Sound Worlds from the Body to the City: LISTEN!

Sound Worlds from the Body to the City: LISTEN!

Edited by

Ariane Wilson

Cambridge
Scholars
Publishing

Sound Worlds from the Body to the City: Listen!

Edited by Ariane Wilson

This book first published 2019

Cambridge Scholars Publishing

Lady Stephenson Library, Newcastle upon Tyne, NE6 2PA, UK

British Library Cataloguing in Publication Data
A catalogue record for this book is available from the British Library

ISBN (10): 1-5275-2388-8
ISBN (13): 978-1-5275-2388-3

TABLE OF CONTENTS

PART III

POSTLUDE

LIST OF FIGURES AND ILLUSTRATIONS

SOUND COMMUNICATION AND SPATIAL PERCEPTION IN ANIMALS
Axel Michelsen

THE HUMAN MOUTH AS A SOUND SPACE
Malte Kob

Figure 3. Neuschaefer-Rube, Christiane. *Entwicklung und Erprobung eines multiparametrischen Konzeptes zur Funktionsbeurteilung der Stimme*. Habilitation thesis RWTH Aachen University, 2000.
Figure 4. Data taken from Adachi, Seiji, and Miichi Yamada. "An acoustical study of sound production in biphonic singing, Xöömij." *The Journal of the Acoustical Society of America* 105 (1999): 2920-2932.

SONIC-TACTILE GESTURES AND DAILY URBAN LISTENING
Deniz Peters

Figure 1. Photograph by Deniz Peters.

SOUND ATTENTION
Raviv Ganchrow

Figure 1. Sabine, Wallace Clement. *Collected Papers On Acoustics*, 168. Cambridge: Harvard University Press, 1923.
Figures 2-4. Photographs and images by Raviv Ganchrow.

CENTREFOLD

Illustrations 1-3. Images: Pascal Amphoux/Filippo Broggini
Illustrations 4-5. Photographs by Brandon LaBelle
Illustrations 6-7. Photographs by Yann Rocher
Illustrations 8-9. Photographs by Raviv Ganchrow

INTRODUCTION

INTRODUCTION

ARIANE WILSON

Some fifteen years ago, I set off with my cello on my back to walk across Zanskar in the Indian Himalayas.[1] As the journey progressed, what had started as a desire to share music with people whose daily activities were still ritually and festively supported by music developed into an acute aural awareness of the spectacular environment of rock, a tuning of my playing with the walking body, and of this walking body, pace and breath, with the rhythm of the elements. The formal shape of music succumbed to powerful patterns of vibration animating the landscape until, one memorable day, I forsook my repertoire and let my bow follow the gestures of a cliff's deep and monumental scarifications, setting in motion what seemed like the petrification of primeval telluric choreographies.

For the young architect I was at the time, this journey was a rite of initiation to a way of perceiving the environment through senses other than the visual. It heralded the question that underlies this book: how does listening, biologically, psychologically and culturally, constitute our spatial awareness, and how do material configurations of space modulate the worlds of sound we perceive?

When later I came to teach at the architecture faculty of a German university, I set myself the task of introducing listening as a necessary skill for architects, a component of architectural education. The laboratory for this was a series of courses named *Hörmal!* (Listen!). Its aim was not to learn to design with sound, but to design with an ear for space. It was neither a class in the composition of sound installations for architectural or urban spaces, nor a technical introduction to acoustics, nor was it a theoretical seminar using music as a metaphor for architecture. Rather it encouraged students to consider how built configurations of forms and materials, such as those designed by architects and town planners, condition the sound of sonic events (that is to say the result of almost any

1. Maya Gratier, one of the contributors to this book, walked by my side, equipped with a microphone and her expert knowledge on early infant vocal communication. The journey, illustrated by her photographs, is related in Ariane Wilson, *Un violoncelle sur le toit du monde* (Paris: Presses de la Renaissance, 2002).

form of movement, be it climatic, human or of a machine), and how this, in turn, conditions our awareness of these spaces and our physical and psychological feelings, our sense of being and behaviour, within them. First and foremost, it was an invitation to listen: to train one's auditory sense; to describe the sounds, sonic effects, thresholds and arenas discerned in urban or other environments; to experiment ways of representing these; to understand the factors contributing to how they resonate; and finally, as the course evolved into a design studio, to design spaces and sequences of spaces with an aural intention.[2]

One of the exercises we undertook aimed to develop systems of notation for sound sequences encountered on our walks in the city.[3] The challenge was to record graphically not just the succession of signals we could hear and identify—dog, car, jackhammer, fountain—but also, more ambitious, the spatial experience provoked by their interaction with the material conditions in which they sounded. How, for example, the intrusion of a high strident sound in a large paved square might, for so many seconds, give the sense of a compressed or expanded space, or how, in an environment of loud deep sounds, passing by a wall covered in moss might give the impression of falling or being sucked into a hole. In trying to note these effects that, along with visual, climatic and other factors, contribute so strongly to the experience of architecture, we realised how unseizable they were, involving as they do a great number of parameters that the visual tools of architectural representations were at a loss to articulate: time and sequence, rhythm, direction, perception behind, above or below our usual angle of sight, immersion, timbre, fluctuating boundaries, or absence of frame. The complexity of heard phenomena defeated the effort, as one definition of notation has it, to reduce a lived experience to a system of description. In their representations, the students, unwittingly experiencing a sensorial overload, introduced

