TOWARDS UNDERSTANDING AND VERBALIZING SPATIAL SOUND PHENOMENA IN ELECTRONIC MUSIC

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ABSTRACT

How do we describe spatial sound phenomena in electronic music? This paper is concerned with the questions whether the electronic music of today takes into account the perception of its audience at all, whether it is necessary to have a typology of electronic music sounds at all, and how to find or generate terms that could be helpful for composition and analysis of spatialized sound. Before going into detail about how to deal with spatial phenomena, it is valuable to review the main concepts of verbalization of sound from the last 100 years of *sound-based music*. Following this, approaches and methodologies are introduced to develop a specific terminology for a certain way of spatial sound projection within the framework of the artistic research project 'Orchestrating Space by Icosahedral Loudspeaker' (OSIL). By this we intent to encourage the aesthetic discussion about spatial sound composition and therefore enlarge the compositional contingencies of this art.

1. INTRODUCTION

In the broad field of electroacoustic spatial sound-composition we are dealing for some time now with spatial sound phenomena that not only come from a direction and head for a vanishing point in the concert or studio space. Rather these phenomena have spatial dimensions like proliferation, width, height etc. forming diverse sound masses that can penetrate, layer, move around each other and define by there properties - space itself. Edgar Varèse has lively described [1] these phenomena in his famous statement[1] from 1936 (!), multiple publications in the fields of musicology and computer music dealt with their causes and their production as well as technical prerequisites. The concert halls are more or less full with a community of specialists and a laymen audience that becomes more and more interested in spatial sound composition.

Thus, these phenomena are perceived by composers, scientists and audiences causing something we call a shared perceptual space. This space is in fact the main research object of the OSIL project and is defined as the intersubjective space where the perception of composers, scientists and audience intersect. However to date with the different formats existing, projection techniques and devices, software tools, spatial concepts explained and discussed it is virtually unresolved what the different listening groups hear where in the created space, how they experience plastic sound objects and how they would describe them for themselves. The question of what is perceived is important in a field of art that claims space and spatial experience as aesthetically being central [2]. While there has been plenty of exchange between science and art since the beginning of computer music, there has been very little between composers and the audience about the possibilities of appreciation and different perceptions of the spatial sound phenomena that are actually inherent in the spatial sound-composition. Electroacoustic music hosts two diametrically opposite cultures: On one side we find the exact sciences of acoustics, informatics, and engineering all of which define conditions of sound production, the very instruments of executing any compositional design. On the other side we find the culture of music appreciation by the ear. Whereas the first aspect is heavily loaded with well-defined verbal concepts that are shared among a community of specialists, the aural, musical aspect that embodies musical thought and projects it to the audience is almost devoid of a consistent terminology as far as electroacoustic music is concerned.

Thus a fundamental problem within every aesthetical discussion in this field resides in the contradicting approaches of science and art: *Scientific discourse seeks to eliminate ambiguity in its terminology and definitions. An artistic discourse would on the contrary often seek to be as polyvalent as possible, suggesting a network of meanings or implications. Thus the scientific ideal is more often than not alien to an aesthetically oriented discourse. However, there is also a need for some intersubjective agreements in the aesthetic field so that music can be meaningfully discussed in words* [3, p.4].

It is not possible to say whether the audience of Varèses *Poème électronique* experienced the 'planes' and 'zones of intensities' or not. Considering the actual technical possibilities and spatial features of the 1958 Philips Pavilion, we might presume that Varèses statement from the 30s includes a good portion of artistic utopia and therefore might be more considered as a foundation myth of electroacoustic spatial music. Today with most of the technical problems and requirements for composing plastic sound objects almost solved, all kinds

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[1] *Today, with the technical means that exist and are easily adaptable, the differentiation of the various masses and different planes as well as these beams of sound could be made discernible to the listener by means of certain acoustical arrangements ... [permitting] the delimitation of what I call zones of intensities. [...]these zones would be differentiated by various timbres or colours and different loudnesses. [they] would appear ... in different perspectives for our perception ... [they] would be felt as isolated, and the hitherto unobtainable non-blending [...] would become possible.*

of control means at hand and a plethora of publications about production and reproduction of 3D sounds in loudspeaker environments, the question might read as follows:

What does the composer know about the perceptive capabilities of the audience? Or more specifically, what does the composer know about the perceptibility of his spatial sound composition?

