations for inclusive design. In doing so, they helped preserve and amplify auditory plurality, rather than reduce it to standardised measures.

The study also showed how this emerging practice contributes to problem framing, a core component of HCD. Rather than defining accessibility issues in advance, the workshop shaped the very conditions through which the "problem" of sound inclusion in museums could be recognised and articulated. This shift – from problem solving to problem framing, as well as from sound accessibility to sonic inclusion – aligns with contemporary design scholarship and demonstrates why inclusive sonic design must begin with in depth understanding.

Taken together, the findings suggest that aural-diverse design can operate as an embedded HCD practice, especially within the early Understanding and Defining phases of established frameworks such as the Double Diamond. What is transferable is not a prescriptive toolkit, nor a replicable sequence of fixed steps, but the logic and mechanics of the practice: orienting attention towards sonic perception, fostering embodied engagement, creating shared artefacts for reflection, and maintaining the plurality of listening experiences as a design resource.

In post-digital, media-rich museum environments – where sound is increasingly central yet often under-theorised – this emerging aural-diverse design practice provides a way for museums to perceive what traditional acoustic evaluation methods cannot. It reveals how sound can support or hinder engagement, how visitors navigate sensory complexity, and how inclusive design must attend not only to technological accessibility but to perceptual, emotional, and cognitive dimensions of experience. By embedding this practice, museums can begin to recognise hearing differences not as a deficit to be accommodated, but as a form of disability gain[78] – a source of insight and lived knowledge that enhances the quality of experience for all visitors.

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Limitations

This study has limitations that shape the scope of its findings. The work was conducted in a single museum and on a specific day, meaning that the sound environment reflects conditions that may vary across time, visitor numbers, or temporary activities. All participants were MA Museum Studies students, representing a specific, self-selecting group with prior academic and practical engagement with museum contexts and visitor experience design. This prior familiarity may have influenced how participants engaged with the workshop tools, particularly in relation to reflective, interpretative, and task-based activities and may not reflect how different museum visitors would engage with the same methods. Further work is needed to consider how the tools and activities might need to be adapted for more diverse participant groups, particularly those with diagnosed hearing conditions such as hyperacusis, tinnitus, misophonia, auditory processing disorders, autistic listening profiles and hearing loss. These groups may be at greater risk of sensory overload, fatigue, or anxiety when engaging with research activities involving complex or unpredictable sound environments. Future applications of this approach should therefore prioritise accessibility, informed consent, and safeguarding considerations, ensuring that participation is designed to minimise discomfort and support positive, empathetic and inclusive research experiences.

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Endnotes:

1 Cortez 2022.

2 Zardini Lacedelli, Stack, Jamieson 2021.

3 Byrne 2012.

4 Kannenberg 2017.

5 Renel 2022.

6 Drever, Hugill 2022.

7 Davies 2023.

8 Weisser et al. 2019.

9 Eardley et al. 2022; Vohra et al. 2025.

10 McEnaney 2019.

11 Bubaris 2014; Cortez 2023; Wiens, de Visscher 2019; Thormälen, Brooks, Stephens 2022.

12 Kannenberg 2017; Mansell, Jamieson, De Little 2022.

13 Mansell 2017; Schulze 2018; Zardini Lacedelli 2027 (forthcoming).

14 Schulze et al. 2027 (forthcoming).

15 The first international conference dedicated to the field, *Sound in Museums*, was held in Kolding in 2024; a second edition followed in Mafra in 2025. See *Sound in Museums* 2025.

16 Parry 2013.

17 Drotner et al. 2018.

18 Popple, Prescott, Mutibwa 2020.

19 Morse 2020.

20 Lackoi, Patsou, Chatterjee 2016.

21 Kelly 2017.

22 Romeo Pitone, Harvie-Clark 2023.

23 Weisser et al. 2019.

24 Heylighen, Rychtarikova, Vermeir 2010; Zhang, Trocchianesi 2023; Eardley et al. 2024.

25 Bitgood 2009.

26 Granland, Sadia, Cooper 2026.

27 Rosas Pérez et al. 2025.

28 Bendo et al. 2024.

29 Renel 2022.

30 Guffey 2023.

31 Hamraie 2017.

32 Drever, Hugill 2022.

33 Çakır 2025.

34 Ferrer-Torres, Giménez-Llort 2022.

35 Jarach et al. 2022.

36 Alanazi 2023.

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37 Kytö 2022.

38 Renel 2019.

39 Palmer, Rees 2010.

40 Renel 2019.

41 Mason 2018; Mason 2022.

42 Parry, Dziekan 2021; Mason, Dziekan, Parry 2025.

43 Vermeeren et al. 2018; Mason 2020; Hornecker, Ciolfi 2022.

44 Mason, Dziekan 2025a.

45 Mason, Dziekan 2025b.

46 Mason, Dziekan 2025a.

47 See Design Thinking Stanford. The Stanford d.school Human-Centred Design (Design Thinking) framework, structured into five iterative phases: *Empathize* (understanding of users and contexts), *Define* (articulating and reframing the design challenge), *Ideate* (generating and exploring possible ideas/solutions), *Prototype* (materialising ideas in tangible forms), and *Test* (evaluating and refining ideas/solutions through feedback). Although visually represented as sequential, the phases are iterative and recursive, with problem framing and solution development co-evolving throughout the process. Source: https://dschool.stanford.edu/.

48 Hou, Riccò 2025.

49 Chiaccheri 2022.

50 Holmes 2018.

51 The Double Diamond by the Design Council is a visual representation of the design and innovation process. It's a simple way to describe the steps taken in any design and innovation project, irrespective of methods and tools used. Source: https://www.designcouncil.org.uk/our-resources/the-double-diamond/ CC BY 4.0 license.

52 Thompson, Biddle 2013.

53 Bond et al. 2021.

54 Harvie-Clark, Romeo Pitone 2020.

55 Westerkamp 2007.

56 Arup 2024.

57 The Aural Diversity Toolkit is grounded in empirical research conducted through a questionnaire completed by 49 aurally divergent participants, followed by in-depth interviews. The research centred lived experience, inviting participants to describe their challenges, preferences, assistive strategies, and levels of confidence across different public acoustic environments. The findings were synthesised into six aural-diverse personas that illustrate varied auditory needs and listening profiles.

58 Kannenberg 2016.

59 Oliveros 2005.

60 Biserna 2022.

61 Kelly 2017.

62 Thulin 2016.

63 Thompson 2024.

64 Dam, Siang 2018.

65 Reckwitz 2002; Schatzki, Knorr-Cetina, von Savigny 2001.

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66 Nicolini 2012.

67 Kimbell 2012.

68 Mason, Vavoula 2021.

69 Mason, Vavoula 2021.

70 Mason, Dziekan 2025a.

71 Vygotsky, Cole 1978.

72 Polanyi 2009.

73 Star, Griesemer 1989.

74 Vavoula, Mason 2017.

75 Within the UK Double Diamond, framing operates primarily across the Discover and Define phases – the exploratory space in which the workshop took place – where broad exploration is gradually synthesised into more focused directions for design action. However, problem framing also extends beyond these phases as an iterative process embedded throughout design practice, where problems continue to be refined and clarified through ideation, prototyping, and testing.

76 Dorst 2015; van der Bijl-Brouwer, Dorst 2017.

77 Dorst, Cross 2001.

78 Eardley, Jones 2025.

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