

Listening Mirrors Prototyping for a Hybrid Audio Augmented Reality Installation

Cécile Chevalier
c.chevalier@sussex.ac.uk

Chris Kiefer
c.kiefer@sussex.ac.uk

Experimental Music Technologies Lab (Emute
Lab), University of Sussex

Abstract

We introduce ongoing developments of *Listening Mirrors*, a sound art installation and live interface for musician and non-musician alike. The piece, in its construction and interaction design, investigates ways in which collective sonic expression can be made possible using Audio Augmented Reality technology (AAR) and acoustic mirrors, whilst asking how such environments promote collective sonic expression.

Listening Mirrors is composed of a virtual acoustic mirror (an iOS app built with OpenFrameworks, LibPD with bone-conduction headphones), parabolic acoustic mirrors (inc. piezo mic), networked with transducers for real-time collective performance. The installation creates interplay between real and virtual sound worlds, and explores the nature of human experience within these borders by drawing on Merleau-Ponty's *Ontology of the Flesh*.

Keywords

Augmented reality
Sound art installations
Collective musical expression
Mobile music making
Merleau-Ponty
Enactivism

Introduction

Listening Mirrors is an instrument for collective sonic expression building on an audience participation dependent system using real and virtual interfaces. This paper discusses the latest developments to *Listening Mirrors*, investigating ways in which realtime collective expression can be made possible using Audio Augmented Reality technology (AAR) and acoustic design, whilst asking how such environments promote musical expression?

Listening Mirrors has been designed as a space in which musicians and non-musicians can play and express themselves through listening to their own body and the bodies of others. This is made possible by constructing a system where environment, audience and interfaces feed off each other, whilst revisiting Merleau-Ponty's (1964, 1960, p67; 1945, p 190) notion of *carnal body* (*corps sauvage*) (e.g. listening to the breath in vocal expression), as the audience's own bodies become more technologised through the use of wearable devices.

The piece, in its aesthetic exploration between sound, space and body, is primarily influenced by the Sound Mirrors (Dungeness, UK), a redundant war technology, in their aesthetics and functionality; and by Bernard Leitner's *Sound Umbrella* (1990) and his view on corporeal hearing, where acoustic perception is heard through the entire body: "I can hear with my knee better than with my calves" (Leitner 2008).

In situating the piece within Merleau-Ponty's *Ontology of the Flesh* (1964, unfinished and published post-mortem), Radical Enactivist thinking (Hutto and Myin 2017; Zavota 2017), and through technological interfaces – more specifically AAR instruments – we aim to alter the way in which the audience *couples* or *intertwines* with the installation environment, to create new channels for sonic expression:

"[T]he body inhabits the world as its expressive place for action. The deftness of the pianist's hands is what transforms the keyboard into something to be played, revealing it as a place for expression, and the playing of this keyboard modulates and reshapes the pianist's general power for playing [...]. The body, then, must be recognized as essentially an "expressive space"; the body is "the very movement of expression". (Merleau-Ponty, 1945, p147)

In this sense we do not locate the body relations with technological interface as embodied, embedded or extended but instead as paradoxically intertwining "immanence" and "transcendence" of the body, as *chiasm* (Merleau-Ponty 1964). Next we clarify our theoretical position around chiasm, flesh and expression.

1.Chiasm, Flesh and Expression

The later work of Merleau-Ponty and related theories of Enactivism provide a theoretical basis for our design approach to *Listening Mirrors*. Merleau-Ponty shifts from his initial phenomenological perspective (1945) in which the body in consciousness is a prime source for knowledge, towards an ontological one in which the body, still in a prime position, is based in the intertwining of immanence and transcendence, the 'sentient' and the 'sensible' (1964, p.136,180), the *corps sauvage* and cultural body, as one 'chair' or 'flesh' (1964).

