

FROM METAPHOR TO MEDIUM: SONIFICATION AS EXTENSION OF OUR BODY

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ABSTRACT

Following Marshal McLuhan's perspective on media as *extensions of man* [14], sonification for the generation of knowledge can be regarded as an extension of our auditory sense toward previously imperceptible properties of our environment. Investigating our own involvement from an ontological perspective allows us to generate conceptual handles for the research, development and use of tools for sonification and the implied extension of our physical body through technology. Based on the nature of our bodies as mediators between the shared exterior and the individual interior, a model of three problematic areas of our extended bodies is presented: the *cognitive*, the *physical* and the *extended*.

When we research, design and develop new applications and methods in sonification, we investigate the models and metaphors used in each of these areas, but it is only when we *use* the developed applications that we actually understand what potentials of perception and exploration we are provided with. It is therefore not sufficient to only build an exterior apparatus: The extended body is each of our own—each researcher and user of sonification develops an individual relationship to all affordances provided.

1. INTRODUCTION

Sonification has been defined as

The transformation of data relations into perceived relations in an acoustic signal for the purposes of facilitating communication and interpretation [1].

According to Thomas Hermann's summary, research related to the field of sonification is centered on the relationship between data and sound: the mapping of data into schemes of sound synthesis and interaction [9]. We are looking at an apparatus that performs a deterministic transformation of a quantified but imperceptible phenomenon into one which can be directly perceived. The resulting modality, *sound*, is well defined on a technical level: Oscillations of pressure transmitted through solid, liquid or gas, composed of frequencies within the range of human hearing. From this perspective, sonification means the encoding of data into audible vibrations.

The demand of *perceived relations* however requires a quantitative model of perception. Empirical approaches that can provide a handle in this area can be found in the interdisciplinary research field of auditory perception, for example psychoacoustics [16], auditory scene analysis [17], music cognition [18], study of phenomena of *presence* [19]—or the environmental approach to sound perception [12]. But the installment of quantifiable handles on what

occurs to us subjectively runs into problems from two directions: the dependence of perception on the subjective involvement of the perceiver on one hand, and the ineffability of perceptual qualities on the other.

From my own experience, I would like to highlight the active role of the listener in the process of perception. In my work as a sound engineer striking perceptual changes seem to occur when my involvement and intention with the sound shifts. Listening from the perspective of the engaging performance of a musician, the balance settings of the mixing console, the loudspeaker projection, recreation of perceptual depth and space, impact, width, pressure etc. all make the sound occur in a noticeably different way. It becomes very evident that what we *listen for* in a sound, the expectation informed by our intentions, can change its perception.

Secondly, our auditory experience can only insufficiently be rendered into words, much less physical or arithmetic expressions. When we attempt to communicate and share our perceptions, we seem to be confronted with a lucent but unapproachable realm of qualia, ephemeral and fleeting impressions connected to inherent or attributed layers of meaning that make up our conscious experience. The description of sound qualities often occurs through synaesthetic and poetic metaphors, comparable to the way we describe the experiential qualities in a sip of wine. Whether working with a composer or as a sound engineer attempting discuss a specific sound with a musician, the language used is often suggestive rather than precise, and harbors a constant danger of sliding into a situation comparable to the one described in Hans Christian Andersen's "The Emperor's New Clothes".

Both this quantitative ineffability of auditory perception and the inherent openness of *listening "for"* cause resistance to the intended deterministic creation of *perceived relations* shared among different listeners, as these phenomena are hidden from the world shared among different individuals and reside in the area of internal and subjective cognitive processes. Before we return to this specific problem, we would like to insert a more general excursion into the relationships between our perceptions, models of reality and our cognitive approach toward the world we find ourselves in.