2. These pedagogical experiments, conducted at the Department of Theory of Architecture at RWTH Aachen University, Germany, are described in Ariane Wilson, "Une pédagogie de l'écoute pour une lutherie architecturale," in *Soundspaces*, ed. Claire Guiu et al. (Rennes: Presses universitaires de Rennes, 2014): 215-222, and in Stephanie Brandt and Ariane Wilson, "Hörmal Labor #01: StairCases," in *The Global Composition*, Proceedings of the Conference on Sound, Media, and the Environment, Hochschule Darmstadt, Media Campus Dieburg, Germany, 25th-28th July 2012.

3. Visual representations of sound phenomena in different disciplinary fields are analysed in Cécile Régnault, *Les représentations visuelles des phénomènes sonores. Application à l'urbanisme,* 2 volumes (Doctoral thesis, Ecole polytechnique de l'université de Nantes, 2001).

expressive deviations from the codes they had carefully and rationally elaborated, and this became the most significant result of the exercise. Moving away from traditional architectural drawings that concentrate on static fixtures and the play of solid and void, letting senses other than the visual guide our perception, we found urban space to be a resonant body, a giant membrane, a vibrating, enveloping environment.

Literature supporting this approach was not abundant in the early days of the course. However, our explorations profited from the meeting of the spatial with the sensual turn in the human sciences and from valuable classics born of the shift, in urban sound studies, from quantitative to qualitative concerns: from an interest in sound nuisance to "soundscapes," then sound effects, cultural and political understandings of sound, and eventually sound ecology. Amongst these studies, each with their different stances, were R. Murray Schafer's pioneering theory of soundscapes and historians' accounts of aural culture and acoustics of the past, research undertaken by the Centre de Recherche sur l'Espace Sonore et l'Environnement Urbain (CRESSON), including its analysis of urban sonic prototypes and terminology of "sonic effects," anthologies of texts on auditory culture in various geographical contexts, and the inspiring account of "aural architecture" by Barry Blesser and Linda Salter, spanning music, architecture, psychology, anthropology. On the biological front, we considered psychoacoustic and physiological explanations of interaural hearing that allows the apprehension of direction, location and distance. On the philosophical, we tapped on phenomenology and theories of atmosphere such as Gernot Böhme's, or on rhythmanalysis.[4] Reading Tim Ingold corrected the defensive tone of much literature on sound and

4. These references, amongst others, are discussed in later chapters of this book. R. Murray Schafer, *The Soundscape. Our Sonic Environment and The Tuning of the World* (New York: A. Knopf, 1977); Emily Thompson, *The Soundscape of Modernity* (Cambridge/London: MIT, 2004); Grégoire Chelkoff et al., *Prototypes sonores architecturaux. Méthodologie pour un catalogue raisonné et des expériences constructives* (Grenoble: CRESSON, 2003); Jean-François Augoyard and Henry Torgue, eds., *Sonic Experience: A Guide to Everyday Sounds*, trans. Andra McCartney and David Paquette (Montreal: McGill-Queen's University Press, 2006); Michael Bull and Les Back, eds., *The Auditory Culture Reader* (Oxford: Berg Publishers, 2003); Barry Blesser and Linda-Ruth Salter, *Spaces Speak, Are You Listening? Experiencing Aural Architecture* (Cambridge: MIT Press, 2007); Henry Lefebvre, *Rhythmanalysis: Space, Time and Everyday Life*, trans. Stuart Elden and Gerald Moore (New York: Continuum, 2004); Gernot Böhme*, Architektur und Atmosphäre* (München: Wilhelm Fink Verlag, 2006); see also a recent collection of essays by Böhme edited by Jean-Paul Thibaud as *The Aesthetics of Atmosphere* (New York: Routledge, 2017).

hearing, vindictive of the hegemony of sight in Western culture, often considered as the adjunct of a modern objectification of the world. Ingold's subtle plea to ground considerations of perception in the anthropology of lived experience both highlights differences between the ways of participating in the environment that each sense allows and dissolves their opposition, sight and audition being interchangeable and interdependent practices.[5] For example, it might be "the element of auditory attention that converts vision into watchfulness."[6] By and by, the explosion of publications in the fledgling field of "sound studies" provided us with further angles of thought, be it with a scientific, technical or cultural bias.[7]

Beyond these theoretical guides and our walks through sonic environments, our awareness of the spatial potency of sound was enhanced by experiencing situations in which it has consciously been exploited. In the sacred buildings of different cultures or the reverberant mirroring halls of palaces for example, we found historical uses to communicate symbolic and social meaning. In more recent occurrences, we found the spatial potency of sound explored by architects-cum-artists-cum-theorists such as Bernhard Leitner in his precursive SOUND:SPACE experiments or Philippe Rahm, whose "physiological architecture" grants attention to the invisible components of space and includes spaces built through sound. And in concerts of contemporary spatialised music with works by Karlheinz Stockhausen and Iannis Xenakis, we felt how powerfully space can be sculpted in time by sound, through the positioning of sound sources or the (sometimes mobile) public in a sound field, but also through modulations of sound within the overall sound texture. Classical experiments demonstrating how sound waves can configure patterns in matter, such as those undertaken in the eighteenth century by Ernst

5. Tim Ingold, "Vision, Hearing and Human Movement," *The Perception of the Environment. Studies in Livelihood, Dwelling and Skill* (London & New York: Routledge, 2000), 243-287.