1.1. Why typology in a 'liberated and free' world of sound art?

A number of publications deal with perceptual aspects of spatial audio, their quantitative and qualitative analysis [4, 5, 6, 7, 8, 9]. Considering the broad field of computer music performance, 3D spatial stability, loudspeaker layouts and projection paradigms, this seemed to be more than exigent and appropriate. For an aesthetic debate - and no art can be spared by this,- we need additional and another kind of knowledge, a certain typological consolidation not only of the 'craft skills' but also of the perceptive phenomena and these at a preferably high degree of generalizability. These demands are not so new and bound to computer music as they might seem. We find similar verbalization problems of sound in score-based music of the 20th century:

So far we have named tones (Klänge) after their origin (Herkunft), [...] until today we have not been able to term musical sounds like we do with red or green for colours. If we say oboe, we mean the instrument, that has been built and with which one generates these sounds. But still a sound of an oboe cannot be described as such among musicians. If musicians hear sounds they have no idea of how they where made, they are absolutely helpless. [...] It does not fit in the categories that we can call by name. That is very important as we suddenly lose the perception, the orientation. And it causes uncertainty. Uncertainty is undesired. [...] we have a very small, yet limited reservoir of sounds, that we can name and this is miserable [10]. Stockhausen clearly hints towards the dilemma that only what can be described is accessible for deliberate perception and therefore eligible for productive discussion. Similar problems are currently discussed in another field of sound production namely film sound design. In her basic work [11, p.100] Barbara Flückiger strongly states:

[...] As long as auditive perceptions cannot be transferred into language, they are not accessible for analysis. Thus, language is the critical interface between sound and listener. Furthermore its value for the refinement of perception per se is claimed: *The more differentiated the linguistic resolution the more differentiated the perception will be and vice versa*. In connection with this Flückiger finds that *[...] in our culture we lack an adequate vocabulary to describe sound objects.* Of course there is the prevalent notion that the composer lives in his or her own world of imagination reflecting these ideas within the composition of a piece. And whether or not and how the piece is perceived thereafter is not part of the composer's business, moreover the musical work like every piece of art is set free after completion to any kind of perception and interpretation.

The difficulties that some people have listening to a piece that only exists as composition of sounds are totally indifferent to me while I compose. [12, p.90] We do not want to counter this artistic point of view as such but with the degree of freedom we reached for artistic creation we are in a position to produce almost sculptural sound phenomena that are 'ghost like', ephemeral mirages whose perception is dependent on many prerequisites not least the vantage point of the audience.

Most of the efforts to verbalize sound phenomena from the last 100 years are solely made from a scholar's or composer's perspective [13, 14, 15, 16, 17, 18]. By summarizing some of the classical positions from Russolo, Eimert and Schaeffer we draw a line towards Smalley's comprehensive works, examining an approach by Thies. introducing recent notable efforts by Grill and Nyström. In doing so we aim to understand the idiosyncracies of different approaches and criteria for a meaningful engagement with the present situation.

1.2. Interdisciplinary listener-based research

Therefore we agree with opinions that claim the necessity of interdisciplinary and intersubjective studies to collimate the field of perception and perceptibility and narrow down simple and applicable terms. *[...] Interdisciplinary work with specialists in areas such as perception could be very useful, not only in terms of providing relevant information for composers, but also in terms of furthering our knowledge of how electroacoustic music is experienced.* [19, p.90]

However, the aim of intersubjective studies would definitely not be to force a certain set of vocabulary onto the imagination of composers, scientists and the audience but to develop an approach for analysis and composition that involves current verbalizations and perceptual capacities to enable a more specific artistic articulation. *Electroacoustic music does not benefit of a unified representation code relying sonorous text with the compositional work of the composer. For this reason, the representation of the listening experience becomes the only mean to understand and study this music*. [20, p.2] The claim for such studies is not singularly pertinent to sound-based music but it is more and more heard in all kinds of performative therefore ephemeral arts. We may find an equivalent in the attempt to describe the 'ungraspable' [21, p.16] (das Unbegreifbare) within the theatre arts of the present. One solution that seems to be feasible is to understand the perceptive capabilities of the audience [21, p.121].