2. EXCURSION INTO THE NATURE OF INVESTIGATION: MODELS

When botanists categorize plants, one possible question to ask is for the physical structure of the plant—for example, the structure of its blossoms. This investigation produces so called inflorescence diagrams: Simplified representations assembled from shapes

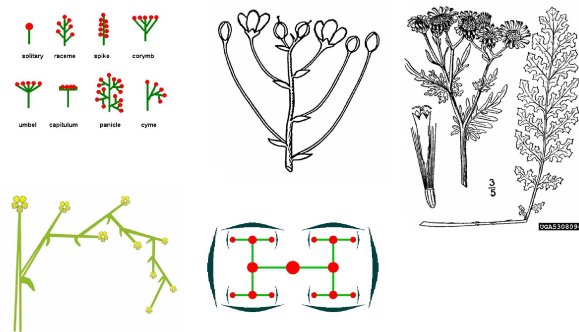


Figure 1: Inflorescence Diagrams (source: Wikimedia)

of clear geometric structure that afford formalization and categorization and can be described, stored, processed and recreated easily.

Interesting about the nature of these diagrams is the degree to which they depart from the actual shape and impression of the original plant. Sometimes, straight sticks and circles representing the flower are enough for a satisfying circumscription. In certain cases, curved structures need to be introduced to depict petals and leaves, or for a correct representation of the structure itself. This requires decisions about the specific geometric shape used: A human observer providing a *best judgement* for the shape used becomes apparent. The more life-like the representation of the plant is required to be to remain accurate, the more unquantified elements appear in the diagram that forego a straightforward modeling of the representation for example by a computer. At the extreme end of this continuum is the creative work of a human artist capturing the essential elements of the plant's structure from subjective point of view—a representation that can no longer easily be recreated or processed. We have traversed a space from simplified representations of complete quantitative transparency to representations of perceptual accuracy that however rely entirely on subjective human perception.

Simplified models are created to remove information from the appearance of the actual plant, allowing us to handle them for a specific purpose—for example to classify them by blossom structure. From this moment on, the plant is no longer regarded as a unique individual, it is handled according to a suiting simplified model chosen as its representation. This process, that we are generally unaware of, allows us to access the world and to use the structures we find for specific purposes according to a matching model of reality that we infer: the metaphors we live by [7]. We are replacing objects we find in our environment with simplified models constructed from structural elements that are implied in the attitude or question of our own approach.

3. MODELLING PERCEPTION

How can we find a model for our perception that we can use to make the sonification apparatus more relevant to us? Through perception, the exterior world becomes present to our thinking and action. How can we describe the way in which perception transgresses the line between what we may describe as our exterior and interior worlds? We tend to view our sensory organs—ears,

eyes, nose, et cetera—as parts of our physical body. But even Rene Descartes, the philosopher known for his support of a dualistic separation of body/physical exterior and mind (*res extensa* and *res cogitans*), regarded sensing (*sentire*) already as a part of thinking (*cogitare*) [6]. Models that describe our senses not as a passive receptors of stimuli from the exterior, but as a part of our mind and already implicating cognitive activity, are pervasive. Investigating the nature and appearance of perceptual illusions, R.L. Gregory generated the model of a perceptual *hypothesis generator* that receives input from three different directions [5]:

- bottom up: from the sensors in our body that are connected to the physical environment
- top-down: from previous experience and accumulated knowledge about the exterior world
- sideways: from being set for a task

Only one of the streams in this model enters this structure from the exterior world, while the other two information streams are created by cognitive activity of the perceiver. Next to these three inputs, this *hypothesis generator* has two outputs: on the one hand the appearance of conscious perception (*qualia*) and on the other hand a behavioral action.

More recently, cognitive models were developed in the area of artificial intelligence and robotics research: From the perspective of machines with intelligent behavior and environmental awareness, the relationships between *mind*, *body*, *perception* and *action* have been framed into models of *embodied cognition* that can be traced back to philosopher Maurice Merleau-Ponty [8] and cognitive linguist George Lakoff [7]. Regarding cognition and perception as a distributed process in which the different parts of the body are already actively involved is in elegant correspondence to the distributed sensing and actuator systems exchanging information used in robotic design [3]. This in turn opens the path toward the interpretation of our body as an extensible structure involved in *active perception* as it can be found in the discourse of post-humanism [4]. The act of perception is no longer implying only cognitive activity, but in fact a senso-motoric loop: the performance of physical movements such as involuntary eye motions or scanning across surfaces with the tips of one's fingers. This effectively dissolves the ontological distinctions between *mind*, *body*, *thinking* and *action*.