6. Ibid., 277.

7. Useful cross-sections through this mass of production are given in a number of anthologies. See Jonathan Sterne, ed., *The Sound Studies Reader* (London: Routledge, 2012) and Trevor Pinch and Karin Bijsterveld, eds., *The Oxford Handbook of Sound Studies* (Oxford: Oxford University Press, 2013). In the former, Jonathan Sterne defines sound studies as "an interdisciplinary ferment in the human sciences that takes sound as its analytical point of departure or arrival. By analyzing both sonic practices and the discourses and institutions that describe them, it redescribes what sound does in the human world, and what humans do in the sonic world." (Sterne, "Sonic imaginations," ibid., 3).

Chladni, or indeed the destructive use of sound bombs, further convinced us of the effect of sound on solid form.

This, the physical power of aural experience in spatial perception and of sound on matter, seems to me of vital relevance to architectural and urban design. Yet little is said about it in recent sound studies, or more generally in reflections on sound and architecture or the city.[8] One strand of research, dealing with links between music and architecture, focuses either on the acoustics of concert halls or on analogies between music and architecture (proportion, processes of creation, translation of musical works as inspiration for buildings, metaphorical comparisons). But is the closest analogy between the two arts not the most literal: the fact that, as with music, sound is a true material of architecture, and listening shapes and structures its experience? [9]

A second strand of research addresses sound design for the urban environment. This often consists in walks accompanied by a composition heard through earphones, large sound-producing instruments or elaborate site-specific electroacoustic installations in public spaces, parks or buildings. Such experimental work certainly raises awareness of the sonic content of the environment, provides rich sensorial and emotional experiences, has an undeniable value as art and adds a subtle layer to the narrative richness of the city. Also, as three of the chapters of this book will show, it questions the critical relationship between our aural experiences and our understanding of space. However, it is not to be confused with, nor be a substitute for, the integration of sonic concerns in the design of the basic material fabric of the built environment.

Most research-by-design symposia and events on sound and the city (some generously endowed by IT companies) have taken their subject to be synonymous with site-specific sound art. As a consequence, design for sound tends to be neglected in favour of sound design; potential skill in the former eclipsed by virtuosity in the latter; and an inconspicuous low-tech daily presence spurned in favour of the seductive and exciting high-tech sophistication of events, the virtue of empowerment erroneously attributed to sonic interaction through digital tools. Thus we may have a city that simultaneously focuses its entire cultural policy on sound art in public spaces and builds public spaces without giving any thought to their

8. A rare exception, Carlotta Darò dedicates a chapter to sound conceived as "material" in her history of intellectual postures on the relationship between the sonic and built environments in particular since the 1960s. "La matière du son," in *Avant-gardes sonores en architecture* (Paris: Les Presses du Réel, 2010), 30-44.

9. Recent research on "sonic urbanism" conducted by Theatrum Mundi takes this direction. http://theatrum-mundi.org (last accessed 15th August 2018).

acoustic quality. Before adorning our environments with additional, deliberately crafted sound signals, is it not important to attend to the design of the material configurations in which the already incredibly rich everyday sounds of our environments ring out and are heard? Before augmenting its content of sounds, to think of the potentials of the container: the sounding body of the city?

When the *Hörmal!* seminars became a design studio, we used as our site the stairwell of an ordinary post-war housing block. Staircases are fascinating vertical sound shafts of which films have made ample dramatic use. They propagate sounds from sources unseen—from below or above the listener, from behind closed doors—, meld public and private, inside and outside; their bare concrete or carpet flooring reflects social status and, by reverberating or muffling steps and whispers, betrays the inhabitants' moods. Following a careful analysis of the sonic dimensions of the staircase, the studio required the students to propose material transformations that would bring about acoustic transformations, without injecting sonic compositions or events into the site. By using materials and forms that affected reflection, frequency modulation, distortion of sounds, and accentuated contrasts, the designs aimed to enrich the acoustic potentiality of the staircase, thus affecting its perception, use and meaning. This is what I would call an experiment, however trivial, in architectural design with an ear for space, and it needs architects trained in the complex practice of listening!

So how do aural perception and listening contribute to our spatial awareness and notions of space? In order to further an understanding of this, it seemed to me useful to intensify the dialogue between various disciplines, including the natural sciences, rarely summoned to discussions on sound and spatiality in the human sciences. With this intention, a conference was held at RWTH Aachen University, which triggered the present book.[10] Four of the book's chapters are extended and revised versions of papers given at the conference, the rest are later commissions and interviews. The result is a collection of essays by scholars and artists that, though by no means exhaustive, spans across fields and practices and covers a range of environments in which sound contributes to forming our sense of space and place: from the space and place of the mother's womb, via the animal world and bodily organs, to spaces and places of the city.