2. INTERDISCIPLINARY RESEARCH AND THE ICO AS AN EXAMPLE

The icosahedral loudspeaker (ICO) is a compact playback device that uses acoustic algorithms to project sound beams into freely adjustable directions, also wall reflections leading to the listener. 'Orchestrating Space by Icosahedral Loudspeaker'(OSIL) aims at increasing the practical and theoretical understanding of electroacoustic sound phenomena in computer music that are defined by their sculptural-choreographic nature, i.e., exhibiting localization, motion, and extent. In particular, the research process focuses on the ICO constructed at IEM in order to project auditory objects into space, a feature that has already been successfully employed in various compositions that have been performed in concerts in different spaces and environments. In the existing compositions, presented at festivals like Darmstädter Ferienkurse für Neue Musik 2014, International Computer Music Conference ICMC and venues such as ZKM

Karlsruhe or Forum Alpbach listeners perceived auditory objects that move away from the ICO and which can have various shapes. However, currently we can neither precisely describe the required ingredients or outcomes yet, nor their psychoacoustic background. In 1991 Marco Stroppa wrote: *Even supposing that all of the scientific and technological difficulties are resolved, it remains unclear as to how we can organize space in its diverse meanings as a musical material* [22]. As of today we still seem to be in the same situation.

2.1. Early Performances and Inquiries

In the exploratory works grrawe 2010 (10'26") and firniss 2012 (11'23"), the authors explored how to employ the ICO technically and aesthetically for electroacoustic music. As part of this collaboration, the ICO has been tested since 2009 following the requirements of an artistic work in progress. The results of these 'inquiries' were in turn integrated into both the development of the composition and the development of the instrument ICO.

The main questions emerging from early performances and shared experiences were: Can the choreography of electroacoustic auditory objects be reproduced in a composition and in different spaces (e.g. physical, imaginary, social, language)? Or does the choreography mostly develop in the (acoustic) imagination of the composer — hence are they to be seen more as metaphorical and programmatic settings that serve the composer primarily as aids in dealing with the technical equipment? How can one stage the auditory-object choreography and make it tangible for an audience? What spatial conditions are required to do so? How can one describe and verbalize these objects for intra- and interdisciplinary exchange of ideas? In the case of many musical effects that emerge and which are being reinforced by the ICO, the question remains: why and how?

2.2. Exploratory evaluation with 7 listeners

In an exploratory auditory evaluation, 7 subjects were presented 8 stimuli, excerpts of the compositions grrawe and firniss, with the ICO in the IEM-CUBE [23]. The length of the stimuli was between 10 and 60 seconds. Each subject was alone in the room when filling a questionnaire with the following three questions for every stimulus:

A. How many distinguishable auditory objects are heard?
B. What characterizes the sounds of these objects?
C. Which object is heard where (including movement)?

Statements and descriptions were transcribed from the paper questionnaires and compared for parallels and significant discrepancies. The terms used by the listeners for characterizing the auditory objects varied, of course, but were surprisingly congruent for some stimuli. For this case study we used the terms that had been similarly used by the listeners. The verbalization results for an exemplary stimulus are summarized in Tab. 1. Given the congruence of where listeners perceived sound objects, the question remains whether location and extent can be understood in terms of simple geometric considerations, or are they estimated by psychoacoustic binaural localization models.

Despite we presently lack evaluation and modeling methods covering dynamical auditory object extent and location description in 3D, it is possible to merge the results, exemplarily. We can gather a conclusion from geometrical and echo threshold-based evaluation, a binaural localization model, as well as the exploratory verbal evaluation by listeners.

Most distinctively, the sound object *squeaks* shows a consistent trend:

- Tab. 1: "*from the right behind me, above my head*",
- 15dB stronger right-wall reflection than front-wall reflection, while sound from other directions is negligible; clearly lies 12dB above the -0.25dB/ms echo threshold,
- *squeaks* exhibit a lateralization contour that moves from the center to the right.

Notwithstanding, also the other sound objects are largely consistent with the verbally given localization of Tab. 1 and the results of the binaural model. The lateralization of *clicks* and *bass* matches the verbal description well. However, more accurate models are desirable.

Object	How listeners characterized the object's sound	Where listeners perceived sound object
clicks	clicks, waterdrops, pulse	at the ico slightly left, some from behind the ico
rays	sound sphere, drone like, bell like, static sound	proceed out of the ico, invade space from the side
bass	bass, deep, deep drone	beginning in front, towards the end from behind
squeaks	high pitchy squeak, high tv-like whistling, high frequency sound: pitch stable, high feedback like sound	from the right behind me, above my head
melody	phrase, iu, low mid sound: moving pitch going up and down, more smooth than the one before	middle of the wall, from behind the ico, jumps

Table 1: Synopsis of how listeners described sound objects in exemplary stimulus.

3. ONE CENTURY OF VERBALIZATION - AN EXEMPLARY OVERVIEW

To understand how verbalization can be used effectively and where it can be applied within the heterogenous field of sound-based music we shall undertake a brief overview of efforts taken within the history of its evolution. Hereby we are trying to extract aspects feasible for meaningful descriptions of spatial sound phenomena in the shared perceptual space.

