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Introduction to sound & listening as psychoenergetic agencies

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Abstract

In this paper, which is a draft for the lecture to be given in January 2020 at "Steklenik," gallery for sound, bio-acoustics & art, in Ljubljana, Slovenia, I would like to bring fundamental traits of sound & listening in close relation with pivotal physical, physiological and psychological bodily functions. With acknowledging both psychophysical and bioenergy dynamics, my final effort is to highlight the possible role of sound & listening in better comprehension of the overall human experience: of oneself, and the all-pervading environment.

"*When I was younger, I use to be a mountaineer. I climbed most of the peaks in this region, some of them pretty high, and I must tell you, it was not easy nor always a fun thing to do. Often it would happen that my body and my strength would just abandon me at the last stages of climbing. I would feel distressed and confused. Until I started to bring a Walkman with me; in those moments only, I would put it on and play my favorite music. I tell you; each and every time it was like something injected me with energy, my slumber and overworked muscles would somehow get electrified, my brain would suddenly find focus, I would start breathing more rhythmically, and in no time the peak would be conquered! Music is an explicit carrier of energy and I have no doubts about that…*"

70-year-old taxi driver from Belgrade, December 2019

One does not need to be a scientist to understand genuine subjective experience such is this one. After this encounter which happened in the middle of the night after my concert in one of Belgrade's cultural centers, I asked my self a simple question: *How many people I know which have no ties to sound professions but use music or some form of soundscape on a regular basis as a means of psychophysical stimuli and/or regulation?*

The answer was really, simple. Almost everyone. Only individuals with sensory processing disabilities might be slightly less excited about the concreteness of the stimuli, due to harshness of an increasing noise pollution level and the cacophony emerging from individual sound discrimination deficiency.

We are well into the 21st century and it is more than necessary that we put more efforts into summarizing our abilities regarding the perception of sound.

In this text I will be mentioning relational dynamics of sound and energy, referring to both living and non-living agencies, but I will also share a few thoughts on our overemphasized technological imprint forced upon the environment. This discourse will tackle a wide framework of interdisciplinary research appreciating some of the grey areas of cognitive science, as well as some boundaries of our somatosensory[1] processing. In a manner of summary, these scientific inputs should be seen as a theoretical inspiration for progressive sound practitioners and researchers.

1 The somatosensory system is the part of the sensory system concerned with the conscious perception of touch, pressure, pain, temperature, position, movement, and vibration, which arise from the muscles, joints, skin, and fascia.

The notion of *psychoenergetics* I find inspiring for investigating complex perceptional and infra-psychic[2] processes. The compound of *psychoenergetics* was pinned down by Dr. Willian A. Tiller[3], and although I am curious about his experimental and theoretical study, with this title I am not describing the work of his institute.

I will try to be consistent in emphasizing the role of multisensory perception in activating overall neural feedback during listening (in its wider sense). Besides this, my aim is to point out the inseparability of sound and energy transmutation in the overall bodily experience of listening, which unconditionally affects both cognitive dynamics and metabolic regulation. Finally, recent acknowledgments in sound studies (regarding the role of sound in the observation of a fast-changing landscape) are providing shortcuts for systematic research on mapping biodiversity dynamics around the globe, but should also in parallel question our perceptual abilities, paving the way for a new culture of listening.

2 Denoting ideas or actions originating below the level of consciousness.

3 Professor Emeritus of Stanford University's Department of Material Science https://www.tillerinstitute.com/

Hyphen between (emerging) subconsciousness and listening?

A century ago KG Jung proposed that psyche has to have its self-regulatory mechanisms, the same is true in another complex biological energy exchange systems of the body (such as for example metabolism which depends on refined control and self-regulation). Among layers of psyche that Jung studied thoroughly, he invested large efforts especially in underlining the functions of the unconscious. He believed that what he called *the shadow*, the hidden or unconscious aspects of oneself, played a significant role in one's psychological growth.[4] Jung claimed that all thoughts, memories and emotional contents which we avoid acknowledging with our conscious mind, end up put away "out of sight," but undoubtedly condition our inner dynamics.

We accept that all that exists is a form of energy (even our thoughts), therefore we can presume that our psychological content can also, contain amounts of bioenergy[5]. As measured with Resonant Field Imaging (RFI), researched as a possible tool for stress diagnostics,

4 See Carl Gustav Jung, *Psychology of the Unconscious: A Study of the Transformations and Symbolisms of the Libido*, ed. William McGuire, trans. Beatrice M. Hinkle, (Princeton: Princeton University Press, 1992 [Routledge, 1917]).

5 I am referring to an electromagnetic biofield found in all living organisms, which also appeared to be related to the overall nervous system.

human bioenergy contains frequency patterns which can be complex information carriers.[6]

In my opinion, apart from asking “where all this energy condemned to the dungeons of the unconscious go” we should perhaps think about how it is distributed within our bodies, including the resonant electromagnetic field which is surrounding and permeating the overall physical body.[7]

The anatomy of human bioenergy is, like all other biological processes, a complex and multi-layered phenomenon. It is hypothesized that it is an integral part of all neurological and metabolic processes and is therefore intertwined with every aspect of psychophysical regulation. Although the science is still looking for the means of exact measuring of the subject there are quite solid implications on its scope and functions derived from researches of biofield and bioelectromagnetism, cognitive neuroscience, phenomenological approaches in contemporary psychoanalytic therapy, as well as Eastern medicine and widely proficient and diverse spiritual practices.[8]

Similar to Earth’s electromagnetic field, also the biofield of the human body is perceived to have a shape of a torus[9]. As in all subjects and objects charged with electric current (which produces a magnetic field) there is a common characteristic observed – a flow. The flow of energy considers a constant movement – a vibratory nature of the all-pervading environment from the tiniest to the largest particles existing. The sustained flow of energy is the basis of all evolutionary adaptable self-regulating systems. For thousands of years diverse approaches in Eastern medicine and philosophy take the energy flow within the body very seriously. Distribution of energy in living organisms is studied in detail and it reveals the existence of a network of energy pathways, that are interwoven within the biological framework.

6 Bioenergy frequency measurement of stressed and non-stressed individuals using Resonant Field Imaging (RFI) frequency counter (IEEE Conference on Biomedical Engineering and Sciences, 2014).