10. *Hörmal! Klangwelten und Klangkörper von Mensch zu Stadt* was held from 9th-11th July 2009 in Aachen. The conference programme can be found on http://theorie.arch.rwth-aachen.de/?p=368 (last accessed 15th August 2018).

The book aims to demonstrate the profoundly constitutive role of hearing at all stages of our biological and social development, as well as the epistemological, phenomenological and emotional importance of sound in relation to our construction of space. As we progress from the body to the city to a conscious revelation of the spatiality of sound in artistic endeavours, it becomes evident that the true topic is less the sense of hearing than listening as a form of attention (an attention not only to signals but to spatialised symbols, giving rise to community) that integrates biological and cultural factors.

In Part I of the book, a developmental psychologist, a bioacoustician, a phoniatrician and a philosopher of musical aesthetics consider the body as a biological and emotional channel of sounds in nature and environments formed by human beings.

Maya Gratier describes the rich world of sounds experienced by the foetus in its mother's womb, where motor and sensory experiences of the body begin to form the human mind, and hearing prepares for cultural tuning. She argues that sound connects the times that precede and follow birth, offering a measure of continuity between the intrauterine and outside environments. Sound and hearing create arenas of belonging in the first months following birth, as adults create sound envelopes for the newborn, who themselves actively shape their acoustic and relational space through rhythmic vocal play with the environment and other human beings.

Axel Michelsen demonstrates the great variety of sound-producing and sound-receiving mechanisms in animals that, in the evolutionary process, have resulted from adaptation to environments. Animals use sound for social communication as well as for spatial orientation and locating prey. The properties of habitats restrict the kinds of sounds that can be used for these purposes. In this way, habitats condition the organs and behavioural strategies that allow animals of different sizes to generate sound and use hearing—be it of air-borne signals or vibration through solids—to analyse frequency, direction and distance for spatial perception.

Malte Kob's chapter focuses on the sound-producing organ which stretches from the vocal chords to the vocal tract to its opening at the mouth, and then extends to the room's response. This pathway is constituted of a sequence of resonating "inter-spaces" with highly variable geometries, which interact at their boundaries to generate, colour and articulate the sound of the voice. Kob describes the dynamic plasticity of this vocal architecture and how it might respond and adjust to what one hears of one's own voice in the acoustic space of its projection.

At the crossroads between the neurosciences, phenomenology and aesthetics, Deniz Peters considers how sound, in music as in the daily

environment, stimulates movement and bodily participation. He argues that this is not due purely to the physical auditory sensation of vibrations. Rather, it actively involves prior crossmodal sensory knowledge arising from everyday embodied actions. The synaesthetic experience of "sonic-tactile gestures" completes auditory perception, bringing associated emotions into play. Sound thereby has a "felt space." Peters recounts experiments in which dancers interact with a spatialised sonic field. In the same way as the dancers hear felt shapes that emotionally induce their movements, our listening in the urban environment performs a kind of contact improvisation with the heard, that co-constitutes a social, physical, somatic and performative acoustic arena.

In Part II, three contributions plead for increased consideration of sound qualities in human habitats, and particularly the city: a manifesto for an anthropology of sound, a historical overview of the sonic turn in the human sciences and urbanism, and an attempt to define descriptive categories for an ecology of sound.

For Holger Schulze, noise reduction policies and building acoustics, relying on standardised models, reflect a reductive attitude to sound. An anthropological perspective, on the contrary, takes heed of the experiential dimension of sound. This experience intertwines sensory imagination with sensory reality that is both subjective and rooted in cultural receptions of the body, and can inform the design of "audile rooms."

Antonella Radicchi traces the history of similar concerns for the qualities of sound that emerged in urban theory and design from the mid-1950s, as part of a broader sensory revolution in the human sciences. She discloses an interest for sound in research undertaken by Kevin Lynch on the experiential quality of the city, even before R. Murray Schafer's ground-breaking study of "soundscapes" around the world, his efforts to name the sonic phenomena that identify places, his understanding of the interplay between physical properties of sound, its expression of socio-economic conditions, perception and behavioural responses to sounds, and his prescription of strategies for acoustic design. Recent theorists have contributed more complex models to the notion of soundscape, such as "sonic events" shaped by urban morphology, or "sonic biographies" that put greater emphasis on time.

The author of the next chapter, Pascal Amphoux, belongs to this latter generation of theorists of urban sound. He can be counted among the rare architects who, to use his terminology, listen to, hear and attend to the sonic quality, publicness and identity of cities, spaces and territories. His essay exposes a three-tier model of sound ecology based on the distinction between environment, milieu and landscape. These definitions help to

differentiate ways of apprehending the sonic ambit of the city that can lead either to protecting it, reinforcing its qualities or contributing to its composition through the design of material configurations.

Part III consists of interviews with three artists, all three also writers or architects, who consciously use sound both to create spatial atmospheres and to enter into a critical debate about space and its physical, social and political dimensions.

Brandon LaBelle, interviewed by Elena Biserna, celebrates the fact that sound unsettles dualities and stable form. It moves between the private and public spheres, shifts boundaries, decentres the self, connects things and people. As a sort of "anti-architecture" that still depends on architecture, sound reveals the immaterial and unconscious dimensions of places, each with their own micro-epistemology. In his artistic pieces, most of them requiring the active participation of spectators, LaBelle destabilises habits of listening and, in so doing, codes and contexts.