3.1. Intonarumori

One of the first recorded attempts of structuring the new 20th century sound material in sound families we find in Luigi Russolo's futuristic manifest *L'Arte dei rumori* [13] from 1913. Russolo refers solely to 'non musical' sounds or 'noises' that he divided into six classes. Within each class he lists sounds that he finds characteristic. However there is no sign in the text of an underlying classification system. In fact the author mixes up categories. Some of the classes contain sounds with similar frequency domains e.g. whistling/hissing/snorting versus murmur/burble. Two classes have been put together mostly from loud noises like roar/bang/thunder and squeal/clatter. Two other groups are solely source bonded: On the one side we find hitting sounds and on the other animal sounds and sounds from human voices. Of course this kind of classification is not qualified to describe sounds in a generalizable manner. However it is remarkable that with the upcoming intention to build new machines for the composition of new noise music it seemed to be a concern to the inventors to install a linguistic descriptive system.

3.2. Serial thinking and musique concrète

Since the early hours of electronic music and musique concrète there have been several classification systems, whose authors where seeking to install lucid schemes. The frequently annotated standpoints of the proponents of electronic music and musique concrète can also be traced within the first attempts of structuring the material in use:

Herbert Eimert based his classification [14, p.44] on Helmholtz by exclusively dividing stationary features in tone, harmonic complex, tone mixture (Tongemisch), noise and consonance (Zusammenklang). He is not referring to the listening experience affected by this material. His main focus is serial composition: *The electronic sound composition requires a thinking in series, sequences, orders and proportions, moreover it is simply a part of this statistical-serial thinking.* [14, p.245]

Pierre Schaeffer was the first to draft a linguistic system that enabled to capture the new musical structures and communicate them. In 1952, in his book *A la recherche dune Musique Concrète* [15] he developed a concise system for describing sound objects. The numerous and novel aural experiences of sound made by composers and technicians working in the studio called for documentation and music theoretical as well as philosophical reflection, so as to counterbalance the proliferating number of engineering concepts that seemed to monopolize the discourse of electro-acoustic music. Pierre Schaeffers *Traité des Objets Musicaux* [24] (TOM) appeared in 1966 consequently summarizing his experiences and research results forming the first and comprehensive attempt of systematization and verbalization in sound-based music. Schaeffer had realized that studio practice would inevitably produce new techniques and sound materials and these would demand new theoretical systems. Moreover he believed that by a careful balance between these new practices and their theoretical ramifications, musicians would develop a more profound understanding of music - all music - as a social and artistic practice. Previously unquestioned classification systems based on the physical construction of instrumental sources and the manner of energy input were no longer viable. *Primauté de l'oreille* in opposition to abstract forms of musical construction became a fundamental schaefferian precept. Consequently his *Programme de la Recherche Musicale* (PROGREMU) resulted from his experience of composing in the new, electroacoustic environment. PROGREMU comprises a system of five interdependent stages: typology, morphology, characterology, analysis and synthesis. By means of typology and morphology sound objects are isolated from their context, classified and described. Thereafter, according to characterology, sounds can be grouped in genres and, by analysis, their potential for musical structures can be assessed. With this information the composer shall be able to synthesize new sound objects. Each stage has a specific function but is subservient to the ultimate aim - musical composition. *Le Solfège de l'Objet Sonore*, a sound recording with listening examples that accompanied TOM, was issued by ORTF as a long-playing record in 1967. *This solfège 'is not yet music', it is the indispensable preliminary to it. It is embodied in the five operations of the program of musical research - Programme de la Recherche Musicale. Solfège is therefore related to the listening experience as well as classification and analysis, and has primarily been created for the composer* [19, p.97]. Unfortunately one of the major achievements of Schaeffer's work, his codification of all sound categories into a grand, unified diagram the Tableau récapitulatif du solfège des objets musicaux (TARSOM), as well as the PROGREMU remained without much practical consequence. But there is hardly any theory on sound classification based on the listening experience or the primacy of the ear, outside the realm of sound engineering, psychoacoustics, and car industries, until today that has not been influenced by or built on schaefferian writings.