In defining what is meant by 'flesh', Merleau-Ponty states, '[w]e must seek space and its content together' (1964, p.141; 1968, p.157–8), that we are 'interwoven into a single fabric' (1945, p.413), a 'universal flesh' (1964, p.137), and 'he who sees cannot possess the visible unless he is possessed by it, unless he is of it' (1945, pp.134–35, 1968). The notion of 'flesh', therefore, is both the 'flesh of the world' and the 'flesh of the body', the relation of the *corps sauvage* and cultural world and its representations.

Merleau-Ponty's *corps sauvage* refers to the body before language, the body based on instincts and senses. 'Flesh' is not materiality, spirit or substance (1964, p.181) but an experience sourced from and based in and beyond perception; it is the paradoxically intertwining 'immanence' and 'transcendence' of the body as it is enveloped by and within 'flesh': [T]his occurs because a sort of dehiscence opens my body in two, and because between my body looked at and my body looking, my body touched and my body touching, my body heard and my body hearing, there is entwining in reversibility, there is chiasm, so that we must say that the things pass into us as well as we into the things (1968, p.123). *Chiasm* is an intertwining of relation such as the visible and the invisible, touched and touching. (Landes 2013, p38).

From this perspective, it becomes possible to think of the body no longer as a main point of perception (Landes 2013) but as pre-body-subject/object, as the *corps sauvage*, and as part of a reciprocal relational system with the 'flesh in the world' as they reflect, encroach and become inseparable (ibid, p.248): *Raising the description of the intentional arc to an ontological level, it seems that the body 'holds things in a circle around itself' such that things of the body's milieu are internally related to what the body is, they are part of its 'full definition' – the body is then, essentially relational.* (Landes 2013, p76)

In this relational system, new forms of sonic expression are found in action. Landes (2013), in discussing Merleau-Ponty, highlights how "[...] given the paradoxical logic of expression, all action is writing and all perception is reading", reflecting Merleau-Ponty chiasm as the "body makes itself the outside of its inside and the inside of its outside" (1968, p144), as my body hears and is heard.

More recently new forms of Enactivism draws strong links with Merleau-Ponty's Ontology of Flesh. Jenkinson (2017) and Zavota (2016) comment on how Enactivism has heavily drawn from Merleau-Ponty's early work (primarily

Phenomenology of Perception, 1945) but by adding Merleau-Ponty's Ontology of the Flesh to the Enactivism discussions, challenges existing dualism between cognition and the body: "*The nature of our conscious experience of being embodied human beings is thus conditioned by the particular structure of our sense organs and their interaction with the environment, in line with embodied and embedded theories of cognition*". Merleau-Ponty goes further than this, however, to argue that "[t]here is a human body when, between the seeing and the seen, between touching and the touched . . . a blending of some sort takes place.". (Zavota 2016, p114); and also bring new challenges in thinking "*how body and world are discretely distinguishable*" (Jenkinson, 2017).

In addition, Armstrong (2007) draws links between enactive theories of cognition and musical instrument design, setting out the conditions for embodied coupling between human and instrument: situatedness, timeliness, emergence, multimodality and engagement. We see AAR as an opportunity to experiment with, modulate and disrupt these conditions to create new audience collective experience.

Further to Enactivist approaches, we draw from the work of gaming theorist Karen Collins (2011), in the exploration of sound in relation to the body in game worlds. Collins discusses how sound can become a sensory extension of the self when exploring a virtual world. In discussing Chion's notion of ergo-audition, which suggests that we have a strong embodied connection to self-produced sounds, it can be argued that self-production of sound is a form of physical exploration of an environment. Consequently, we can consider the fine-tuning of mappings in the installation to encourage self-vocalisation as a form of exploration and self-establishment within a game world, as well as a form of sonic expression. Collins approach sound as a transcendent medium and how in the mixed reality context, the audience can hear and their body be heard, thus echoing Merleau-Ponty's *chiasm*.

In summary, we have presented theories that continue to influence our thinking around the ingoing design of this installation. Next we introduce our instrument design and aesthetics around audience's bodies and mixed reality worlds.