Before losing focus in the appreciation of the power of this model to enable the emergence of complex self-regulatory systems that display intelligent behavior, we need to remind ourselves that the focus of this presentation is the question what the respective models afford to us as participants in the design and use of sonification. An analysis of information flow in the cybernetic post-human perspective of our embodied cognition will not provide us with a sufficiently reliable concept of *subjectivity*. We have to insist on an approach toward the world that is based on our *Being* and *Caring* for the world when we are looking for answers to questions such as:

What does a specific model afford us in our perceptual access to the world through audible data relations? How does specific model of cognition and perception allows us to address ourselves with the apparatus we are constructing? What possible actions can we take to enhance our own subjective attitude toward these model mechanisms and the way we use them?

The deconstruction of the subject is the necessary outcome of empirical self-analysis, yet the questions we want to consider im-

ply us as personal designers and users of sonification. We will therefore base our notion of subjectivity on a concept of *personal involvement* and *care* that follows Heidegger's assertion that *the existential purpose of Being is Care* [2]. On this basis, we can regard the sensimotor extension of our body provided by the sonification apparatus as an expansion of our *care for the world* towards previously imperceptible relations in abstract data. This extension is not exclusively *outwards* however: the successful use of new tools requires an extension into the *interior*, into our cognitive approach toward the world. We hope to make this perspective more transparent on a short expedition into the discourse of *embodied interaction* introducing the different areas of the *extended body* that are proposed here as an organizational strategy for the functional elements that sonification engages and the questions that might be implied in them.

4. ONTOLOGICAL APPROACH TO THE COGNITIVE BODY

An example often cited in the context of "embodied interaction" is Heidegger's description of a shoemaker using a hammer to drive a nail into the heel of a shoe in order to repair it [11, 2]. A well trained craftsman will be so versatile with the tool that it functions like a part of his body, allowing the shoemaker to focus his *care* completely on driving the nail into the heel without thinking about how to handle the hammer. The hammer becomes part of the shoemaker's skilled arm, a transparent physical extension to his hand: the established in-order-to has become intuitive and familiar through practice. A good hammer will enable the craftsman to provide exactly the right transformation of the force exerted by the body and gravity to allow a maximum amount of control over the nail. With the terminology of McLuhan, we could say that the material that the hammer consists of is becoming a medium for the activity of the craftsman through its *use as* a hammer [14]. When the hammer breaks however, *using-it-as* a hammer is no longer possible: The *care* is shifted toward fixing it, for which in turn other tools might be applied.

Thus the hammer in this example can be in two different ontological states: it can be a part of the craftsman's extended body by which he approaches the exterior world to care for the shoe, or be a part of the exterior world and itself a recipient of care. *Using something as* allows us to extend our bodies dynamically by turning models and metaphors into media for our intentions and using them in our improvisatory approach to the world. Paul Dourish cites Suchman, who drew attention to the improvisatory nature of our moment-to-moment actions:

The sequential nature of action is not a formulaic outcome of abstract planning, but rather is an improvised, ad hoc accomplishment, a moment-by-moment response to immediate needs and the setting in which it takes place [11].

We are improvising our way through life, using the objects around us as media for our intentions, depending on what we need to get done and what setting it occurs in. So much for the relationship between our physical body and its extension by exterior objects. We would now like to extend this perspective to the models we use in our cognitive access to the world: the metaphors underlying our actions that are not externalized into a specific use of our physical body or the objects we find in our environment, but that we use in our *thinking about the world*.

Science philosopher Paul Feyerabend argues against formalized scientific methods and for an anarchistic use of all available models in our access to knowledge [13]. Feyerabend's *epistemological anarchy* can inspire an extension of the concept of the *use-as* of exterior objects to the metaphors we use in our cognitive access to the world. If we allow the exterior world and our physical body to be used in our daily improvisatory performance, why not care in a similar way for the cognitive and perceptual tools we use to approach the world? This is possible if we have access from both of the ontological states we have described above for the shoemaker's hammer: if we are able to construct suitable metaphorical models and then are also able consciously use and apply these metaphors in the way we handle the world.