3.3. Lists of Adjectives and listening-based refinement

Being fully aware of the works by Eimert, Schaeffer and also Fennely[2] [25], Wolfgang Thies in 1982 developed in his book *Principles of a Typology of the Sounds* [26] (*Grundlagen einer Typologie der Klänge*) a list of adjectives, trying to systematize the sound describing vocabulary of everyday German language. *With the advancing increase of sound repertoire, orienting oneself within the diversity of available sounds becomes more and more difficult. Ever since the emergence of electronic music, the problem of systematization and description of sound properties has to be seen in a new light. A comprehensive and efficient descriptive system is prerequisite for orientation in the realm of sound [...] to facilitate the understanding of the world of sounds* [26, p.14]. Thies' descriptive system

[2] We are aware that there have been other concepts but their exposition would exceed the scope of this paper by far.

exclusively rests upon the properties of sound (musical, non musical) that can be perceived. At first he created a vast collection of sound describing words starting with the studies by Anneliese Liebe [27] from 1958 in which she listed 1600 German words for describing sounds. By a systematic sieving process (e.g. no valuing adjectives, no interpretive adjectives, no adjectives that hint towards a sound generator, no locally bounded adjectives) he reduced the collection to 433 adjectives. Dividing the new reservoir he created categories like onomatopoeia, corporal features, activity, material, miscellaneous dividing the last again into dynamic/intensity, clarity and continuity. At last he distinguished between the spatial position and surrounding space [26, p.34]. The categories are then again divided in further subgroups applying mostly theories from linguistic sciences. In a next step he developed 32 sounds [26, p.77] that where played to listeners collecting their free descriptions. These descriptions where compared with the repertoire of adjectives, which then was complemented with new words that where derived from the questionnaires. The procedure was repeated testing the suitability of the terms, deleting and amending the list. As far as we could research, the typology by Thies was never used in practice by composers and only a few authors are referring to his book [11, p.106], but we find it notable that he undergoes the difficult and relatively unpopular procedure of listener-based research entering the field from three sides namely linguistics, the listeners experience and statistics. Thies knew that this scheme could not solve many problems of verbalization, but he undertook notable efforts to clarify the field: *Principally one should not expect from a sound-typology that it enables a rational understanding of the sound realm, - it shall simply be a tool for orientation* [26, p.40].

3.4. Spectromorphology

In his groundbreaking article *Spectromorphology: Explaining Sound-Shapes*[3], Denis Smalley attempts in 1997 to create a vocabulary and an aesthetic reference to explain and understand electroacoustic music by using spectromorphologies[4] [28] as a descriptive tool. Smalley begins his framework by noting that the *lack of a shared terminology is a serious problem confronting electroacoustic music because a description of sound materials and their relationships is a prerequisite for evaluative discussion* [29, 63]. These concepts are related to the theoretical categories: organizing sound from micro- to macro level, modes of discourse, analysis and representation, new means of presentation (as far as spatialization is concerned), the listening experience, and classification. Smalley's framework is not tied to traditional tonality, but instead includes tonality as one part of a much larger system. Spectromorphology is an approach to sound materials and musical structure concentrating on the spectrum of available pitches and their shaping in time. In an earlier paper he states that *spectromorphological composition, like other musical languages, is concerned with expectations gratified and foiled, and such expectations are founded on shared perceptual experience* [29, p.75]. Hence he strongly insists on the aural experience as a starting and aiming point of all structuring and interpretational processes. *[...] today we continually need to reassert the primacy of aural experience in music. The heritage of twentieth-century formalism and the continuing propensity of composers to seek support in non-musical models have produced the undesirable side-effect of stressing concept at the expense of percept* [29, p.63]. Smalley propounds that *the practice of listening, and the perceptive observation of the listening process must therefore form the foundation of any musical investigation*. [29, ibid.] In laying out the spectromorphological framework, Smalley defines three main areas: Spectral typology, Morphology, and Motion. Lastly he deals with structuring processes. The whole system has been extensively described, interpreted [30, 19], applied [31, 32] and criticized [33] in many places. The efforts yield one of the most extensive vocabularies for (not only) acousmatic sound phenomena today, which requires to be condensed for practical application in intersubjective testing and verbal, aesthetic discussion [34]. Some parts of the vocabulary were proven to be useful in spectromorphology profiling to interpret electronic music. Newly developed applications like EAnalysis[5] by Pierre Couprie , and the OREMA (Online Repository for Electroacoustic Music Analysis [6]) a forum for sharing and discussing analyses - encourage and make several interpretations and therefore applications of spectromorphology available. Multiple examples of electroacoustic music are given that the authors relate to the spectromorphological terminology.
One could still criticize the lack of (a) experimental intersubjective evidence, and (b) a database of sound examples for the spectromorphology vocabulary, with the article focused on sound transformations [35] as the only exception. This article is accompanied by a sound example for every term discussed.