Yann Rocher makes use of the immersive potential of sound to dissolve consciousness in a boundless space and simultaneously to envelope it in a circumscribed space. In the settings he creates for a total aesthetic experience, involving light and carefully positioned sound-generating objects, he both confronts the immersed public with a loss of references and induces associative listening by evoking the history of cultural practices of sound.

Finally, Raviv Ganchrow insists that there is no possibility of objective descriptions of sound. Our perception of sound and its spatial dimensions is conditioned by ways of listening that are historically conditioned and anchored in cultural and technological contexts, so that what we call sound at a certain moment is, in effect, one of many possible formats of listening. Part of Ganchrow's work consists in revealing the circuits of contextual factors that determine our perception of sound. Another aspect involves creating technical devices that allow various vibrational fields and spatial resonances to become audible, thus extending our perceptual threshold, for example to electromagnetic phenomena, infrasounds or the vibration of solids. The atmospheres he creates in his sonic installations intertwine listener, building, sound, technology, history and modes of hearing music, into a sharpened form of sonic attention. Most recently they also involve landscape and its inanimate memory of sound.

Ganchrow's works, like Rocher's, are immersive, but Ganchrow is closer to LaBelle in working with specific sites and engaging with the question of context, whereas Rocher's installations need to be cut off from the surrounding environment to be effective. All three, however, place their projects between larger existing cultural (including scientific)

frameworks and something more personal, physical and, to various degrees, immediate.

Closing the book, a postlude muses on the uses of (relative) silence as a sonic material for contrast, on the one hand to help construct meaning in language, music and urban itineraries, on the other to open and expand spaces of experience and the experience of space.

Each author contributing to this volume, is, of course, a listening subject; each, to follow what Ganchrow contends in his chapter, with a specific ontology of sound. Nevertheless, perhaps because their ontologies belong to the same historical moment of the second decade of the second millenium and to a shared cultural context, a number of motifs recur from chapter to chapter, allowing a dialogue across disciplines.

One theme that emerges from all the chapters is the importance of movement both in the generation of sound and in relation to listening. All movement produces sound, and movement is inflected by sound. Hearing occurs in many animals when the hearing organ is set in vibration by the movement of air particles. As the various chapters show, be it in birds reacting to echoes, newborns purposefully orienting to proximal sound, aural contributions to proprioception, gestures motivated emotionally by the felt quality of a sound, or more generally the sensorimotor knowledge gained from making sound, sonic signals and atmospheres animate bodies, and aural perception coincides with a dynamic, temporal perception of space.

Derived from this kinetic aspect, audition has a tactile dimension that several of the authors evoke. This arises partly from the fact that the entire body, constantly immersed in a dynamic environment of sound, is involved in listening and resonates with sensory events: the experience of sound, beyond pure audition, is in fact multisensory, multimodal or synaesthetic, and, for Peters, its tactile dimension is reinforced because we embody the knowledge of what it feels like to make and hear sounds.

This tactile dimension of hearing arises more literally in cases where the transmission of sound is not airborne. Signals are sent by insects through substrates like leaves; the foetus hears the mother's voice through the amniotic fluid, the spine and the pelvic arch; microscopic physical movements can provoke large atmospheric movements; landscape and the built environment are bustling with vibrating solids. This points towards a significant new way of apprehending and thinking about our designed material environment, that not only creates the conditions of resonance, but is itself constantly vibrant and heard through touch.

While hearing thus acts as a kind of feeler, situating the body within its environment, it also extends the self. Beyond individual bodies, sound envelops a relational and associative space that Gratier describes as intimate and intersubjective, LaBelle as personal and collective. Shared experiences of sound and rhythm connect beings, delimit communities and create social and cultural acoustic arenas. These shared territories, however, are all but fixed and static. Each in their own field, the authors of this book describe the fluctuating nature of sonic territories. This adds another aspect to the kinetic dimension of listening: as well as affecting corporal mobility and the vibrational movement of organs and matter, sound sets immaterial boundaries in motion. While Ganchrow discusses the dynamic "phased space" of acoustic territories in the light of Bergson's notion of duration, LaBelle evokes a Deleuzian idea of deterritorialisation in his observation of how sound incessantly codifies and decodifies social and spatial fields, forbidding any dualism or dichotomy.

A corollary of this versatility of sonic territories is the dynamic tuning that occurs between bodies or between bodies and their environment. While Michelsen's chapter on the acoustic world of other animals makes clear that organisms and environments constitute each other, Gratier and LaBelle show how individuals, from babyhood, shape their own sound worlds or listen in to sonic contexts, thus actively making and unmaking place and community. Applied to the city, this inspires a truly dynamic comprehension of public space.

What transpires strongly from the collection of essays is the active role of the listener: listening is identified as a practice. As Peters writes, listening has the power to reconfigure space. It chooses what to respond to or what sensorimotor knowledge to convoke. For LaBelle and Rocher, it taps into imagination and memory to generate narrative structures. Different ways of listening, according to Amphoux, largely define our relationship and attitude to environments like the city, and it is important to distinguish them: passive aural perception is in fact a symptom of phonic pollution. In Ganchrow's theory, sound itself can never be defined independently of the format of listening applied to it. This active involvement of the listener leads several authors to describe listening as a form of "attention," with varying emphasis on the degree of intentionality or historical, cultural and technological determinism at play.