7 One of the ground braking studies that paved the way for experimental research in this field is publication by R. O. Becker, Cross Currents a. P. Tarcher, Inc., Los Angeles, CA, 1990.

8 The vast field of bioenergy and its anatomy in all these approaches is described as a cascade system of electromagnetic fields interwoven with current distribution pathways and diverse in frequency resonance. This frequency resonance organization is summarized to the nature of harmonics. Although largely perceived as vertical order there is no doubt that has synchronized energy exchange functions and that is deeply embedded in overall psychophysical regulation.

9 The torus, or primary pattern, is an energy dynamic that looks like a doughnut – it’s a continuous surface with a hole in the middle. The energy flows in through one end, circulates around the center and exits on the other side. We can find it everywhere – in atoms, cells, seeds, flowers, trees, animals, humans, hurricanes, planets, suns, galaxies and even the cosmos as a whole.

In modern-day cognitive neuroscience we still have many questioning attitudes spanning from sensory embodiment to the autonomous origin of consciousness, but regarding the synthesis of an overall bodily experience only one thing seems to be certain – that all physiological, psychological and bioenergy functions of our slightly "extended" body are in fact mutually interdependent.

To return to the unconscious and to look for pathways of its dynamics within the body, the research I will open discussion with is the polyvagal theory, proposed by Dr. Stephen Porges. Furthermore, in the context of listening and the neurological feedback it builds, we should especially take a closer look at theory's practical applications, such as the therapeutic module called Safe and Sound Protocol, also proposed and developed by Dr. Porges.

> The polyvagal theory describes an autonomic nervous system that is influenced by the central nervous system, sensitive to afferent influences, characterized by an adaptive reactivity dependent on the phylogeny[10] of the neural circuits, and interactive with source nuclei in the brainstem regulating the striated muscles of the face and head.[11]

Polyvagal theory is the understanding of bodily reactions to various challenges, having in mind that the evolution of our nervous system shaped those reactions. During this evolutionary process, we developed certain circuits that function in hierarchical synchronicity. Basically, the more recent circuits can inhibit the older evolutionary circuits, but the older circuits also have a powerful intrinsic impact, such as for example the circuit of defense. Psychosomatic and psychotherapeutic research all agree that physical diseases are embedded in dysfunctions of the autonomic nervous system. Another way around, regulation of the autonomic nervous system can largely improve brain functions that can have positive feedback on the psychophysical level. The polyvagal theory is acknowledging interaction between more recently developed neuro-circuits such as social interaction, with our instinctive (self-regulatory, subconscious) mechanism of self-defense.

The theory is focusing on Vagus Nerve that connects the brain and the heart, being crucial for the social engagement system and neuro regulation of the facial muscles that control expression, gestures, muscles used for listening and vocalization. Considering that all these

10 Phylogenetics is a hypothesis about the history of the bio-evolutionary relationships of a group of organisms that developed relationships through phylogenetic inference, methods that evaluate observed heritable traits, such as DNA sequences or morphology.

11 Stephen W. Porges, "The polyvagal theory: New insights into adaptive reactions of the autonomic nervous system," *Cleve Clin J Med* 76, Supplement 2, 2009: 86-90. https://dx.doi.org/10.3949%2Fccjm.76.s2.17.

regulatory points are involved in the regulation of the heart, all these become interactive co-regulatory elements that influence the overall regulation of the autonomic functions. But if they become unfunctional or suffer a dysfunction due to trauma or exposure to stressful circumstances, the autonomous nervous system leaps in a state of mobilization (mobilized behavior such as rage, irritation, anxiety, tantrums, etc.). Furthermore, polyvagal theory refers to another defensive system identified from the studies of the evolution of the autonomic nervous system, which is the ability to shut down. This includes immobilization with fears and emotional dysfunctions and can lead to a variety of psychological and psychiatric issues.

On the basics of polyvagal theory something called neuroception is proposed.

> Neuroception represents a neural process that enables humans and other mammals to engage in social behaviors by distinguishing safe from dangerous contexts. Neuroception is proposed as a plausible mechanism mediating both the expression and the disruption of positive social behavior, emotion regulation, and visceral homeostasis.[12]

12 Ibid.

Our nervous system is constantly taking in sensory information from both the external environment and internally from inside of our bodies. By processing this information our nervous system continually evaluates risks. Neuroception describes how neural circuits distinguish between situations or people to know if they are safe, dangerous or life-threatening. Because of our heritage as a species, neuroception takes place in the ‘primitive’ parts of the brain, without our conscious awareness. The detection of a person or an environment as safe or dangerous, or even the internal state of our body as safe or dangerous triggers neurobiologically determined prosocial or protective behaviors.

Even though we may not be aware of the danger on the cognitive level, on the neurophysiological level our body has already started a sequence of neural processes that can lead to one of three basic modes of defense: fight, flight or freeze. Neuroception is a mechanism that detects threats and adjusts our metabolic demands according to the situation. There are many applications of polyvagal theory and neuroception in psychotherapy, developmental disorders and behavioral cognizance. Subconsciousness seems to be strongly wired to the autonomic nervous system, and for our sound research and practice, the role of the ear in these neural functions and psychological processes are an intriguing matter.

Growing interest in contemporary psychotherapeutic practice is looking into effects of the particular experience within the body, developing a therapeutical field dealing with the possible storing of the traumatic memory within cells, glances, organs, etc.

For example it is hypothesized that unprocessed trauma gets stored not just in one's subconsciousness but throughout physical being as well, and that, in addition to more traditional modalities like cognitive psychotherapy, some sort of a sensory stimulus may be helpful in releasing it (tactile – massage therapy, audible – sound therapy, acupuncture, reiki, chi gong, etc. – energy flow maintaining therapy). During a traumatic event neuroception is challenged, and if the experience possess intensity that can shock the autonomic nervous system, often a chain of consequential psychophysical imbalances can occur. The storing of the trauma within the body happens when the event is so upsetting that the memory of it gets "buried" as a self-preservation mechanism (when this is happening consciously it is considered suppressed, when this is happening unconsciously it is considered repressed trauma).