These necessarily condensed considerations motivate us to separate three ontological regions or realms of *body* that will allow us to build a structure into which we can organize the problematic areas within the field of sonification:

5. THE THREE REGIONS OF THE EXTENDED BODY

First, our *physical body* is the most obvious interface between our interior and our exterior worlds, between what we perceive as belonging to ourselves and that which belongs to the exterior space that we share with others, or—as Heidegger describes it—between the world and that which is *not* me [2]. The body is the medium by which we are connected to the exterior in perception and action, and the locus of *sensimotor knowledge* [15].

Secondly, in our daily lives, we use apparatuses that modify or *extend our physical bodies*, providing additional affordances in our approach to the world: exterior objects we use as tools according to a learned or developed scheme of action that extend our interface with the exterior world. These *media* in the sense of McLuhan [14] can provide extension to both the reach and capabilities of sensing as well as behavioral action and ideally provide a successful coupling between extended sensing and extended action.

Thirdly, in addition to this realm of external objects that we use according to a metaphor to extend our body as media for our action and perception, another realm of metaphorical use patterns can be found in our *cognitive approach to the world*: the sensory, abstracting and behavioral capabilities we have made available to us. This third realm of body is differentiated from the projection of metaphors on the physical body and exterior objects: It describes our capability to shift the nature of our cognition and perception, changing our involvement with the world surrounding us: in my practice as a sound engineer, I learned to listen to music *as* an engaging performance, a sound quality, a tight mix, a spectral distribution, a technical transmission, et cetera, all of which correspond to different perspectives on the *audible* sound between which one can change at will.

Perceptual effects caused by shifting cognitive models can be observed in everyday life: an artwork may look quite different before and after we have listened to an art historian provide us with context about its making and historic significance. The way we drive a car might change drastically after we have attend theoretical driving lesson. The carefulness by which we handle a piece of technological equipment might change after we learn how expensive it was. These effects can be attributed to the two cognitive inputs to Gregory's *hypothesis generator* [5]. Some of the cognitive models are obviously not accessible from the ontological perspective of *detachment*: for example, we obviously have difficulties to hear the audible vibrations produced by a person speaking in our

native tongue as anything but *language*. However, we can for example choose to listen and *pay attention* to a specific person at a cocktail party, or with some training choose to follow the viola voice in a string quartet recording.

There is a continuum between what is accessible to our conscious choice and will and that which we seem to be simply subjected to—a grey area that is somewhat comparable to the continuum in the ontological status of external objects from being detached from our body to becoming so familiar and integrated that they effectively become transparent parts of it.

The aspects of our cognition and perception which can both be observed and consciously used in our approach to the world constitute what we would like to describe as the third area of the extended body: the *cognitive body*. It contains the analytical tools we have at our disposal to access the world, the focus of our attention, learned schemes, models and thought structures that we can use to voluntarily shape the way the world occurs to us.

We can expand the *cognitive body* by learning to *see-things-as* and *consider-things-as*, or on the contrary, buy into the Zen ideal of *not* seeing the world *as* something, and let the world occur to us differently thereby. There is empowerment in keeping our minds flexible in the approach of something unknown, when we want to learn about something unfamiliar. We may venture to ask if Feyerabend's demand for epistemological anarchy should receive more attention in the education of the young.

Before moving back to the topic of sonification we would like to summarize: Cognitive models available to our improvisatory behavior of *thinking* can inform, influence and educate our perception, abstraction and thereby our behavioral/physical approach toward the world.

6. THE EXTENDED BODY IN SONIFICATION

Regarding the field of sonification, we can now start to place the different strategies under investigation into the three realms of body and consider them in their dual ontological status as *metaphorical models* that await construction and care and as *media in use*. This may grant us a better overview of elements that play a role in the application and use of sonification and their interrelation. From the perspective of care, we can analyze the questions that are relevant to each area. From the perspective of *use*, the three layers form an interconnected senso-motoric media channel that is ideally transparent to the data relations present. Due to the scope of this presentation, we can only deliver a pointillistic collection of possible considerations. The gentle reader is invited to draw up a corresponding table for their own sonification research and development project.

