ON THE NON-COCHLEARITY OF THE SOUNDS THEMSELVES

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ABSTRACT

What is non-cochlear sound? This open question is followed by way of an initial explication of the psychophysiology of audition. Non-cochlearity in sound is posited firstly in terms of synaesthesia and the skin and body cavity reception of infrasonic and low frequency sound waves. The auditory imagination is a further example that can produce a perception of sound without any direct acoustic stimulation of either the ear or skin and body. However, one's imagination still retains a relation to the sounds of the world we live in. From a phenomenological perspective this worldly relation is a fundamental characteristic of sound as something that is heard. On this basis the causality associated with empirical accounts of auditory perception as a product of biological processes are contrasted with an interrogation of sound qua sound. It is posited that the sounds themselves are non-cochlear in the sense of being non-physical phenomena disclosed in the lived experience of hearkening to the meaningful sounds one hears in the world.

1. INTRODUCTION

"Only he who already understands can listen [zuhören]" Martin Heidegger, Being and Time[1]

1.1. An Empirical Perspective

What is non-cochlear sound? This question is presented in the negative sense, 'non' being the negation of the adjective 'cochlear', meaning an absence or lack of the cochlea in sound. In order to answer this, one would then presumably first have to ask - what is cochlear sound? From an empirical perspective this question asks about the role of the cochlea in the perception of sound, for which we have a reasonably thorough psychophysiological understanding. From acoustic energy propagating through air and other media, reflected via the pinnae into the ear canal, absorbed by the tympanic membrane that articulates the auditory ossicles and on to the coiled fluid filled bag of the cochlea, its tapered basilar membrane and hair cells – such is the cochlear in audition. Yet where is the 'cochlear sound' in this biological and kinetic mechanism?

1.2. Neurological Sound

After the cochlear structure of course there is the electrochemical propagation of binary signals triggered by the hair cell excitation of the auditory nerve through to the brain's auditory cortex as well as the cerebellum, limbic system and beyond. Audition being a whole brain phenomenon, these acoustic vibrations traveling via the cochlea and their approximately 3500 hair cells produce highly complex neuronal excitations that are intimately related to the perception of actual sounds. The physical complexity of this neuronal network is gigantic as each neuron can have from 1-100 axonal connections firing off an electrochemical impulse 40-1000 times per second. The axons themselves are very dynamic and can grow new connections or whither away depending on the signals they receive in a neurological network of around 55,000,000,000 neurons.

We also know that the auditory pathways in the human brain are especially adapted to organized sounds, exhibiting 'pattern sensitivity' to different sequences and 'sensitive tuning' to different discrete signals[2]. This sensitivity is exhibited even in newborns indicating that an attunement to organized sound is an evolutionary adaptation in the human species. Furthermore, the brain exhibits plasticity in frequency and pattern discrimination such that aural training can improve sensitivity to the trained frequencies and produce measurable cortical changes in the brain[3]. We are not only born with a developed auditory cortex but the brain continues to adapt to our evolving soundscapes throughout life.

It would seem then, at least from an empirical perspective, that we have a preliminary definition of 'cochlear sound'. It is the perceived sound associated with the kinetic energy vibrations within the cochlea that produce electrochemical signals in the brain. Just precisely what this 'association' is, between the perception of actual sounds and the evolved, biological mechanisms of our audition, remains somewhat ambiguous. One might be tempted to simply conclude that all perceived sound is merely a subjective psychological affect caused by neuronal

[1] From section 34, "Being-there and Discourse. Language", p. 208 [1] on which the notions of 'hearing', 'hearkening' and 'listening' in this paper are based.

[2] In Weinberger, pp. 88–95 [2]

[3] Cf. Pantev etal [3]

excitation. However, the precise character of this presumed causality and its 'effects' still remains ambiguous. Any attempt to define this ambiguous relation must first overcome the naive psychologism inherent to such seemingly logical assumptions. Nevertheless, given this ambiguity, we can still proceed in a provisional sense to ask: What then might a 'non-cochlear' sound be?