> "When traumatic memories remain unspeakable or unthinkable for too long, they often impede our brain's natural process of recovery after trauma. They become stuck points that inhibit the mental reintegration that is needed for healing to occur."[13] The effect can prolong the fight, flight, or freeze response and have very real physical consequences. Consider PTSD, which "brings disruption to hormone secretion, neurochemistry, and immune system functioning, all of which contribute to diseased cells, organs, and other bodily systems. [...] Chromosomal studies have shown that PTSD patients have shorter telomeres, the segments on the ends of chromosomes that are a measure of cellular age, than their healthy counterparts do. Up to 35% of chronic pain patients also have PTSD, and there is an even higher overlap between fibromyalgia and PTSD. Symptoms of traumatic stress can also become somatized (present as genuine physical complaints as opposed to complaints of emotional distress) when the psychological nature of the symptoms is too scary or daunting for the patient to accept, considered taboo by society, or not understood by the physician."[14]

Psyche is considered to be a multilayered self-regulatory structure in charge of integration of an overall experience of oneself.

13 Shaili Jain, The Unspeakable Mind: Stories of Trauma and Healing from the Frontlines of PTSD Science, May 2019.

14 Ibid.

On the other hand, the experience itself being built with multisensory compounds is supported by a diverse neural circuit responses, that mirror an ability to categorise stimuli (internal[15] or external), which will further condition immediate (conscious or subconscious) reactions but also latter cognitive modeling. Multisensory perception deployed along with neural circuits largely depends on one's ear functions. Furthermore, next to the ear functions multisensory perception also depends on a wide pallet of cognitive attentiveness related to listening, which is engaged around discrimination, translating and categorisation[16] of the information. These processes are also fully characterized by one's brain attributes as well as an overall individual neurological imprint.

In this complex neural chain placed between functions of the ear and cognition, an array of attention aspects also take place. Our brain has to put up with a variety of attention types, such as phasic alertness, automatic versus voluntary attention, selective versus focused, shared or divided, and all that is heavily dependent on the changes in the environment or in oneself (noise, situational stress, psychological processing, tiredness, etc.).[17]

To simplify, there is a myriad of health-damaging effects that are linked to untreated hearing variations further connected with attention and cognition deficits. Hearing loss increases the risk of dementia, depression and cardiovascular diseases. Studies have documented that even people who have only slightly poorer hearing can experience cognitive deficits. In everyday life that means a diminished ability to think clearly, plan rationally and remember accurately.[18]

Large spectrum of listening abilities therefore affects range from intrinsic physiological regulation to the highest cognitive functions,

15 For example the transient neural response evoked by each heartbeat plays a role in cognitive functions [...], such as emotion, self-related cognition, and also subjective visual perception. […] heart and gastrointestinal tract intrinsically generate their own electrical activity, thereby continuously sending information to the brain. (Visceral Signals Shape Brain Dynamics and Cognition, Damiano Azzalini, Ignacio Rebollo, Catherine Tallon-Baudry, Trends in Cognitive Science, April 29, 2019DOI: https://doi.org/10.1016/j.tics.2019.03.007).

16 Categorisation is a fundamental cognitive process that plays a central role in everyday behavior and action, supporting the organisation of knowledge (i.e. through the development of taxonomies) and permitting inductive inference about the world (i.e. through the assumption that members of the same category share similar properties). The process of categorisation is grounded in perceptual and attentional mechanisms capable of detecting similarities and correspondences in the environment. Woodcock, W. J. Davies, T. J. Cox, A cognitive framework for the categorisation of auditory objects in urban soundscapes, Applied Acoustics, Elsevier 2017. https://doi.org/10.1016/j.apacoust.2017.01.027.

17 See Melissa-Ann Mackie, Nicolas T Van Dam, Jin Fan, "Cognitive Control and Attentional Functions," *Brain Cogn.* 82, no. 3 (2013):301-312. https://dx.doi.org/10.1016%2Fj.bandc.2013.05.004.

18 Justin S Golub, Adam M. Brickman, Adam J. Cialeglio et. al., "Association of Subclinical Hearing Loss With Cognitive Performance," *JAMA Otolaryngol Head Neck Surg.* 146, no. 1 (2019): 57-67. https://doi.org/10.1001/jamaoto.2019.3375.

which also include concepts of awareness and consciousness arousal with their dynamics and dispositions.[19]

Although at this point, we cannot deepen discourse on the contemporary approaches of the origin of consciousness we can take in consideration the question closer to the notion of self-awareness: what are the traits conditioning a unique personality? Apart from neurological and sensory capacities, experience integration and memory processing (weather personal or inherited), can we also leave unique psychological imprint through possible morphological coherency with the environment?

For the modest start we can look into potential interactive dynamics of complex neural mechanisms in relation to bioenergy anatomy and our sensory abilities relating to it. Energy perception and distribution within a body and between a body and surrounding could expand cognizance of mutual conditionality of psychophysical dynamics, since there is no doubt that all living structures are fully dependant on energy – flow, distribution, processing and modulation.

19 Consciousness has two main components: arousal, or the level of consciousness, and awareness, corresponding to the contents of consciousness *per se*. Arousal and awareness are usually positively correlated. However, they involve different brain structures. Mélanie Boly et. al., "Intrinsic Brain Activity in Altered States of Consciousness." Annals of the New York Academy of Sciences 1129, no. 1 (2008):119-129. https://doi.org/10.1196/annals.1417.015.

In Eastern medicine as well as spiritual practices there are explicit insights on this topic, but we would need to dedicate a separate discourse to that subject only. Today, I would like to stick to the physiology, concretely to the complex phenomena of listening. Before that, we should also look into some contemporary ideas on the physics of sound.