6.1. The physical body

Our physical body appears (for example) as a biological senso-motoric system: It affords us with sensory reception and behavioral action. We are obviously highly experienced in its use as a versatile medium for whatever it is we may be doing. In most cases, our body in fact becomes transparent for our intentions leaving us unaware of how it is used specifically in the activities we are involved in.

When we regard the physical body in the ontological status of a *recipient of care*, we can analyze its audition-related aspects: how can we describe the affordances of hearing and physical action in the most fitting way for what we plan to be doing? How can we

allow our physical body to hear a sound and interact with a sound generating strategy in the most effective way? Maybe with gestures? Many aspects of our bodies are involved in the way sound occurs to us, most obviously the ear itself and its various physiological components, but also our shoulders and head shape the sound by characteristic reflections and diffractions depending on its direction of arrival. These spatial cues can be disabled when the sound reaches the cochlea through bone conduction, as underwater sound, or is generated inside or at the body (such as wind breaking at our outer ear), or otherwise bypasses shoulders, head and pinnae, for example by the use of headphones. Sound as vibration may also be detected through the skin by our tactile sense. Simultaneously, we can use physical movements that trigger, scan and explore a sounding structure. What is the best ergonomic range of motion? Where are we most sensitive to changes, what are the preconditions for the best motor control? Caring for our physical body in the context of sonification implies an investigation of how to best extend the relevant affordances toward the data in a loop of *active perception*: How does the acquisition and use of sensimotor knowledge that is postulated by Noë operate?

Using these auditory affordances of our physiological body in the ontological state of a *medium*, the perspective shifts. We are no longer in contact with theoretical models of how our body is supposed to operate or with measurements and descriptions, but with what we as individuals can actively do to get in contact with the *data relations* we would like to investigate or perceive. We can make experiences, develop usage strategies, train ourselves in them, become better at it. We are becoming involved in an active physical improvisation in order to *hear better*. We can change the positioning of our ears—approaching the object emitting the sound, using our hands to amplify or block the sound. We can also move our body to touch something, scan, trigger, move, organize, etc. external objects to name only very few of the in fact innumerable possibilities of how we can use our bodies in the task of *active listening*. While far from conclusive or complete, these considerations may suffice to support that our physical bodies afford more *action-in-perception* for the designer and the user of sonification than the frequently implied model of listening to a sound in a passive position of sitting, and highlight the important role of the performance based on the approach of the individual listener that often goes unconsidered and is replaced by an implied passive and standardized model human.

6.2. The physical-extended body

The extended body contains all aspects of the external apparatus we are using with our physical body to get in perceptual contact with the data relations. These extensions can be *tools* such as the hammer in Heidegger's example, but they ideally extend the affordances of physical *sensing* as well as those of *action* simultaneously. In the case of sonification, the extension of sensing is implemented with *audible vibrations*, while the mode of *action* is a free choice. On the one hand the creation of an environment that enables *action* of a participant while producing *audible vibrations* implies a suitable physical *display system*. On the other hand the information encoded in the display targets our *cognitive body*: According to McLuhan's analysis that "the content of a medium is always another medium" [14], what is encoded in these *audible vibrations* connecting the external apparatus to the physical body is always in fact another medium: content that targets our freedom to perceive, the potentials of our cognitive body to focus and explore

specific aspects and elements. The *care* for the exterior sensorimotor extension can therefore be split into the aspects of *display* and *encoding*.

6.2.1. Display

In the *care* for this area of the extended body, we can find an optimization of the display infrastructure as well as its physical setup to target the sensorimotor capabilities of the body in the most effective way. This can mean for example the design or choice of equipment such as loudspeakers, headphones, converters and amplifiers, video screens, projectors and interaction devices, ergonomic considerations in the setup, the choice and treatment of the room, the removal of unwanted sound sources. What frequency range can our ears pick up? What is involved in making a 3D screen that avoids the sense of nausea? Is the table we have placed the tangible interface elements on too large or too small?