2. WHAT IS NON-COCHLEAR SOUND?

Following on from the above empirical definition of a 'cochlear sound' one might say that non-cochlear sounds are perceived sounds associated with the excitation of the auditory cortex in the human brain by means other than cochlear vibrations transmitted through the hair cells to the auditory nerve. Three such cases of non-cochlear excitation should suffice to demonstrate this particular psychophysiological phenomenon.

2.1. Synaesthetic Sound

The first example deals with synaesthesia or the perception of one sense via the stimulation of other senses. Most commonly this presents itself in the form of black printed characters appearing coloured, however there is another form of synaesthesia for which colour is heard as sound. A Miami University study of 572 synaesthetes also found that 1% of the subjects heard sound via smell, taste or touch[4]. The mechanism for this effect appears to be some form of cross talk in the brain between auditory and other sensory pathways.

2.2. Infrasonic Sound

A related but somewhat more problematic example is that of infrasonic or very low frequency sound waves (generally below 20Hz) that can be felt via the body rather than the ear. This is problematic in the sense that the bodily perception of very low frequency sound may or may not be considered a form of hearing. At very low frequencies, around 16-18Hz or lower depending on the subject, cochlear audition fails to detect tonal information at all and sensitivity to the sound falls away the lower the frequency. This is simply a physical limitation of the biomechanics of the middle and inner ear at very low frequencies[5]. Amplitude thresholds for perception vary depending on age and other physiological factors but there is a crossover in perception between the auditory pathways of the cochlea and the bodily sensation of such low frequency sound. Various studies have pointed to the Merkel cell, Meissners corpuscles and Pancinian corpuscles in the body's largest organ, the skin, as possible receptors for low frequency sonic vibrations[6].

Alongside these skin receptors the chest cavity can resonate from around 80Hz and lower, depending on one's physical build, and thus also plays a role in low frequency, non-cochlear perception of sound[7]. These effects are commonplace in loud, amplified music venues and are especially emphasized in contemporary electronic music genres such as Hip Hop or Techno as well as in various forms of experimental music[8], sound art and so on. One has to feel the bass, and it is an embodied, somatic and synaesthetic auditory experience.

Such effects can also be felt in the ultra low frequency vibrations that herald an earthquake[9], or in the near imperceptible rumble of machinery that can cause various public health and safety problems for those afflicted with a heightened attention to infrasonic frequencies[10].

However, the relation between the bodily reception of sound waves and the auditory perception of the sound is not clear. There is a gray area where the sensitivity crosses over to bodily reception of the sound without cochlear input, and whether or not one considers this a form of non-cochlear hearing is an interesting question. The percussionist Evelyn Glennie, although profoundly deaf from a young age, describes hearing/feeling sounds with her body and makes the point that hearing is merely a specialized form of touch. It may be that her early percussion training as a child through the gradual onset of her deafness synaesthetically blurred the distinction between audition and touch. Whatever the case may be, her finely nuanced and bodily enhanced perception of sound as evidenced in numerous compositions over a long career challenges our concept of what 'hearing' means [8].

2.3. Auditory Imagination

The third example of non-cochlear sound in this empirical sense is demonstrated by one's own auditory imagination. The remembrance of past events and their signatory sounds, auditory dreams or hallucinations (including hypnagogic and hypnopompic experiences), the recollection of a melody, or for musicians the precise recall of a performative work of music, and for composers the contemplation of a new work and its possible auditory aesthetic: All these works of the imagination can involve the perception of sound and the excitation of the auditory cortex without cochlear input.