Sonic geometry of life

> Sound traveling through the air may be defined as the transfer of periodic vibrations between colliding atoms or molecules. This energetic phenomenon typically expands away from the epicenter of the sound event as a bubble-shaped emanation. As the sound bubble rapidly increases in diameter its surface is in a state of radial oscillation. These periodic movements follow the same expansions and contractions as the air bubble surrounding the initiating sound event.
>
> The out-dated, yet widely accepted model of sound depicted as a "wave" is incomplete because it proliferates the idea that sound's motion through a given medium is wave-like. This wave model is a purely graphical representation, typically shown as sound pressure level in the vertical axis versus time on the horizontal axis. […] [T]he sinusoidal representation of a pure sound tone is

> correct in the mathematical and graphical sense, it does not accurately depict how sound actually moves through gases, fluids or solids. […]
>
> The concept of spherical propagation in both sound and electromagnetism is well known in the fields of acoustic physics and electromagnetics respectively. The spherical concept of energy propagation was also well known even all the way back to the ancient Sanskrit philosophers.[20]

More recent acoustic researches that are strongly founded on the understanding of spherical propagation of sound as well as electromagnetism is conducted in the field of echolocation (bio sonar), discovering their traits in both sensory and cognitive purposes. Unfortunately, we are still persistent in using terms "sound waves" and "electromagnetic waves" in order to describe these occurrences.[21]

Further on the nature of sound, it is presumed that every atomic particle contained within a sound bubble, whether it is coming from a living or nonliving source, shares all of the information that describes the sound.[22] The compression and rarefaction in any sound bubble have no effect on the distribution of data in different parts of the bubble. When sound vibration enters the cochlea, the cilia in the Organ of Corti respond to the vibrations of individual molecules. Each molecule carries all the vibrations of the sound. Therefore, “sonic frequencies imparted to atomic and molecular particles may be considered as quasi-holographic in nature.”[23] Due to the holographic nature of sound, the sonic data is identical throughout the bubble, only the intensity of data varies at different points.

> When sound propagates in the air, every atom or molecule lying in the path of propagation is involved in the process of passing on the “data” of the sound source. Every atom and molecule within a pure tone sound bubble carry only one sinusoidal periodicity. When the sound is complex, every atom and molecule carries all of the periodicities.[24]

To simplify, if we “zoom in” at any point of the sound bubble’s surface, we find the same vibrational data that exist at any point within the bubble. Now, for better understanding of sound propagation, we should

20 John Stuart Reid, “The special relationship between sound and light, with implications for sound and light therapy,” *Subtle Energies & Energy Medicine* 11, no. 3 (2006): 216, 217, 218.
21 Ibid., 218.
22 Ibid., 221.
23 *The Mereon Matrix: Unity, Perspective and Paradox*, eds. Lynnclaire Dennis, Jytte Brender McNair, Lous H. Kauffman (London: Elsevier, 2013), 297 quoted in John Stuart Reid, “Secrets of Cymatics,” (presentation, Water Conference, Sofia, Bulgaria, 6 to 9 October, 2016). https://youtu.be/uMK3OVBjx2Q.
24 John Stuart Reid, “The special relationship between sound and light, with implications for sound and light therapy,” 222.

look into the interrelatedness of a sound and electromagnetism, as is well described within the concept of Sonic Propagation of Electromagnetic Energy Components (SPEEC):

> Sonic bubbles expand at approximately 700 miles an hour. Theoretically, this expansion generates an accompanying electromagnetic sphere that rushes away at 300,000 kilometers per second. It is proposed that the frequencies of electromagnetism created by sound are typically in the infra-red and radio frequency spectrum, depending upon the initial sound pressure. That is, high-intensity sounds will likely generate infra-red energy and low-intensity sounds will likely generate low levels of radiofrequency radiation. […] Whereas the energy in the sonic bubble falls off rapidly with distance (sound outdoors typically radiates one mile), the electromagnetic sphere is not significantly attenuated by clear air. The electromagnetic sphere travels relatively unimpeded through the atmosphere to outer space where a myriad of examples of starlight show us that it will travel virtually forever unless it meets dense matter. Sound pressure rapidly decreases as a result of the initial energy in the sonic bubble being distributed over a greater and greater surface area as it expands. The sonic bubble can only expand by the jostling of air molecules, which cause friction at the atomic level. As we have seen, theoretically, this friction creates electromagnetic energy. Sound pressure also decreases because a small amount of heat (electromagnetism in the infra-red/radio spectrum) results from each collision. Thus, sound energy dissipates, in part, due to its conversion to electromagnetism.[25]

In other words, the electromagnetism created by sound propagation through the air will be modulated by the specific sound periodicities.

If we embrace the theory of SPEEC can we claim that there would be less electromagnetism in our surroundings without sound and that electromagnetic properties of the environment could be considered sustained by the dissipation of sound energy?

When the sound is observed as a possible heat-producing vibratory event I always consider reports of the freedivers swimming with sperm whales and collecting data about their social behavior and communication abilities. Sperm whales emit one of the strongest and loudest sonic imprints – a variety of clicks that serve as an echolocation tool for spatial orientation and precise sight but also, as recent research shows, for sophisticated language-based communication. Divers also reported intense heating up of their bodies while being exposed to the whale clicks (due to immense amounts of energy carried by the clicks),

25 https://www.cymascope.com/cyma_research/physics.html

as well as partial paralysis of the limbs, placed directly in the way of their sonic propagation.[26]

Another intriguing feature of sound is a vibratory organization of the matter. Studies are carried out investigating "tantalizing possibility that sound was involved as an organizing force for minerals and for organic compounds that were brought to the early Earth by comets."[27] [...] When sound interacts with matter, cymatic forces organise the matter into microscopic and macroscopic structures that we call "sonic scaffolding".[28]

In a very inspiring presentation titled "Sound is an aspect of life, but is life an aspect of sound?" given by acoustic physics pioneer John Stuart Reid (Water Conference, in Bad Soden, Germany, November 2019)[29] showed striking resemblance between simple life forms and cymatic visualizations[30] of a sonic frequencies which could be related to the competing theories for the creation of life (most of them proposing that primitive life forms arouse in the harsh environment around hydrothermal vents on the ocean floor). Investigating acoustic imprints of the vents as well as physics of the air bubbles emerging from them disclosed two possible approaches how sonic energy and matter organisation could have played crucial role in bringing building blocks of life into a form.[31]

Now when we have some insights on the actual physics of sound as well as its possible contributions to the energy properties and organisation of the environment, we should go back and look into our "equipment" for interaction with it.