Designing with an aural attention involves being mindful of the sonic dimension of the environment, both microscopic and vast, and caring for it. It therefore has aesthetic and ethical implications. The essays in this book describe a number of parameters of the sound world that, as Schulze, Radicchi and Amphoux show, scholars have attempted to identify, and

that designers might strive to take into account: time, movement, experience, narrative, atmosphere, effects of material objects on immaterial phenomena, the vibration of solid matter, non-geometric space.

Ultimately, the sonic attention of the designer produces the material conditions for sound to propagate in such and such a way—a vaulted or corbelled volume, trees, a paved surface, an open space with several levels, a continuous or faceted glass surface, the possibility for people to stand close or far from one another. But it never freezes a sonic design. The sounds diffusing within this framework, and the specific sonic attention and sound-producing presence of each listening individual using it, animate, define and transform space at every instance of time. This is the condition conveyed in the postlude, where a listening stroller plays his or her own score within the acoustic potentials of the material fabric of a city designed to offer contrasted spatial experiences.

Acknowledgments

Within the RWTH Aachen University Department of Theory of Architecture, Professor Axel Sowa open-mindedly gave me the freedom to pursue my interest for sound and listening in my teaching. He was also supportive of my organisation of *Hörmal! Klangwelten und Klangkörper von Mensch zu Stadt* in 2009, the interdisciplinary conference at which several contributions to this book originated. I also thank Stephanie Brandt, co-creator of the *HörmalLabor* design studio, as well as Bruno Ebersbach-Röver, Sabine von Fischer, Raviv Ganchrow, Thor Mc Intyre, Emmanuelle Somer and Andreas Lindenbaum for the ideas they brought as guests of the *Hörmal!* seminar and *HörmalLabor* studio.

I am deeply grateful to John Wilson who kindly and skillfully undertook the proofreading of this book, covering specialised language from diverse fields and texts written by authors of various nationalities. Brigitte, Sybille and Thierry also regularly contributed their insightful comments and indefatigable support.

Finally, I extend my warmest thanks to the editorial and typesetting team at Cambridge Scholars Publishing for its responsive and careful preparation of the volume. And, of course, to the authors of the chapters that follow, for their trust and patience, and for our inspiring exchanges.

PART I

COMING INTO THE WORLD: IN SPACE AND THROUGH SOUND

MAYA GRATIER

This chapter explores the idea that the ontogenetic shaping of the human mind is rooted in a space experienced through the body, the space of a mother's womb in which a foetus grows but also moves, reacting to sounds coming through biological tissue and to the mother's movements. Sound can be seen as a vector of early human development, forging continuity between the weeks preceding and following birth. With birth, the entire experiential realm of a foetus/infant changes, from the medium he or she lives within to the kinds of sensations encountered. Yet, the mother's voice—as well as some other familiar sounds from the world beyond—reaches the foetus in the private space where it grows. These sounds will be encountered again and recognised in the new world whose unbounded space comes to be defined and delimited by the virtual boundaries that voices make between them as they talk and sing to the infant. These ideas build on scientific evidence gained from the field of developmental psychology and in particular from research on prenatal and postnatal communication. We begin with an overview of studies on prenatal motor and sensory development focusing in particular on auditory perception *in utero*. In the following section, the types of sounds a foetus hears and responds to are described. The third section deals with newborn infants' communicative ability and in particular with how sound enables them to make sense of their surroundings by connecting with other people. The final section presents the view that the social exchange of sound, with its myriad qualities, creates new spaces for sharing meaningful experience.

The first inhabited space: body movement, space and sound *in utero*

In humans as in all mammals, conception marks the beginning of two parallel processes of growth and transformation, those of the foetus and of the mother. As the cells that will give rise to a human embryo multiply and reorganise themselves, the body of a woman becomes a home and

makes place for life within it. This first inhabited space inside the body is the result of active, adaptive, mutual processes involving physical, hormonal, psychological and neuronal modifications in both the developing foetus and the mother. Space is made as the uterine muscles extend and are reshaped so that the young foetus, from just eight weeks after conception, can begin to move freely, perhaps already exploring both the physical boundaries of its living space and the proprioceptive reality of its own body.

Recent research using innovative live three-dimensional and transvaginal four-dimensional ultrasound technology offers detailed descriptions of foetal movement from the first weeks of gestation.[1] These are the first signals of a foetus, expressing its potential as a member of this strange species that stands upright and claims consciousness. Indeed, foetal whole-body movements are described as nonstereotypic, graceful and adapted to the changing environment within which they are performed.[2] Foetal movements are smooth and expressive. Neurophysiological maturation enables the foetus to perform more and more complex and subtle movements at a rapid pace so that the forms and qualities of its body movement are continually evolving.