6.2.2. Encoding

Also in the physical-extended body, we find the transformation and modeling of the data relations into audible vibrations, possibly mediated by physical interaction of the participant. The resulting vibrations are designed to target our auditory perception, mediated through the physical display setup and our own physiology.

The strategies of mapping and modeling in the processes of sound generation in the external apparatus as well as the provided affordances of interaction and display are of special interest in the design of the *extended body* and a central concern to design of sonification tools. They can in fact be regarded as a mirror image of our own *cognitive body* of auditory perception: our concepts of what we supposedly can actually *hear and distinguish by listening*, what we consider to be *relevant features of sound* that allow us perceive data relations most clearly. *The sound generation strategy implies the cognitive model we expect to apply when we listen.*

A popular model of auditory perception found in this context is listening for pitch. Other models of auditory cognition are for example derived from the field of music cognition: meter, rhythm, harmony. The strategy of auditory icons employs a model of environmental perception placing relevance on metaphorical references to objects found in the physical environment [12]. In other fields, auditory perception is seen under the model of segregated streams: our capability to distinguish different simultaneously sounding sources of audible vibrations in our environment and to pay selective attention to them [17]. In my own work experimental work I regarded the auditory body as a receiver of information quanta in the form of sine waves accumulating into additive spectra [20]. Examples of strategies that are attributed to the cognitive body of auditory perception include:

- Frequency/Pitch
- Amplitude/Volume
- Tonality/Harmony
- Rhythm, Meter
- Timbre
- FFT/Spectral composition
- Expectation/Form
- Localization
- Stream Segregation
- Intuitive impression of physical process modeled

But are these really the models and metaphors that are closest to the way we get involved with sound? Or do we only use them because we invested so much effort in working our cognitive way through them during our musical training?

For the context of media art, David Rokeby describes the *use* of an interactive computer installation as the development of a belief system about how the installation works [21]. In adopting the apparatus we explore and test as we attempt to extend our sensorimotor knowledge into the realm of the physical-extended body. Like the Hammer in Heidegger's description, we have the ability to become so familiar with this extension that it in fact becomes invisible in our use, but this use of the tool or apparatus is not only dependent on its own making and structure and the strategies that it externalizes, but also on the purpose and context of its use. Our expertise and training grows every time we engage the apparatus for what we are involved in. Do we understand how to use the tool well? Is this tool the right one given our way of thinking about the problem and the context we are using it in? Is it us who do not understand how to use the apparatus properly, or is the apparatus not suitable for what we are trying to achieve? Do I need to change my cognitive approach, or are there problems with the way the display addresses my physical body, or with the encoding strategy used? What affordances do I have with my cognitive and physical bodies in relation to this apparatus? What controls or functions would it need in order to be more suitable to what we are trying to do? These and other considerations highlight the interconnectedness of all three areas of the extended body in use. Once we start to use the tool we have been building, the physical body, its technological extension and the cognitive body appear in the shape of a tunnel that we orient and apply toward what it is we want to get done: Perception of data relations through sound, for example.

6.3. The cognitive body

The cognitive body allows us to choose to a certain degree what we *hear sounds as*. How can we train and expand this ability? How can we make the apparatus usable from as many cognitive perspectives as possible and how can we communicate these perspectives to a possible user? Can we expand any of these aspects through education about the sound generation, music theory and analysis, or ear training of technical or musical orientation? What strategies could we be educated in that could later be used in the context of the sound generation strategies implemented in the externalized apparatus? In Thomas Hermann's approach to Model Based Sonification for example, the quality of the sound in terms of the quantities of pitch, timbre, amplitude that are usual targets for parametric mapping become secondary consideration to the behavior of a sound-producing data-structured physical model [9]. This seems to resonate with Gibson's concept of *direct perception* [10]. So what is the best attitude a listener should approach these sounds with?