2.Design Aesthetics

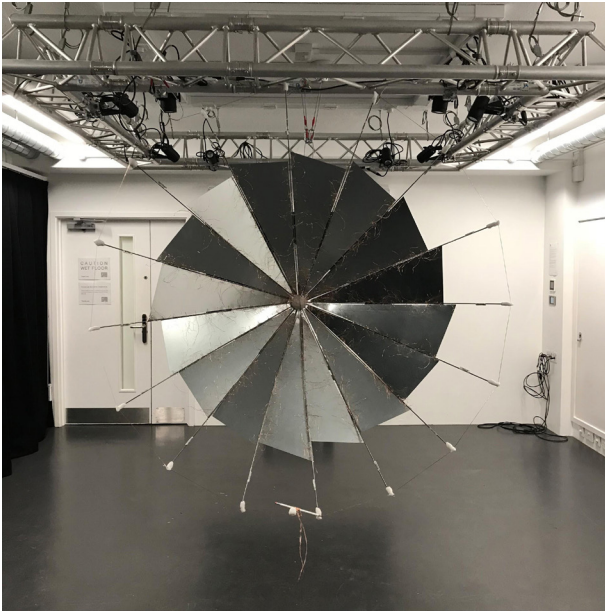


Figure 1. A Listening Mirror

In designing Listening Mirrors the main ambition was to offer new experience and expression through the combining real and virtual world manipulation. The development of the Listening Mirrors began in Summer 2017, by initially developing our concept and reflecting on others and our own position around AR technology with the “*Forum for Augmented Reality Immersive Instruments*”, which invited multidisciplinary artists and researchers to discuss AR and the arts (Chevalier and Kiefer, 2017).

Once we had experimented with different software mappings and looked at a wide range of practical designs for acoustic mirrors, we decided to use as pattern a parabolic design for DIY solar reflectors (Zhu, 2002) combined with aluminium material to maximize the acoustic resonance for collective immersive experience.

We ran a formative audience study, to elicit initial feedback about the audience experience of the installation elements with the aim to establishing key issues (Kiefer and Chevalier, 2018). The results demonstrated the potential of the system to be immersive, to encourage playfulness within the installation environment and to provide a space for collective musical expression: “*It did feel like a safe environment to experiment in, because you kind of feel enclosed in this sound world ... a big safe space which is making your voice sound really great*”. It also highlighted issues around social inhibition in collective environments: “*I was a little bit reticent to use my voice*”, and the fine-tuning of balance between virtual and real worlds. This feedback led us to the iteration we are currently testing, that uses networked audio and transduction in the mirrors, giving more opportunities to the audience for expression and interaction. As Listening Mirrors reaches its final design stage we will be conducting further audience studies to fine-tune the mappings, in the context of the relational system earlier mentioned.

3.Listening Mirrors Prototype

The installation is an audio feedback system that channels and transforms sound through real and virtual domains. It merges together audience worn AAR with shared physical acoustic objects. These are linked through transduction of sound through the physical objects and the environment. Figure 2 shows the objects in the system and how they are connected.

Audio Augmented Reality & Virtual Mirrors

The AAR system comprises an app running on a mobile device, paired with bone conducting headphones. These headphones are worn in front of the ears, allowing the wearer to hear digitally processed sound layered with normal hearing. The sound environment is monitored using the microphone of the mobile device, reprocessed and played through the head-