The foetus lives in a suspended space, one that expands rapidly in the first months, as the foetus itself grows, but that gradually begins to shrink, as its rate of growth increases. By the fifth month, the foetus must make do with physical confinement and body movement is severely restricted. By the end of gestation, movement inside the womb is barely possible though mothers frequently experience kicks and prods. Another remarkable feature of womb space is that it moves. When the mother walks or dances, the foetus must shift to find its centre and actively adjust to the rhythmic motion that underlies most human motor activities.

From fourteen weeks, the foetus can extend its legs to push against the uterine wall, and by seventeen weeks it will arch backwards so that the head touches one side of the uterine wall while pushing with the legs on the diametrically opposite side.[3] The foetus can thus use its own body as a measure of its living space. Soon, the foetus starts to explore the uneven surfaces of the uterine wall and placenta with its hands and abdomen, recruiting its physical environment to explore new postures and bodily

1. Alessandra Piontelli, *Development of Normal Fetal Movements: The First 25 Weeks of Gestation* (Milan: Springer-Verlag, 2010).
2. Heinz F.R. Prechtl, "Continuity of neural functions from prenatal to postnatal life," *Clinics in Developmental Medicine* 94 (Oxford: Blackwell Scientific Publications, 1984).
3. Piontelli, *Development of Normal Fetal Movements*.

configurations. Already in the first trimester of gestation, foetuses use their hands as tools to elicit sensation. They touch their faces for instance more frequently than any other part of their body.[4]

It is clear from biological studies of the evolution of the intrauterine environment through gestation that the relationship between the foetus and its environment is the result of an extraordinary ecological and dynamic tuning that involves bodies moving together, sensations of inner and outer experience, and ultimately sensitivity to spaces and bodies. The aqueous medium of foetal life is not just a physical space, it is a lively and vital space which lets in the essential molecules that sustain life, such as oxygen and nutrients, but also sensory elements such as sound, light, temperature and taste. The placenta is a mysterious organ that grows between the mother and her child, and whose biological status is in fact ambiguous, its tissue belonging neither entirely to the mother nor entirely to the child. It is a great spongy, densely irrigated filter, encircling the environment-foetus community, protecting it, and providing it with *the stuff that life is made of*. It also channels hormones and enzymes and neurotransmitters that may contribute, in older foetuses, to a precocious *life of the mind* emerging through emotion and sensation. Paradoxically, although the intrauterine environment is a changing one, its biological purpose is to remain constant: temperature is thermostatically controlled for example, as in the rest of the body, light is filtered so that only small changes are potentially perceptible. Sounds are attenuated by tissue and liquid. The foetus is thus literally *suspended* both in space and in time.

It appears then that our primary relationship to space, at the earliest stages of life, is achieved through touch and proprioception (sensing our own body position in space) not sight and not yet sound either. A fascinating study of twin foetuses by Umberto Castiello and his collaborators shows the precocity of foetuses' sensory capacities.[5] Indeed, twins sharing the same intrauterine space touch each other and respond differently to touch coming from their own action and from that of the twin.

The multisensory environment of prenatal experience provides the future infant with a set of abilities on which its survival as a biological organism and as a cultural being will depend. Existence does not start at birth, it is well known today that the foetus has experiences and remembers them. Its experiences stem from both the world inside the

4. Asim Kurjak et al., "Fetal hand movements and facial expression in normal pregnancy studied by four-dimensional sonography," *J Perinat Med* 3, (2003): 496–508.

5. Umberto Castiello et al., "Wired to be social: the ontogeny of human interaction," *PloS one* 5, no. 10, e13199 (2010).

mother's body and the world that lies beyond, whose sounds, tastes and rhythms permeate the protective membranes of the maternal body.

The senses develop early on in gestation. As we have seen, the sense of touch and the vestibular sense are probably the first to become functional. The sense of taste is functional by mid-gestation and is inseparable from the sense of smell, which develops only after birth. The amniotic fluid carries molecules of taste that foetuses react to.[6] They have been shown to screw up their faces when they taste bitter substances and to lick their lips when they taste sweet substances. The sense of sight is the last to become functional though its anatomical basis is in place by mid-gestation. Foetuses open their eyes intermittently and for very brief durations from twenty-three to twenty-four weeks up until birth. They are known to press on their orbits with their hands, an action by which they probably experience pressure phosphenes—that is, flashes of light not dependent on external visual stimulation. It is also known that they react to sudden flashes of intense light applied to the mother's abdomen[7] but it is unlikely that they perceive more gradual changes of light.

The sense of hearing has perhaps been the most intensely studied sense in the human foetus, using diverse methods such as behavioural response, anatomical description and the physiological measures of heart-rate variation or brainstem auditory evoked potentials. Foetal responses to sound can be elicited from a wide range of sound frequencies, from 250 Hz to 5000 Hz[8] starting from the twentieth week of gestation, which is the age at which the cochlea begins to process sound. It reaches adult size five weeks later.[9] It is interesting to note that this early development of audition does not serve echolocation as in most species capable of locomotion. *In utero*, sound is not localised and not therefore associated with a type of source.[10] From twenty-eight weeks, foetuses respond reliably to loud airborne noises (greater than 100 dB) with startle