3.5. Space-form

Space-form [2] builds upon the terminology of spectromorphology and is Smalley's comprehensive attempt to describe and define spatiality within acousmatic music. It is an aesthetically created 'environment' that structures transmodal perceptual contingencies through source-bondings and spectromorphological relations. Furthermore, it integrates attributes particular to musical culture and tradition (e.g. pitch and rhythm). Acousmatic space-form inhabits domains between space as lived and enacted, and the spaces afforded through spectromorphological contemplation by the perceived and imagined configurations of spectral and perspectival space. The author introduces a phenomenology of the potential spatial forms afforded by acousmatic music. His space-form mode of analysis, while acknowledging the co-evolution in music of space and time, offers emphatically *an approach to musical form, and its analysis, which privileges space as the primary articulator* [2, 40]. In this regard the starting point of his considerations is very interesting: On the basis of an auto-ethnographic description of an evening soundscape in a village in southern France, Smalley derives a remarkable

[3]The whole concept was developed within three key texts: Spectro-morphology and Structuring Processes (1986), Listening Imagination: Listening in the Electroacoustic Era (1992), and Spectromorphology: Explaining Sound Shapes (1997).

[4]See Smalley (1997) for a comprehensive explanation of spectromorphology. In his words, the two parts of the term refer to the interaction between sound spectra (spectro-) and the ways they change and are shaped through time (- morphology) (ibid.:107). When considering the lower-level constituents of spatial texture we are often dealing with sounds which are primitive, or obscured and confused by other activity. Nevertheless, they are both spectral and temporal thus spectromorphological and exist in the context of a larger textural spectromorphology

[5]`http://logiciels.pierrecouprie.fr/?page_id=402`

[6]`http://orema.dmu.ac.uk`

taxonomy of analytical terms for the perception of spatial sound: e.g. zoned, proximate, behavioral, perspectival, distal, utterance, agential, vectorial, panoramic, ouverture/enclosure, approach/recession, diagonal forces etc. In referring to his *Spectromorphology: Explaining Sound-Shapes* article, Smalley observes that *[...]we needed to know about spectromorphology before we were in a position to understand space* [2, 54].

3.6. Perceptually Informed Organization by Repertory Grid

Thomas Grill's PhD thesis from 2012 is titled *Perceptually Informed Organization of Textural Sounds* [36]. A central topic of the thesis is the inquiry into perceptually meaningful descriptions of textural sounds. The repertory grid interview technique has been used to elicit bipolar personal constructs representing relevant characteristics. Therefore a subsequent large-scale online survey has been conducted to refine and evaluate those descriptions. Utilizing this model, he explores structure discovery in digital audio, covering segmentation into slices of coherent content and semi-automatic identification of representative sound materials. These techniques are useful e.g. for quickly surveying audio data, or for preprocessing musical material. The method is evaluated against examples of music annotation for two well-known works of electroacoustic music. His central research questions were: How can digital sound material be described by the criteria of human perception? How can fundamental steps of music creation in the context of sound-based music practice be supported by perceptually informed tools? Here we encounter an approach that tries to combine musical practice, empirical studies and computer-aided statistics in a challenging way.

3.7. Interdisciplinary Topology

Erik Nyström's PhD thesis[7] from 2013 is titled *Topology of spatial texture in the acoustic medium* [18] exploring the dynamic fabric of experienced space in acousmatic music. His topology of spatial texture is *a network of concepts treating music as a flexible, textural space, which deforms, shapes, and transforms in time* [18, p.13]. Building on Denis Smalley's spectromporphology and space-form an advanced comprehensive terminology is introduced. The theory draws from research on the cross-modality of texture perception, philosophical discourse on embodied meaning, physics, psychology of visual art, and discourse on space in acousmatic music. Several different structural perspectives are discussed, which reveal how spatial texture incorporates lower sound-structural levels, materiality, states and processes, motion, global networks and terrains, and relationships between space and time. The concepts and terminology are intended as a *contribution to theory in the acousmatic medium, relevant to composition, analysis, and listening* [18]. In the approach taken in his thesis, structures as we know them in our minds are viewed as having a form of graphic spatiality because of their spatial articulation. Nyström states that what we often face are the kind of sonic conditions that are more conducive to the attribution of visual properties to sounds themselves rather than their supposed sources. *Thus, this visualization is highly reliant on intrinsic spectromorphological features, and the manner in which spectral and perspectival space are articulated generally, but also the physicality of textures* [18, p.29]. The artistic works presented in this thesis were all realized with an attitude engaged in visual exploration of spatial texture. The visual listening attitude is embedded in many of the concepts introduced. Nyström develops his terminology from experiences with compositions for 8-channel loudspeaker circles. He only sometimes refers to different multichannel systems such as the BEAST. Although he does not limit his topology to 8-channel loudspeaker compositions the author is fully aware of the fact that some of the terms can only be applied within a given setup: *For composition, I expect that at least six channels would be necessary for full manifestations of the structures presented here. In concert diffusion, of both stereo and multichannel pieces, extended loudspeaker arrays can be used to enhance and emphasize composed spatial relationships and processes.* Thus the instrument specific aspect in spatial composition is part of his overall considerations. At present Nyströms thesis is probably the most comprehensive proposition for a verbalization system of spatial textures in the field of acousmatic composition.