Thoughts on listening

The ear has several other functions besides translating auditory information. Primary functions of the vestibular system of the ear include maintaining postural balance, regulation of muscle tone (that includes all gesticulation and nonverbal interaction of the body with its

26 James Nestor, *Humanity and the Deep Ocean*, October, 2014. https://theinterval.org/salon-talks/02014/oct/07/humanity-and-deep-ocean.
27 https://www.cymascope.com/cyma_research/biology.html
28 Ibid.
29 https://youtu.be/VqMl-W8H7T0
30 Cymatics is the science of sound made visible. It is based on the principle that when sound encounters a membrane such as the surface of water, it imprints an invisible pattern of energy. In other words, the periodic vibrations in the sound sample are converted and become periodic water ripples, creating geometric patterns that reveal the once hidden realm of sound. If we could see the sounds around us with our eyes we would see myriads of holographic bubbles, each with a kaleidoscopic-like pattern its surface. https://www.cymascope.com/
31 The theory of Abiogenesis.

surrounding), coordination of the position of the head and eye movement, as well as spatial updating for spatial dynamics of the brain which are further supporting the vision. In fact, our joints and muscles and everything related with a posture that opposes gravitation can be also correlated with the labyrinth of the ear. Furthermore, there are 2 additional senses, connected with the vestibular system of the ear, proposed and widely monitored in the development of individuals with sensory difficulties. They are referred to as proprioception and interoception.

The proprioceptive system senses the position, location, orientation, and movement of body muscles and joints. Proprioception provides us with a sense of the relative position of neighboring parts of the body and enables estimation of the effort needed to move body parts. The proprioceptive sense combines sensory information from neurons in the inner ear (detecting motion and orientation) and stretch receptors in the muscles and the joint-supporting ligaments for stance. Because of proprioception, if you raise your hand in the air, you know that it is over your head. You don't have to think about it or look in a mirror.

> Interoception refers to sensations related to the physiological condition of the body. Interoceptors are internal sensors that provide a sense of what our internal organs are feeling. Hunger and thirst are common examples of interoception.
>
> [It] detects responses that guide regulation, including hunger, heart rate, respiration, and elimination. Interoceptive stimulation is detected through nerve endings lining the respiratory and digestive mucous membranes. It works alongside the vestibular and proprioceptive senses to determine how a person perceives their own body. Well-modulated interoception helps the person detect sensations normally. For example, if a person feels their heart pounding, while it is not comfortable, trauma from the stimulation is not likely; nor will the stimulation be craved.[32]

Now we are moving to the cochlear function of the ear – which comprehends analysis and translation of the sound. When we refer to the cochlear function it is commonly presumed that we think of an ear dealing with external stimuli. What is quite often neglected is the cochlear function of the ear turned inward – listening to one's own body. Apart from hearing own voice and resonance of it in the areas involved (scull, mouth, throat, lungs, resonance within torso) one would think that there is not much else. But there is. With some effort in attention, you can hear joints squeaking, muscle tension, breath harmonics and of course a heartbeat. Hearing it or not, there is an important electric

32 Star Institute, "Your 8 Senses," https://www.spdstar.org/basic/your-8-senses.

activity happening between our guts, heart and a brain, that is involving ear functions.

> Visceral signals automatically contribute to shaping spontaneous large-scale brain dynamics, even when not consciously experienced. There are several reasons why cardiac and GI inputs might influence brain dynamics and cognition. The first distinctive feature of these two organs is that they generate their own intrinsic oscillatory electrical activity, even when disconnected from the brain, from the first weeks of gestation until death. […] Second, cardiac and GI signals are characterized by intrinsic time constants [...], compatible with the timescale of cognition. Importantly, these signals reach not only brainstem nuclei but also many subcortical and cortical regions involved in cognitive tasks. Last but not least, monitoring internal visceral variables is a core function of the CNS, and the drive behind many life-sustaining behaviors that are tightly related to high-level sensory and cognitive functions. For instance, the basic behavior of searching for food is motivated by internal states such as hunger and requires visual search, action planning, navigation, and learning and memory. Given all these features, cardiac and GI signals stand out as a continuous source of information that may influence both brain dynamics and high-level cognition.[33]

33 Visceral Signals Shape Brain Dynamics and Cognition, Damiano Azzalini, Ignacio Rebollo, Catherine Tallon-Baudry, Trends in Cognitive Science, April 29, 2019DOI: https://doi.org/10.1016/j.tics.2019.03.007.

In creative cognition, “focusing hearing inwards” can effect dynamics of mental visualization and intero-spatial movement such as imagination.

The overlaps of ear’s functions and their possible effects on cognitive activities such as imagination, thought process, psychological processing, are often accounted for in space-sound acoustic properties in contemporary architecture, sound design and virtual reality. Auralisation became widespread, therefore artificial calibrations of the perception of space through sound are inevitably modulating our cognitive development as well.

If we consider the implications of sound recognition and discrimination, there are several proposals on how listening is interwoven in cognitive development. Some children with Autism spectrum disorder exhibit auditory brainstem processing deficits specific to speech stimuli, such as deficits in neural synchrony (timing) and phase locking (periodicity encoding, transcription of pitch contour), as well as degradation of the morphology of the responses in quiet and background noise. Reduced amplitude, delayed timing and overall degraded morphology of cortical responses have also been reported.[34] There are insights that the most

34 Nicole M Russo et al. “Biological changes in auditory function following training in children with autism spectrum disorders,” *Behavioral and Brain Function*s 6, no. 60 (2010), https://doi.org/10.1186/1744-9081-6-60.

common psychological cause of dyslexia (varying in cross-cultural language diversity) is a deficit in auditory processing of the sounds of language (phonological processing). In relation to that, it is hypothesized that the left temporoparietal region of the brain which supports the cross-modal relation of auditory and visual processes during reading shows a significant deficit in children with dyslexia (respectably acknowledging that causes of dyslexia can be considered at multiple levels of analysis and probably reflect multiple interacting mechanisms that vary across individuals).[35] These insights supported the development of remedial tools, such as Sonic learning, which uses sound stimuli and controlled listening to strengthen attention and to increase both auditory discrimination and neuro-plasticity. Apart from remedial sonic tools, there are also some neurotherapeutic tools, based on the Safe and Sound Protocol, which consider the implementation of the Polyvagal Theory.