Contributing from my own experience as a sound engineer once more, a music production is most successful if it works on all relevant cognitive perspectives, if there are many different ways of listening and all of them deliver a rich and rewarding experience, none reveal striking flaws: Frequency composition, dynamic range, the creation of spatial depth or width, pressure, presence, transparency and artifacts of data compression are among the more quantifiable aspects. But there are others that can only be accessed through subjective and intuitive criteria that quickly start to pre-

clude quantitative evaluation—the quality of the captured instrumental performance or electronic sound, engagement, musicality, expressivity, etc cetera. Each form of listening implies a different internal attitude of the listener.

What seems of greatest importance is the *freedom of the listener to apply all areas of his extended body to the exploration of the sound in an improvisatorial manner*, shifting between as many different cognitive tools along the way as possible, in order to discover the best position of the extended body that allows the clearest listening perspective on the *relations* to be represented by sound.

7. SUMMARY

The apparatus of sonification is accessible from two different perspectives: its design or enhancement, and its use. Shifting the care toward design and enhancement of the apparatus brings the metaphorical handles of each area to the foreground. In its use on the other hand, the apparatus becomes a medium extending our auditory perception toward the relations found in the data we are investigating. Our improvisational skill in each area of the body involved can now be explored, experienced, trained.

7.1. Organizing the metaphors

The model of the *extended body* with its three regions can be seen as a shelf on which the problems that the design and use of sonification implies can be organized and seen in overview. This can provide us with better access to what is needed for a successful *translation of data relations into perceived relations*.

The *cognitive body* contains considerations about our perceptual approach to sound, how it is influenced by experience and task orientation and what possibilities we have to both expand and dynamically shift between the different cognitive involvements in listening. This will allow us to find better criteria for the models we use for encoding data into vibrations through interaction inside the apparatus.

Focusing on the *physical body* allows us to consider the affordances of its sensimotor capabilities for exploration and active perception.

The *physical-extended body* finally is the locus for considerations about the design of the display system and the implementation of modeling, mapping and interaction used in order to address the physical and cognitive bodies most efficiently.

7.2. Using the medium

Shifting our consideration towards the medium *in-use* we enter our models from the perspective of each of our own bodies, from the perspective of our individual subjectivity. Ideally, the apparatus will become a transparent medium: moving the apparatus with our own motoric skills and sensing the responses, we create a loop of active perception that ideally extends our ability to approach the world.

However carefully we design the apparatus, the *relations* are invisible from the perspective of *care* and *detachment* - they only appear in the use of the implemented apparatus for *sonification*. This use is each of our own responsibility - every person can choose to actively improvise in order to hear the *perceptual relations* better, or approach the environment and their life in any other way they see fit.

From this perspective it becomes possible to shed light on the relationship between *sonification* and *art*, which continues to be an area of much confusion.

8. CONTEXTUAL EXCURSION: EXPRESSION, NARRATIVE AND THE COGNITIVE BODY OF LISTENING

Sonification implies that we as participating listeners are interested in the data underlying the auditory representation: the sound becomes part of a medium the data is observed through.

Often, the word *sonification* is used in contexts in which the sound is related to or generated from non-musical data, but the connection between the *perceived relations* and the data they were created from remains a mere suggestion: The transformation is engaged as an inspirational element of a narrative, such as the suggestion of a specific place or the evocation of an invisible or imaginary structure. The interest is diverted from the investigation of the actual phenomenon that produced the data into a narrative of artistic expression. In the cultural context of audio-art and music, the interest of the listener that the *extended body* is oriented towards in order to *hear better* becomes the expression of an artist or an artistic collaboration, or the inner imagery that is evoked by the sounds but contributed by the listener: due to the different nature of intentional involvement, the origin and structure of data occurs to the participating listener with an essentially different perceptual mode of *aesthetic appreciation*.

Gustav Holst's 1916 composition "The Planets" is an orchestral suite in which the listener's interest is not the retrieval of knowledge about celestial bodies of our solar system, but the sense of being absorbed and entertained by an imaginary dramatic narrative based on an astrological interpretation of characters attributed to each of the planets. In musicology, this genre of music with a suggested *program* that serves as a launch pad for the interior imagery of the audience is called *program music*. Other examples include Beethoven's "Pastorale", Berlioz' "Symphonie Fantastique" or Richard Strauß "Alpine Symphony".