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[4] Leventhall p. 21 [4]
[5] Cf. Watanabe and Møller, [5]
[6] Leventhall p. 22 [4]
[7] Cf. Takahashi and Maeda [6]
[8] Cat Hope's [7] practice led research project and performance group Abe Sada, for example, uses electric bass guitars and amplification to specifically explore this embodied low frequency effect in music composition and performance.
[9] Sound artist Jo Burzynska aka Stanier Black-Five is another example of the use of low frequency vibrations in musical performance. Specifically she uses recordings of tremors from the 2011 Christchurch earthquakes.
(see http://audiofoundation.org.nz/artist/stanier-black-five)
[10] The "cognitive itch" as described in Leventhall, p. 23 [4] is related to brain plasticity. Continued attention to an annoying low frequency sound can have the effect of training the auditory pathways to become even more sensitive to that frequency and thus increasing the perceived loudness.

The inner world of one's own imagination is replete with auditory perceptions that have no direct cochlear or somatic input although undoubtedly they have an analogue in electrochemical patterns in the brain. This everyday fact implies that the sounds themselves are not necessarily an artefact of cochlear or even acoustic excitation, although the sounds of our imagination are still largely derived from those of the world we live in. Even the fantastic sounds heard in hallucinations and dreams with seemingly no worldly counterpart are meaningful precisely by being other than the worldly sounds we hear. That is, they derive their unique strangeness only in contrast to and in the context of the worldly sounds of our everyday experience.

This relation between the sounds themselves, as in the perceived sounds we actually hear, and both the world we live in as well as our auditory brain functions, is an interesting conundrum. Where does the sound, non-cochlear or otherwise, actually occur? Is it in the brain, in the dynamic cascade of electrochemical impulses that never ceases until death? Or do sounds occur in the world, in a sense yet to be fully explicated? And what is the logical difference between these two propositions?

3. ON THE MEANINGFULNESS OF SOUND

3.1. Sound as Concept

An interesting example of this ambiguity (at least interesting for myself as a philosopher and musician) and an extrapolation of this notion of non-cochlearity in sound, can be found in John Cage's composition 4'33". In the performance of this work the sounds themselves are called to presence simply by their absence. In place of the music one's musical imagination is challenged by a void, by a silence that is filled with worldly sounds, and by a musical relation that reveals itself as a tension between audience and performers and the mutual space they occupy. The composition is non-cochlear due to the absence of any organized sounds and yet the silence is not silent, one still hears. More to the point one hearkens! Attention is given to both the absence of the work and the loudness of the silence that fills the musical void. Beyond this apparent silence of the work one's attention is drawn to the musical relations at work in a traditional performative context between audience and performers on stage.

Here we have come to a fourth possible definition of non-cochlear sound, via the imagination, in terms of the conceptuality or meaningfulness of sound. The sounds themselves - whether associated with cochlear vibrations, with synaesthesia, with infrasonics or with the imagination - can direct our attention to something other than the sound. Sound art, such as Cage's work, is especially adept at this form of sonic manipulation of the imagination and its relation to the world and perhaps it is from sound art that this non-empirical notion of non-cochlear sound might best be demonstrated. The question here has become: What is the relation between the worldly meaningfulness of the sounds themselves and the biological basis of sound?

3.2. Sound as a Worldly Phenomenon

One possible answer might be to postulate a chain of events starting with the electrochemical stimulation of neurons in the brain that then cause the perception of a sound which in turn is identified in terms of other sounds with various aspects of what we cognize as the world we live in. In short, we hear because we have the cochlear and somatic apparatus that allows us to piece together the flux of perceptions that makes up our everyday world. But what is it that we actually hear first and foremost? Is it cochlear vibrations producing raw noises and tone complexes? Or is it the meaningful sounds themselves? Does one hear the familiar melody first or a pattern sequence of tones that are identified after the fact as this or that popular tune?