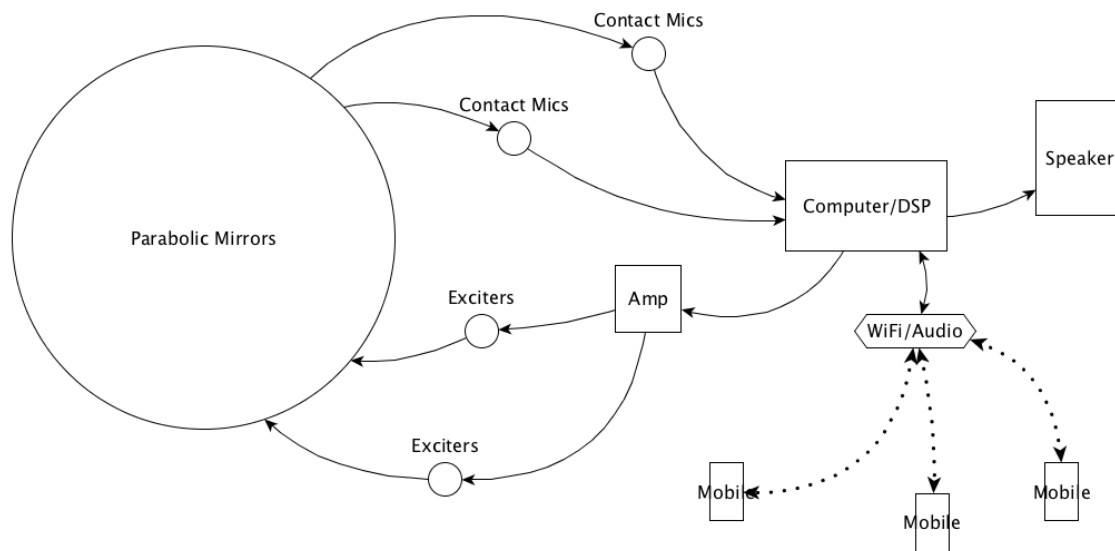


Figure 2. The objects in the installation and their connections

phones, thereby creating an augmented audio environment which is a mixture of the natural environment and synthetic reprocessing of it. The mobile device runs an iOS app, which hosts a Pure Data sound engine (using LibPD, Brinkman, 2012) within an OpenFrameworks app. The sound processing uses heavy compression coupled with mid to high frequency emphasis of the microphone signal, emphasising the sound of the breath, with the addition of a convolution reverb to modify the sense of space.

Parabolic Mirrors

The physical objects in the installation are two identical parabolic mirrors (see figure 1). These are constructed from cut aluminium sheeting, wired to 3mm diameter piano wires in a circular formation. The support wires are mounted on a central plastic support, and have plastic connectors on the end through which bass strings are fed. The strings are pulled tense, to draw the structure into a parabolic shape. The mirrors are augmented with two types of transducers: (a) contact microphones are mounted to record vibrations in the structure and (b) audio exciters are mounted to induce vibrations in the structure. The design

of the mirrors lend them multiple roles; as reflectors of environmental sound, as transmitters of sound and as responders to physical manipulation by the audience.

Audio Connections

There are several vectors for sound in the installation. The acoustic environment echoes sound made by audience members, and is shaped by the focusing of sound between the parabolic mirrors. A computer acts as a hub for further sound routing. It is connected to contact microphones on the parabolic mirrors, collecting acoustic sounds made by the audience manipulating Listening Mirrors. It is also connected to the audio exciters on the parabolic mirrors. The computer also hosts an audio-over-IP server that allows it to exchange networked audio streams with the audiences' mobile devices. This creates a network of audio routings that allows exchange of sound between audience, environment and the parabolic mirrors.

4. Listening Mirrors and Collective Expression

We consider Listening Mirrors as a mixed reality relational system and instrument from which new expressive, playful and collective experiences take place. In *Augmented Reality in Art*, Geoffrey Rhodes (2014) discusses AR as an *inhabited environment* from which the digital and the physical *co-produce and co-construct one another*, from which expression can be found in its enmeshment (Chevalier and Kiefer 2018). This recalls Merleau-Ponty's discussion on *chiasm* and *flesh* and new forms of Enactivism earlier mentioned, leading us towards further investigation of the potential value of this work as a theoretical basis for our approach to audio augmented reality and other work in AR and the arts. We continue to develop and test this installation, but we believe that AAR demonstrated abilities to enhance collectiveness through sound and network technology, suggesting that how AAR is a form of *chiasm*: my body hears and is heard.