6. Benoît Schaal, Luc Marlier, and Robert Soussignan, "Human foetuses learn odours from their pregnant mother's diet," *Chemical Senses* 25 (2000): 729-737.
7. Hari Eswaran et al., "Magnetoencephalographic recordings of visual evoked brain activity in the human fetus," *The Lancet* 360, no. 9335 (2002): 779-780.
8. Peter G. Hepper and Sara Shahidullah, "The development of fetal hearing," *Fetal and Maternal Medicine Review* 6 (1994):167-179.
9. Rémy Pujol and Adini Uziel, "Auditory development: Peripheral aspects," in *Handbook of Human Biologic Development*, ed. Paola S. Timiras and Esmail Meisami: (Boca Raton: C.R.C Press, 1988), 109-130.
10. Richard Parncutt, "Prenatal development and the phylogeny and ontogeny of musical behaviour," in *Handbook of Music Psychology* ed. Susan Hallam, Ian Cross and Michael Thaut (Oxford: Oxford University Press, 2011), 219-228.

movements and cardiac accelerations. By thirty-five weeks, auditory processing is fully mature and based on similar thresholds to the term newborn but with longer response latencies.[11]

What is the soundscape of the intrauterine space? Does auditory experience itself contribute to the developing sense of hearing (and therefore moving and therefore "being") or does hearing progress through biological maturation alone?

The sounds that filter into and through the amniotic fluid—some of them causing liquid vibration—are highly varied but they can by and large be categorised into a few types (by adults who like categorisation, not most likely by foetuses!). The sounds can be produced either inside the mother's body or outside. They can be produced either by intentional human agents, such as when they speak, sing or use tools in a coherent predictable fashion, or they can be produced without volitional control. They can be produced by other animals (humans, birds, dogs) or by mechanical or natural events (a gate banging in the wind, internal gurgling during digestion of food). That is they are either sounds or noises, they either have some predictability built into them or are highly unpredictable.

Intra-amniotic recordings in women during delivery have provided some description of intrauterine soundscapes.[12] Different auditory streams, with their own spectra and envelopes, are present simultaneously and often vary together in time. Because of mismatched impedances, mainly between air and biological media, some components of external sounds are attenuated inside the amniotic fluid. However, frequencies up to 500 Hz are not attenuated; attenuation increases with frequency at a rate of about 6 dB/octave and does not exceed 30 dB at 4 kHz.[13] Complex sounds, such as the sounds of human speech are less attenuated than tones and band noises. Furthermore it appears that background noise is louder closer to the placenta[14] suggesting that the soundscape inside the uterine cavity is not homogeneous. The sound-world of the foetus is never silent then; over the background of heartbeat and blood flow, sounds of digestion emerge, at times very loudly and suddenly, and mingle with the sounds of the outside world. Can the foetus distinguish the sounds from here and the sounds from there, the sounds of the mother and its own

11. Carolyn Granier-Deferre et al., "A Melodic Contour Repeatedly Experienced by Human Near-Term Fetuses Elicits a Profound Cardiac Reaction One Month after Birth," *PLoS ONE* 6, no. 2 (2011).
12. Denis Querleu et al., "Hearing by the human fetus?", *Seminars in Perinatology* (1989): 409–420.
13. Granier-Deferre et al. "A Melodic Contour..."
14. Querleu et al., "Hearing by the human fetus?"

sounds of moving through water? Probably not in any clear-cut manner. But what is emerging from scientific investigation of foetal sound perception is that foetuses are learning the coherent streams of sound that will provide comfort and meaning after they are born; they are becoming familiar with voices, learning to predict their lilts and rhythms, and with the cadences of specific languages and musical genres.

Familiar voices from outer space

The maternal voice is transmitted internally through the amniotic fluid, via body tissue and bones, but it is also transmitted externally through aerial vibratory components. The voice of a person has the strange status of being both internal and external, a subjectively experienced object, private and public at the same time. The experience of the mother's voice, for the foetus, is itself multisensory, an experience gained though auditory, vestibular and tactile sensation. It is heard both from within the mother's body and as an external voice, re-entering the body. And it is perhaps one of the few sounds the foetus can associate with its source because it does not move. Indeed the mother's voice is close to the foetus' body and that distance remains constant compared with sounds coming from varying locations in the external world. Yet the mother's voice does vary in quality, unlike heartbeat, its pitch, intensity and timing expressing varying emotions and levels of interest. One of the seminal discoveries in foetal and neonatal psychology was the ability of the newborn to recognise the mother's voice a few hours after birth.[15]

The fundamental frequency of the mother's voice is fully conducted through the spine and the pelvic arch. Studies show there is little difference in SPL (sound pressure level) between the maternal voice measured in air and inside the amniotic fluid though some studies report a small attenuation and others a small amplification. Voices, including laughter, emerge clearly from background noise. The prosodic and phonetic features of human speech in particular are well preserved and the oral resonance of vowel sounds is almost entirely intact.[16] The voices the foetus hears, including the mother's, are involved most of the time in conversational exchange with each other. The foetus becomes familiar then, not only with the particular phonemes, syllable sequences and prosodic contours that define the language spoken by the community it

15. Anthony J. DeCasper and William P. Fifer, "Of human bonding: Newborns prefer their mother's voices," *Science* 208 (1980): 1174-1176.
16. Querleu et al., "Hearing by the human fetus?"