More contemporary interpretations of program music that are sometimes regarded as *sonification* can for example be found in Alvin Lucier's piece "Panorama" of 1993, in which a Trombone traces the outline of an alpine mountain range by sliding along micro-tonal intervals. While it might be possible to indeed re-trace the mountain range from listening to the piece, it can hardly be said that the listener will have any interest in learning more about the alps or the mountains through this mediation of elevation data - the interest of the audience is captured by intricate beating patterns resulting from the microtonal glissandos against the partials of the simultaneously ringing chords of the piano—while harboring a mental image of the alpine skyline. Albeit a very poetic experience generated through a composition method informed by physical properties of sound, the implied involvement of the listener is nevertheless akin to imagining planets spinning in space while listening to the powerful orchestral textures of Gustav Holst. The *data* are not a point of investigation: their origin is taken as a source of poetic imagery that is projected onto the *perceived relations* which constitute, together with the visual impression of the trombonist and the pianist, an *aesthetic experience*.

Neither the composer, not the performers or the audience are sincerely interested in extending their auditory world access towards relations in the underlying data structures *behind* the sounds, which would be the purpose of becoming involved in sonification

under the perspective we have laid out in the previous sections of this article.

Without intending to offend my dearest friends and colleagues, the works of *sonification* in which environmental, climatological, demographic, geophysical data are not used to learn about the underlying phenomena but as a narrative reference within a context of an aesthetic strategy can form a long list. The interest in *perceived relations* is shifted towards an interest in *sounding good*, (almost) like music or *fascinating*—in some instances it can even be said that these relations do not matter at all but are in fact only used as a reminder of the context of the data and their origin. If successful, the aesthetic experience achieved can justify this approach - in less successful cases, the participating listeners get stuck between being unable to read patterns and structures from the sound while not being able to enjoy it as music either. The audience is then lead into a confusing space of *bad sounding suggestion*.

On the other hand artistic, creative and expressive expertise and sensibility DO have a strong purpose in sonification: In the cognitive models a listener can apply to approach sound, which are largely inaccessible to quantitative description. In this area artistic practice, as a *cognitive body regarding the creation and interpretation of meaning through sound*, is in fact an indispensable aspect of the extended body. It can inform both the strategies implemented in the external apparatus as well as in the possibilities of *how to listen*. The sound-design strategy, the effective mapping of parameters or assembly of rendering models can all benefit greatly from an access to the palpable expressive potentials of sound structures that may otherwise be the subject of a music composition or production, in a similar way in which the accurate representation of a plant may require subjective human judgement. This contribution does not require the composer or artist to work with *data* however. For an access to *new ways of listening*, it may for example be revealing to investigate the work of composers of the classic modern period such as Schaeffer, Stockhausen and Xenakis who approached technological creation and modification of sound with the intention of creating new aesthetic strategies [22, 23, 24]. Sound Art is a necessary activity and experience both to gain deeper access to the potentials of meaning encoded in sound, and to advance the openness of listening "for".

9. CONCLUSION

I hope it became transparent that from the perspective of *personal involvement* in the care for and use of sonification, the contribution of musicians, artists, composers et cetera is not so much in the area of creating *aesthetic experiences related to data*, but in the *expansion of cognitive models available to the actively exploring listener*. These conscious strategies to approach the perception of sound are in turn implemented, as mirror images, in the encoding of data occurring in the sonification apparatus: it is the individual listener who has to adopt this extension as his or her own in order to *listen to audible data relations*, it needs to *fit* the listener's cognitive and physical body. This generates questions that we may ask ourselves when we get involved with sonification:

As a researcher, developer and creator of sonification tools, the question becomes: How can I enable the listener to take better care for the perception of *audible data relations* that he or she is involved in?

As a listener, the question is: How can I use all tools available to me in order to *hear better*?

What I have attempted in this article is to create a framework of conceptual analysis to support us in extending our auditory sense toward structures in our environment that are otherwise imperceptible.

I firmly believe that we are in the process of scratching the surface of what we are actually able to hear.

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