35 John D E Gabrieli, "Dyslexia: A New Synergy Between Education and Cognitive Neuroscience," *Science* 325, no. 5938 (2009): 280-283. https://doi.org/10.1126/science.1171999.

The Safe and Sound Protocol

> uses the auditory system as a portal to the vagus complex, which controls our physiological state. Once the physiological state is regulated, we can accelerate or enhance subsequent therapy.
>
> […][T]he program is derived from nearly four decades of research on the relationship between the autonomic nervous system and social-emotional processes. It is designed to stimulate nervous system regulation by exercising and systematically challenging the auditory system with specifically processed [sound].
>
> The [sound] trains the auditory pathways by focusing on the frequency envelope of human speech. As the client learns to process these speech-related frequencies, they improve the functioning of two cranial nerves that are important for promoting overall social behavior. Cranial Nerve VII (Facial Nerve) helps clients focus on human voice and tune out irrelevant frequencies. Cranial Nerve X (Vagus Nerve) enables self-soothing and autonomic regulation.[36]

36 Integrated Listening Systems, "The Safe and Sound Protocol: What is the SPP?: How Does It Work," Integrated Listening Systems, https://integratedlistening.com/ssp-safe-sound-protocol/. See also selected research articles "ILS Research & Supporting Data," https://integratedlistening.com/research/.

To return to the primary functions of the ear, we should observe the role of the ear in charging the organism with electric potentials. Thanks to this function, external stimuli enter the ear and reach cortical areas really fast, thus they are "feeding" the brain.

It is acknowledged that the brain needs a huge number of sensory stimuli in order to function vitally. Concretely, the brain needs 3 billion stimuli per second in the continuity of 3 or 4 hours in order to maintain awaken conscious state. There is a hypothesis that almost 90% of these stimuli are processed and further distributed through the functions of the ear.[37] In the frame of this mechanism – which is energizing – there are also studies considering endocochlear potential (EP), "a battery-like electrochemical gradient found in and actively maintained by the inner ear,"[38] that could be used as a power source for electronic devices. Researchers achieved "designing an anatomically sized, ultra-low quiescent-power energy harvester chip integrated with a wireless sensor capable of monitoring the EP itself."[39] With future optimization of electrode design, researchers "envision using the biologic battery in the inner ear to power chemical and molecular sensors, as drug-delivery actuators for diagnosis and therapy of hearing loss and other disorders."[40]

But auditory sensory stimuli are not exclusively directed to the ear. They are also absorbed by the skin, muscles, and bones (hypothetically, also by the bioenergy fields). It is not realistic to expect that the sound, which propagates spherically, so to say in all directions, simply gets sucked in by your auricle.

Our body is absorbing sound and its energy features in many different ways. When thinking about sound meeting a membrane of any kind so as well a surface of the skin, I cannot skip thinking of cymatics vibrational phenomena[41]occurring within our own bodily structures. Within this context, we need to take into serious consideration the fact that sound propagation through different substances is conditioned by those media, which causes patterned frequency and subsides in a large amount of modulation.

37 Don Campbell interview with Alfred Tomatis quoted in Don Campbell, "Chant: The Healing Powers of Voice and Ear," in Don Campbell, *Music: Physician for Times to Come*, (Wheaton, Chennai: Quest Books, 1991), 13.

38 Patrick P Mercier, Andrew C Lysaght, Saurav Bandyopadhyay, Anantha P Chandrakasan, Konstantina M Stankovic, "Energy extraction from the biologic battery in the inner ear," *Nature Biotechnology* 30, (2012): 1240-1243. https://doi.org/10.1038/nbt.2394.

39 Ibid.

40 Ibid.

41 Modal vibrational phenomena, patterns emerging by exciting a surface – plate, diaphragm or a membrane by particular frequency, resulting in frequency patterns being visible in a thin coating of particles, paste or liquid, depending on geometry of the plate and velocity of the driving frequency.

Usually, the speed of sound in gases is lower and mass density is much smaller than in liquids, resulting in a very strong acoustic impedance contrast at a gas-liquid interface. Sound transmission through a boundary with a strong impedance contrast is normally very weak.

These are known approximates of the "absorption coefficient of the human body surface that varies from 0.1% to 10% and decreases at higher frequency. The resistances per cm^2 varies between 10^3 and 10^5 ohms and are dependent upon the area of application and the pressure upon the skin and muscles.[42] […] These acoustical impedances and the absorption coefficients of the surfaces were determined from the resonance characteristics of an air-filled tube. The end of the tube was closed first by a rigid wall and then by the examined surface."[43] This was examined in 1949, and the results were largely confirmed 51 years later using a similar method.[44]

Every musician is familiar with the different acoustic effects of playing in an empty room and playing in the same room full of people. We still need to discover various effects of the sound absorption of the body, but taking into serious consideration the resonant energy fields which are surrounding it. The strong interplay of sound and electromagnetism is also a possible pathway to understand the scale of energy modulation that takes place while our bodies are being exposed to sound.

> There are several studies that have been concerned with how listening plays a central role in how we attune to places and situations. […] [Also several studies showed] that listening can generate communicative channels between bodies that are near each other or far away, revealing things that are not available to the other senses, and reconfiguring bodies through its affective qualities. [...] These studies have argued that bodily reactions to sound cannot be reduced to the reception of the aural stimuli by the ear. Instead, they are intensely visceral, and instigate several bodily reactions. [...] Furthermore, these studies show that the act of listening cannot be conscribed to the individual body. Listening is an intersubjective practice in which the social and cultural context shapes or directs the act of listening to certain sounds.[45]

42 H. E. von Gierke, "Sound absorption at the surface of the Body of Man and Animals," *The Journal of the Acoustical Society of America* 21, no. 1 (1949): 55. https://doi.org/10.1121/1.1917027.

43 Ibid.

44 Utilizing the two-microphone impedance tube method, the acoustic absorption of human skin and hair is measured in the frequency range 1-6 kHz. Various locations on a number of human subjects are measured to determine if the presence of bone or an air pocket affects the acoustic absorption of human skin. Results for skin measurements compare well with previous work… Brian F. G. Katz, "Acoustic absorption measurement of human hair and skin within the audible frequency range," *The Journal of the Acoustical Society of America* 108, no. 5 (2000): 2238-2242.