To conclude, we have described an installation environment that employs a combination of audio augmented reality with a physically augmented acoustic environment, designed to encourage collective sonic expression. The design uses mobile AR technology, together with acoustic reflectors that also double as sound transducers between real and virtual worlds. We have outlined the development history of the project, and introduced the theoretical background we are drawing on to help us to understand new modes of collective sonic interaction that involve hybrid real/virtual interfaces. We see Merleau-Ponty and theories of Enactivism as a way forward to think about AAR technology and collective sonic expression. Questions in future development of this piece concern how the body is conceptualised at the borders between real and virtual worlds, and how AR interventions in perception can lead to collective expressive interaction.

- Armstrong, Newton.** 2007. *An Enactive Approach to Digital Musical Instrument Design Theory, Models, Techniques.* VDM Verlag Dr. Müller.
- Brinkmann, Peter.** 2012. *Making Musical Apps Using the Libpd Sound Engine.* O'Reilly & Associates.
- Cantz, Hatje.** 2008. *Bernhard Leitner - P.U.L.S.E.*
- Chevalier, C and Kiefer, C.** *Forum for Augmented Reality Immersive Instruments, University of Sussex, 2017.*
- . "What does Augmented Reality Mean as a Medium of Expression for Computational Artists?", *Leonardo* (In Press), 2018.
- Collins, Karen.** 2011. "Making Gamers Cry." *Proceedings of the 6th Audio Mostly Conference on A Conference on Interaction with Sound - AM '11*, doi:10.1145/2095667.2095673.
- . 2017. *Playing with Sound: A Theory of Interacting with Sound and Music in Video Games.* MIT Press, 2013.
- Hutto, Daniel D., and Erik Myin.** *Evolving Enactivism: Basic Minds Meet Content.* The MIT Press.
- Jenkinson, John.** 2017. "A New Framework for Enactivism: Understanding the Enactive Body through Structural Flexibility and Merleau-Ponty's Ontology of Flesh." *Scholarship@Western*, ir.lib.uwo.ca/etd/4383
- Kiefer, C and Chevalier, C.** "Towards New Modes of Collective Musical Expression through Audio Augmented Reality". *Proceedings of New Interfaces for Musical Expression, 2018.*
- Landes, Donald.** 2013. *The Merleau-Ponty Dictionary,* Bloomsbury Academic, London ; New York.
- Magnusson, Thor.** 2009. "Of Epistemic Tools: Musical Instruments as Cognitive Extensions." *Organised Sound*, vol. 14, no. 02, 2009, p. 168., doi:10.1017/s1355771809000272.
- Merleau-Ponty, Maurice, and Claude Lefort.** 1964. *Le Visible Et L'invisible ; Notes De Travail.* Gallimard, 1993.
- Merleau-Ponty, Maurice.** 2002. *Phenomenology of Perception: an Introduction.* Routledge.
- . 1945. *Phénoménologie De La Perception.* Gallimard, 1994.
- . 1960. *Signes.* Gallimard, Paris.
- . 1968 *The Visible and the Invisible: Followed by Working Notes.* Northwestern University Press, 2000.
- Rhodes, G.A.** 2014. "Augmented Reality in Art: Aesthetics and Material for Expression". In: Geroimenko V. (eds) *Augmented Reality Art.* Springer Series on Cultural Computing. Springer, Cham, pp. 127-137.
- Zavota, Gina.** 2016. "Expanding the Extended Mind: Merleau-Ponty's Late Ontology as Radical Enactive Cognition." *Essays in Philosophy*, vol. 17, no. 2, pp. 94-124., doi:10.7710/1526-0569.1558.
- L.-Y. Zhu.** 2002. Making a parabolic reflector out of a flat sheet. <http://solarcooking.org/plans/parabolic-from-flat-sheet.htm> (Accessed July 2017).