3.8. Summary

We can resume that there had been many different efforts made to verbalize and therefore systematize sound phenomena from the very beginning of sound-based music composition and engineering. From the futuristic believes manifested in Russolo's Intonarumori, towards the controversial positions of Schaeffer and Eimert, to the statistical efforts by Thies and the comprehensive writings from spectro- to spatiomorphology concluding in space-form by Denis Smalley interpreted by Nyström, the different approaches reflect controversial ideas of composition and sound production at their respective time, and which offer valuable input to the current discussion. The coexistence of styles and techniques may require different approaches of systematization and description. The efforts to generate terms or a terminology had often been made from a scholar's or composer's perspective. Nevertheless, already a few authors, e.g. Grill and Thies, considered an audience's perspective on verbalization, and others few, e.g. Schaeffer, Grill, Nyström, give comprehensive sound examples for the terms in the vocabulary. We believe that both, intersubjective studies and sound examples are promising concepts for future investigation, and in particular, involving space and spatial attributes is highly topical, as, e.g., in Smalley and Nyström.

4. AN APPROACH TO LISTENING-BASED VERBAL DESCRIPTION FOR SPATIAL SOUND PHENOMENA

Having reviewed the concepts of former verbalization efforts and the questions remaining from our initial OSIL experiments, we propose what we consider as necessary steps to advance the current understanding of spatial sound phenomena in electronic music, using the icosahedral loudspeaker in particular.

[7] supervised by Denis Smalley

4.1. Bottom-up Composition: Miniatures, Etudes, Pieces

The methodology of OSIL revolves around the notion of the artistic case study, in a kind of bottom-up concept. OSIL will produce a number of such case studies (a set of musical miniatures, a set of etudes), each of them focusing on a few, clearly defined, separable, and researchable questions. Even if the bottom-up concept is not completely suitable to work on all the final and finest nuances of the compositions, this formalization gives us a strong tool to create from models a software environment with a well-distinguished set of tools, each of which suitable of producing particular and pronounced ideas. This concept enables an iterative circular process encompassing the stages composition, listening experiments, psychoacoustic modeling, and conceptualization. The idea of informing the creative compositional process with the research outcomes (feedback) and making the results available for other composers, musicians, musicologists, and engineers (peers) for further investigation and understanding is one thing but we also want to know what the listeners perceive when listening to the sculptural sound phenomena. *Because if the artists work exists too far away from a recognizable and sensible expression or even gesture* [28] the gap between recognition and unfamiliarity is too wide to bridge by educated listening.

4.2. Listening experiments and verbalization

As a first step each miniature is described verbally by the composer in an accompanying process and recorded in writing. For this purpose, we need to study, compare and superimpose many kinds of descriptions and taxonomies for (electro-)acoustic music phenomena like texture [26, 36], spectromorphology [28], especially spatiomorphology [28] and space-form [2], musical space [37], topology [18] and common acoustic effects [38] to name a few sources. Furthermore terms from electroacoustics (e.g. low-pass filtered, amplitude modulated) shall be combined with the traditional musicological descriptions (e.g. crescendo, chordal, glissando) and metaphorical terms (e.g. behavior, growth, motion). Here it is essential that an appropriate choice is made. Consultation in the form of questionnaires and interviews are planned to determine the tacit concepts of the composer. In this way, an annotated basic vocabulary will evolve to describe at first simple space-sound compositional models with the ICO. This first description of the phenomena aims for a standardization of the description models at a verbal level, so facilitating an exchange. The underlying assumption is that music can only develop further in a differentiated way if one can speak about it, too. In order to make this possible, a vocabulary must be available, or be created, that can describe certain phenomena and necessarily have a generalizing function. *It is astonishing how, for example, so much analysis has been undertaken without a generally accepted foundational vocabulary* [19]. Approaches were done to refine terminology to fit the needs of virtual acoustics [4], a formal process that took about two years. In [9], it was moreover found that despite typical spatial audio terms can be significant descriptors in terms of classical and popular music, they might, however, be irrelevant when it comes to contemporary music. Our exhaustive approach is therefore closely linked to the particular perceptual space that is to be explored:

1 Auditory objects in miniatures can be initially tested by the following response tasks completed by members of the listening panel:

   a direct scaling in terms of known verbal attributes from literature (e.g. direction, width), or in default specific terms devised by experts in project team (experimental design is, e.g., MUSHRA-like [39], a pointing method [40], etc.),

   b dedicated verbalization to retrieve attributes by repertory grid technique or similar [41], possibly supported by multidimensional scaling [39]. Is the resulting vocabulary the same as or similar to the given one from literature or the experts in the project team? Which terms were missing?

2 Repeat point (1) with the extended attribute vocabulary until no additional expressions are found in (1.b). This is hopefully the case after one repetition, which enables (3).

3 opt. depending on (2): The procedure (1) is to be done with the new, more elaborated miniatures or those of the guest composer, in order to find whether the vocabulary spans the required perceptual space or which extensions are missing.

4 Procedure (1) is to be applied to more complex material: etudes

5 Procedure (1) is to be applied to more complex material: pieces

Psychoacoustic modeling should be done gradually in parallel to experimentation, so that, ideally, the model is able to predict everything that is perceived by the listening panel at each stage of the project. The intention of this method is to achieve precision of descriptions (a coherent vocabulary) and an increased conceptual clarity in the investigation of the intellectual and practical process and its results. The terms found to be suitable will be utilized in new compositions and new terms will be added. The proposed process should be as accurate as to demonstrate points in which the intended and the audible result may become detached from linguistic intelligibility.

5. CONCLUSION

Ideas of plastic sound objects often only manifest in the perception of the composer as composition elements after hours of reduced listening. These composition elements sometimes have little in common with the audience's listening experience or the psychoacoustically known sound objects. Even an experienced composer frequently reaches a point in which the creative potential and craft skills can only unfold after developing an own notion of the spatial sound phenomena in the composition and their intersubjective perceptibility. By retrieving a shared perceptual space, we want to open an intersubjective field with composers, audience and scientists as 'share holders'. To understand this field better we need to imply listening- and listener-based research. Reviewing different concepts of verbalization and systematization helps us to gather similar endeavors and their results, referring to electroacoustic sound phenomena per se and their spatial attributes, in particular. By this we inform our interdisciplinary art-based research approach that suggests a combination of artistic case studies with listening experiments and psychoacoustic modeling.

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PDF | On Nov 1, 2015, Gerriet K. Sharma and others published Towards Understanding and Verbalizing Spatial Sound Phenomena in Electronic Music | Find, read and cite all the research you need on ResearchGate.Â Proc. of inSONIC2015, Aesthetics of Spatial Audio in Sound, Music and Sound Art Nov 27â€“28, 2015, Karlsruhe, Germany. Towards understanding and verbalizing spatial sound phenomena in. Electronic music. Gerriet K. Sharma Matthias Frank Franz Zotter. Institute of Electronic Music and Acoustics. University of Music and Performing Arts. Inffeldgasse 10/3, 8010 Graz, Austria. sharma@iem.at frank@iem.at zotter@iem.at. ABSTRACT. How do we describe spatial sound phenomena in electronic music? Towards Understanding and Verbalizing Spatial Sound Phenomena in Electronic Music. Conference Paper. Full-text available.Â The Spatial Audio Quality Inventory [5] was used to construct a questionnaire and rating scales for perceived deviations from reality in a qualitatively differentiated way. The SAQI is a consensus vocabulary comprising 48 verbal descriptors for auditive qualities considered to be relevant for the assessment of virtual acoustic environments. Musicological research paper with spatial approach on electronic music.Â 1.1 The research focus. In this essay I am researching spatiality in electronic and live electronic music. I am analyzing spatiality in three compositions: Karlheinz Stockhausenâ€™s Gesang der JÃ¼nglinge (1955-56), Kaija Saariahoâ€™s electroacoustic composition Journey (1991) and PÃ©tals (1988/19) for solo cello with live electronics.Â Music is acousmatic, when the sound and the sound source are not in the same space. The amplifiers are not considered as sound sources, they are just reproducing the composed music. (Smalley 1997, 105; Wishart 1996; 67).