45 The first impression in the urban sonic experience: transitions, attention, and attunement, Daniel Paiva, Herculano Cachinho & 12 Anonymous Participants,

Further research on listening that could be interesting for our topic includes studies on diverse brain processing of data emitted by living and non-living sound sources. In the study that

> used magnetic resonance imaging (fMRI) to identify brain regions showing preferential activity to four categories of action sounds, which included non-vocal human and animal actions (living), plus mechanical and environmental sound-producing actions (non-living) [, t]he results showed a striking anteroposterior division in cortical representations for sounds produced by living versus non-living sources. […] Additionally, there were several significant differences by category, depending on whether the task was category-specific (e.g. human or not) versus non-specific (detect end-of-sound). […] Overall, this multi-level dissociation of networks for preferentially representing distinct sound-source categories provided new support for grounded cognition models that may underlie organizational principles for hearing perception.
>
> […]
>
> Due to the inherently different nature of acoustic versus visual input, some fundamentally different sensorimotor properties might drive the central nervous system to segment, process, and represent different categories of an object or action-source knowledge [of sound perceived] in the brain. This, in turn, may […] be associated with distinct network representations that show category-specificity, therefore reflecting a gross level of organization for conceptual systems that may subserve auditory perception.[46]

Scientific studies on brain cognition showed that evaluation of sounds from living sources is biased towards sound independent semantic[47] information whereas sounds from non-living sources are biased towards physical properties of the sound.[48]

Geografiska Annaler: Series B, Human Geography, Volume 100, 2018 - Issue 4, https://doi.org/10.1080/04353684.2018.1444943.

46 Lauren R Engel et al., "Different categories of living and non-living sound-sources activate distinct cortical networks," *NeuroImage* 47, no. 4 (2009): 1778-91. https://doi.org/10.1016/j.neuroimage.2009.05.041.

47 Semantic cognition refers to the appropriate use of acquired knowledge about the world. This requires representation of knowledge as well as control processes which ensure that currently-relevant aspects of knowledge are retrieved and selected. […] Semantic knowledge, of the meanings of words and properties of objects, shapes our understanding of the world and guides our behavior. (Hoffman, P., An individual differences approach to semantic cognition: Divergent effects of age on representation, retrieval and selection. Sci Rep 8, 8145 (2018). https://doi.org/10.1038/s41598-018-26569-0.

48 B. L. Giordano, J. McDonnell, S. McAdams, Hearing living symbols and nonliving icons: category specificities in the cognitive processing of environmental sounds Brain Cognition, 73 (1) (2010), pp. 7-19. https://doi.org/10.1016/j.bandc.2010.01.005.

The relationship between environmental sounds and semantic processing mirrors proposed distinction between *musical* and *everyday* listening.[49]

Musical listening occurs when the listener focusses on low level auditory features, whereas in everyday listening the listener uses sound to interpret information about the environment. In the perception of soundscapes […] for example, there are many […] categorisation systems proposed to differ between "expert" and "non-expert" listeners[50] according to the emotional response to the sound.[51] This suggests that listening mode influences categorisation.[52]

From the literature suggested in this section we can assume that "the strategies used by listeners to form different categories of sound are reliant on context, the scale at which attention is focused, and listening mode."[53]

The perception of complex auditory scenes has been explored within the field of soundscapes,[54] which aims for listener-centric assessments of environmental sound scenes. Work in this area has focused on perceptual dimensions of listener experience,[55] emotional dimensions,[56] the influence of expectation and contextual factors,[57] and ecological validity of artificial reproduction.[58]

Despite this relatively large body of work, little is known regarding how listeners categorise auditory objects in complex soundscapes.[59]

49 W. W. Gaver, What in the world do we hear? An ecological approach to auditory event perception, Ecol Psychol, 5 (1) (1993), pp. 1-29. https://doi.org/10.1207/s15326969eco0501_1.

50 G. Lemaitre, O. Houix, N. Misdariis, P. Susini, Listener expertise and sound identification influence the categorization of environmental sounds, J Exp Psychol: Appl, 16 (1) (2010), p. 16, https://doi.org/10.1037/a0018762.

51 P. Bergman, A. Sköld, D. Västfjäll, N. Fransson, Perceptual and emotional categorization of sound J Acoust Soc Am, 126 (6) (2009), pp. 3156-3167, https://doi.org/10.1121/1.3243297.

52 Woodcock, W. J. Davies, T. J. Cox, A cognitive framework for the categorisation of auditory objects in urban soundscapes, Applied Acoustics, Elsevier 2017. https://doi.org/10.1016/j.apacoust.2017.01.027.

53 Ibid.

54 W. J. Davies, M. D. Adams, N.S. Bruce, R. Cain, A. Carlyle, P. Cusack, Perception of soundscapes: an interdisciplinary approach, Appl Acoust, 74 (2) (2013), pp. 224-231, http://dx.doi.org/10.1016/j.apacoust.2012.05.010.

55 Davies, W. J., Bruce, N. S., & Murphy, J. E. (2014). Soundscape reproduction and synthesis. *Acta Acustica united with Acustica*, *100*(2), 285-292. https://doi.org/10.3813/AAA.918708.

56 R. Cain, P. Jennings, J. Poxon, The development and application of the emotional dimensions of a soundscape Appl Acoust, 74 (2) (2013), pp. 232-239, DOI: 10.1016/j.apacoust.2011.11.006.

57 N. S. Bruce, W. J. Davies, The effects of expectation on the perception of soundscapes, Appl Acoust, 85 (2014), pp. 1-11 http://dx.doi.org/10.1016/j.apacoust.2014.03.016.

58 C. Guastavino, B. F. Katz, J. D. Polack, D.J. Levitin, D. Dubois, Ecological validity of soundscape reproduction, Acta Acustica United Acustica, 91 (2) (2005), pp. 333-341, https://www.researchgate.net/publication/228347731.

59 Woodcock, W. J. Davies, T. J. Cox, A cognitive framework for the categorisation of auditory objects in urban soundscapes, Applied Acoustics, Elsevier 2017. https://doi.org/10.1016/j.apacoust.2017.01.027.