From a phenomenological perspective what one first hears is the melody as it flows and never a series of tones, noises and abstract timbres[11]. One hears Wagner's symphonic crescendo, the wind in the trees, the car in the street and the voice of a dear friend[12]. Sounds, whether associated with cochlear vibrations or not, are always in the first instance meaningful sounds. Even so-called noise music is meaningful precisely as noise music, as an attempt to negate or transcend the timbral, harmonic and rhythmic limitations of the Occidental tempered scale and metric rhythm tradition from which the genre largely derives its reversed, mirror image. Which is to say, the concept of noise in music is defined by the world in which it is perceived as noise. Likewise, if one awakes suddenly at night on hearing an inexplicable sound, its inexplicability is meaningful only in the context of everything that is already explicable, that is, in contrast to the everyday sounds of our everyday world.

Furthermore, this form of meaningful hearing is not random as it occurs in the context of a life that is lived by oneself. Hearing in this sense is even further removed from any psychological notion of piecing together random noises, for all active hearing is a form of hearkening, that is, a form of directed auditory attention and understanding. One does not merely hear the sounds themselves, if one listens one hearkens to them. This is especially so in the case of musical perception where the sounds themselves are lifted up from the background noise and brought to presence as the musical work - unless of course one is bored with

[11] Husserl's early foundational work on the phenomenology of internal time consciousness is replete with examples of musical melody as a temporal process. The unity of the melody is not given after the sequence of tones but rather in the process itself as it flows where "if we hear a bit of a melody, we do not hear merely single tones, even less moments of single tones or mathematical tone-nows ... We rather hear enduring tones" p. 355/343-344 [9].

[12] Again following Heidegger, p. 207, "What we first hear is never noises or complexes of sounds, but the creaking waggon, the motor-cycle. We hear the column on the march, the north wind, the woodpecker tapping, the fire crackling. It requires a very artificial and complicated frame of mind to hear a pure noise" [1].

the music in which case attention may lapse and one hearkens to the sound of another drum, perhaps one's own thoughts or perhaps the hum of the stage lights and so on.

4. BACK TO THE SOUNDS THEMSELVES

But where has this particular argument taken us? From the empirical notion of non-cochlear sound in terms of synaesthesia and infrasonic vibrations to sounds of the imagination with no immediate acoustic input; then to sound in terms of artistic conceptuality and on to sounds as first and foremost meaningful, worldly phenomena. If sound art points us in the direction of the world within which we hear and hearken then is this merely an artistic contrivance or does the world that art discloses bring us to a far more fundamental phenomenon in non-cochlear sound?[13]

The fact that the sounds we hearken to are already meaningful would indicate that the conceptual in sound is not merely an afterthought, an artistic abstraction, or a subjective, psychological construction. The meaningfulness of what we hear is a fundamental aspect of the sounds themselves as we encounter them in the first instance. The non-cochlear conceptuality of sound in this everyday sense is thus both an abstract and yet also a most concrete phenomenon associated with hearing sounds in our world.

4.1. Scientific Limits of Sound

Yet what is the relation of the actual worldly sounds of our lived experience to the psychophysiological processes associated with our everyday perceptions? Which is to restate our initial question: Where is the sound in a (non)-cochlear vibration and its neurological effects? In a colloquial sense one might claim that self-evidently sound is perceived 'in' the brain or 'in' the mind and leave it at that. However, a practitioner in sound for whom the sounds themselves are the very medium of their craft may not be satisfied with such an easy answer. Of course there are no worldly sounds 'in' a brain for the brain is quite simply a biological network of neurons floating in cerebrospinal fluid in a skull.

Also, at least from a phenomenological perspective, there are no sounds 'in' a mind for the mind or ego is itself not a thing, a receptacle, but rather it is an ongoing process of perception and reflection forming the lived experience of one's own being in this world. Which is to say, sounds are heard in the world we already live in and understand in one sense or another – sounds occur in the world.