As it seems listening tend to have complex implications and are directly responsible for a large amount of nervous system regulation, having feedback in functions of both psyche and metabolism, brain energy transference and distribution as well as translation of myriads of sensory information. The amount of stimuli processing and discrimination body has to put up with in maintaining sensory-perceptual mechanisms seems overwhelming. Only functions of the ear are covering an immense amount of psychophysical regulations. In that sense, the statement that complex sounds are, by definition, multidimensional[60] also could describe the constant interplay between automatic (self-regulatory) and voluntary (conscious) actions the brain and overall neural network are executing and are exposed to.

Noise of the world, a great example of overlapping realities

What technology and the science around it are pointing out clearly – are our perceptual limits. The range of our basic senses is deplorably limited. Among numerous examples, we unconditionally accept enormous density of electromagnetic and radiofrequency pollution, accepting an increasingly dangerous electrical environment that has largely abandoned systematic monitoring. We are familiar with the facts that higher frequency EMFs, which include x-rays and gamma rays, the ionizing radiation part of the electromagnetic spectrum, and can damage DNA or cells directly. But in everyday life, we use more often the low-to-mid frequency EMFs, which include static fields (electric or magnetic fields that do not vary with time), magnetic fields from electric power lines and appliances, radio waves, microwaves, infrared radiation, and visible light that is in the non-ionizing radiation part of the electromagnetic spectrum and are not known to damage DNA or cells directly.[61]

A large body of observational evidence strongly suggests that some electromagnetic fields pose a potential hazard to human health, and are a climatic factor that is of no less significance then temperature, pressure, and humidity. […] A low-frequency magnetic field permeates a living matter without any apparent hindrances. It affects all the particles of the tissue, but not all of the particles are involved in the process of transferring information about the magnetic field to the biological level.

60 Robert Dooling, “Chapter 7 – Audition: can birds hear everything they sing?,” in Robert Dooling, *Nature’s Music: The Science of Birdsong*, eds. Peter Marler and Hans Slabbekoorn (San Diego, London: Elsevier, 2004), 206-225.

61 The American Cancer Society medical and editorial content team, “Microwaves, Radio Waves, and Other Types of Radiofrequency Radiation,” American Cancer Society, https://www.cancer.org/cancer/cancer-causes/radiation-exposure/radiofrequency-radiation.html.

Primary processes of the interaction of a magnetic field with matter particles, such as electrons, atoms and molecules, are purely physical processes. Charged particles of living matter, ions, that take part in biophysical and biochemical processes seem to be intermediaries in the transfer of magnetic field signals to the next biochemical level. Such a subtle regulation of the activity of proteins of enzyme type, affected via biophysical mechanisms, involving interim ions, shifts the metabolic processes.[62]

> It is well known that all matter is comprised of atoms. But sub-atomically, the matter is made up of mostly empty space. […] when electromagnetic waves pass through a material, they are primarily moving through free space, but may have a chance encounter with the nucleus or an electron of an atom. Because the encounters of photons with atom particles are by chance, a given photon has a finite probability of passing completely through the medium it is traversing. The probability that a photon will pass completely through a medium depends on numerous factors including the photon's energy and the medium's composition and thickness. The more densely packed a medium's atoms, the more likely the photon will encounter an atomic particle. In other words, the more subatomic particles in a material, the greater the likelihood that interactions will occur. Similarly, the more material a photon must cross through, the more likely the chance of an encounter. […][63]

When a photon does encounter an atomic particle, it transfers energy to the particle. The energy may be re-emitted back the way it came (reflected), scattered in a different directions or transmitted forward into the material. Let us first consider the interaction of visible light. Reflection and transmission of light waves occur because the light waves transfer energy to the electrons of the material and cause them to vibrate.[64] [...]

> However, X-rays and gamma rays have enough energy to do more than just make the electrons vibrate. When these high energy rays encounter an atom, the result is an ejection of energetic electrons from the atom or the excitation of electrons. The term "excitation" is used to describe an interaction where electrons acquire energy from a passing charged particle but are not removed completely from their atom. Excited electrons may subsequently emit energy in the form of x-rays during the process of returning to a lower energy state. Each of the excited or liberated electrons goes on to transfer its energy to matter through

62 Magnetobiology—underlying physical problems: Vladimir Binhi, Academic Press, San Diego, 2002, Elsevier, https://doi.org/10.1016/S1567-5394(03)00011-2.

63 Interaction of Electromagnetic Radiation and Matter, https://www.nde-ed.org/EducationResources/CommunityCollege/RadiationSafety/theory/interaction.htm.

64 Ibid.

> thousands of events involving interactions between charged particles. With each interaction, the energy may be directed in a different direction.[65]

The higher the energy of a photon, the more likely the energy will continue traveling in the same direction. As the radiation moves from point to point in matter, it loses its energy through various interactions with the atoms it encounters. If the radiation has enough energy, it may eventually make it through the material.[66]

Still, we *a priori* consider electromagnetic pollution to be non-harmful without assumptions of possible inter-generational exposure, or structural effects on the resonance of a living environment that in most non-human agents depends on perceptual range other than ours. Diverse species are undoubtedly biologically encoded with diverse perceptual range, therefore electromagnetic and other dense noises of the world perhaps might be invisible and inaudible for humans but are concretely present for other species. We enjoy the era of the ultimate electronic device dependence with great infantility and without delay, leaving a reckless impact behind us for the all-pervading environment.

65 Ibid.
66 Ibid.

Conclusion

The overall human experience of oneself and the all-pervading environment significantly depends on one’s ability to perceive and process sound observed as an energy-potent information transfer. Characteristics of a sound can condition patterned frequency, maintain both internal (body) and external (environment) energy levels, modify cognitive abilities and trigger distinctive changes of one’s psychophysical condition, behavior and reality disposition. The human body is well equipped with layers of synchronized self-regulatory mechanisms involving a great deal of dynamic functions in psychophysical and bioenergetic systems that are highly receptive to, and partially sustained by, the existence of sound. This brings us to the conclusion that the overall feedback received from exposure to sound in its wider sense exhibits the formative implications of both human and environmental evolutionary development.

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