Furthermore, the sciences (biology, natural physics or chemistry and so on) still have as yet been incapable of demonstrating a causal mechanism linking our neurological processes with the supposed subjective effect - the world of our perception. There are of course concrete associations between our biological organism and the sounds themselves as evidenced in the medical sciences, but there is no empirically verifiable mechanism for how electrochemical patterns in the brain actually become something heard.

The strictly empirical sciences by definition deal with objectively verifiable physical phenomena and the mathematically calculable data associated with these. Other phenomena such as the everyday world of our lived experience and its ongoing flux of perceptions are by definition 'subjective' and not directly amenable to empirical analysis. Science, from this perspective, is a discipline the limits of which are clearly defined by its physical scope. All other non-physical phenomena such as the sounds themselves are thus beyond the scope of strictly empirical science. Put another way, there is no empirically verifiable causal relation but rather a strictly associative relation between physical processes such as neuronal activity and the perceptions associated with those processes.

4.2. The Question of Sound's Causality

Given these empirical difficulties I would like to propose that there is therefore no such thing as a cochlear sound in any demonstrable empirical sense, there are only in the first instance the sounds themselves we hear and hearken to. By simple inference all sound, as something heard in the world, is therefore non-cochlear (or more precisely a non-physical phenomenon).

One might however object that this conclusion regarding the non-cochlearity of the sounds themselves is merely an empty exercise in semantics, and if we were to leave the matter there I would tend to agree. Yet what is at stake in this argument is not merely a specific interpretation of the terms "non-cochlear" and "sound" but also the notions of causality that inform our everyday understanding of sound in general and the ways we talk about it.

For those of us with a scientific background, including those of us schooled in a modern education industry, it can be easy to assume a form of popular psychologism in regard to the causal relation between scientific reality and the phenomenal world it attempts to describe, the world of lived experience. Thus it might appear stubbornly self-evident that the perception of sound occurs 'in' the brain or mind and is caused by electrochemical stimulation. Such a basic presupposition can be the cause of a good deal of confusion when talking about sound, for sound in this case is explained in terms of something other than the phenomenon of sound itself. In fact here the sounds themselves are relegated to an 'inner' sensibility that remains mysterious while the biological 'cause' assumes priority in terms of understanding those very sounds.

[13] The function of art in this sense is not as mere entertainment or craft, rather the artwork "opens up a world" in an originary philosophical sense, cf. Heidegger's 'Origin of the Work of Art' p. 169 [10].

While an understanding of the psychophysiological processes associated with audition is obviously useful, such as in the psychoacoustics of digital reverb modelling, it does not necessarily require a psychologistic worldview. If as a musician – composer or performer alike – one wishes to understand sound in terms of the sounds themselves, then it might also be useful to deconstruct one's own presumptions about sound and its relation to the physical and perceptual phenomena associated with hearing in the first instance.

From this critical perspective the term 'sound' stands for an open question disclosed in the lived experience of hearing and hearkening. The causality of sound is here proximally related to one's directed attention (intentionality) within the world, or in other words, one hearkens and thus hears. This is a very different relation to causality than the psychologistic notion of the biological provenance of sound, and it is a relation that perhaps opens up the possibility of talking about sound qua sound.

Such an open perspective also problematizes the causal relation between sound and our biology. For example, one could say that in an evolutionary sense we do not hear because we have evolved the biological mechanisms for audition. Rather, precisely the opposite, we have evolved the biological mechanisms for audition because we already hearkened to sound. Why else would the human species have developed a complex auditory cortex if not for the evolutionary advantage of hearing and hearkening to the sounds themselves?

One has to first already have come to understand what sound is by having heard and by hearkening to sounds in our everyday world. It is on this straightforward perceptual basis that we might then come to talk about those sounds in terms of say, the sounds themselves; or neurological/cochlear processes; or Duchampian conceptuality; or the world of everyday lived experience. From the perspective of this premise the sounds themselves are not mere products of biological processes nor subjective epi-phenomena, on the contrary they are precisely the matter to be investigated.

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