Musical Motion Graphics – Communicating Live Electronic Music[1]

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Abstract:

Live electronic music, including acoustic instruments and electronic sound generation and manipulation, faces specific challenges regarding its composition and performance. There is no music notation available which could equally represent the acoustic and the computer instrument. Due to the often complex musical structure and the possible lack of expressiveness during the performance, live electronic music is not easily accessible for the audience. These challenges are based on a lack of communication.

This article discusses the use of Musical Motion Graphics (MMG) linked to visual communication theory to tackle the above-mentioned challenges. MMG cannot be considered as music notation in the sense of western music notation since the eighteenth century since its aim is not a normative canon or universal validity. Nevertheless, it has a music notational purpose, which manifests in video scores. It offers an open framework of so-called determined ambiguity, allowing the mapping of visual and acoustic parameters. MMG communicates time structure and indicates musical objects and their relations. The exact synchronisation of actions and events of all the instruments involved is possible. An MMG score supports audience understanding of the music by visualising the composition through an intuitively understandable score.

Introduction

The starting point leading to the artistic research project that I would like to introduce in this paper lies almost 15 years back. As a composer and a computer musician, I found myself unable to notate my musical ideas for a live electronic music piece adequately. Live electronic music in this case featured the interaction of acoustic instruments and electronic sound generation and manipulation. Staff notation would meet the requirements of the acoustic instrument only when extended by additional symbols. The electronic instrument, with its almost infinite possibilities of sound generation, could not be depicted in all its fullness. Furthermore, live electronic music faces challenges not only regarding its composition but also regarding its performance practice, especially with regard to its perception. Live electronic music, like other types of contemporary music, often features complex musical structures lacking familiar rhythm and harmony, and is not easily accessible. Compared to the intrinsic and familiar connections between player, sound and sound source with regard to acoustic instrument performance, in electronic music the live generation and manipulation of sound remains hidden in electronic and digital devices. Plucking a string on a guitar results in a predictable sound; but what does turning a knob or waving a midi glove mean musically? The whole musical idea, the concept of a work, might be hidden behind technical devices. And in the end the enjoyment can evaporate quickly. My artistic and compositional practice revealed that such difficulties arose from a mere communication deficit between myself as a composer, the performer and the audience. Due to my background as a media designer, I found the basis for a solution to the problem in visual communication theory.

This article introduces the outcome of this artistic and scientific journey to tackle the problems of communication in live electronic music: Musi-

1 The article is based on my doctoral thesis (in Music) *Musical Motion Graphics – a tool to improve live electronic music practice*, defended at the Estonian Academy of Music and Theatre in 2016 (supervisor Professor Kerri Kotta), https://www.ema.edu.ee/vaitekirjad/doktor/Christian_Fischer.pdf.

cal Motion Graphics (MMG). It was developed as a communication platform between composer, performers and audience. MMG has a music notational purpose and is based on visual communication theory. It manifests in video scores and offers an open framework of determined ambiguity, allowing the mapping of visual and acoustic parameters to communicate music intuitively. It cannot be considered music notation in the sense of western music notation since the eighteenth century, as it does not propose a normative sign system. MMG communicates time structure and indicates the musical objects and their relations to be interpreted by the performer. MMG scores are a tool to compose live electronic music visually, and are intended to be presented to performers and audience alike.

The purpose of this article is to describe how MMG came to life, to put it into a historical context, and to explain the theoretical background behind it, how I applied it in artistic practice, and how it solved my artistic problem. A description of the historical context and the theoretical background forms the biggest part of this paper. This is necessary as there is still a lot of misunderstanding and misconception in the world of musicology and artistic practice regarding alternative music notation approaches, their purpose, their advantages and disadvantages, as well as their application. Furthermore, it is essential to understand that the MMG described here is just one tool among others which have been developed recently. As a tool, it was shaped by my individual artistic needs. Nevertheless, the outcomes of my research, especially the proposed typology and the visual communication levels adopted in the context of music notation, will support other composers and performers as well as further research in the field of alternative music notation.

1. Historical Background

The need for an alternative music notation to display new musical ideas or an unusual playing technique is not new. Furthermore, the use of moving images in connection to music and music notation can be traced back to the beginning of the 20th century. Looking into music and art history, I will introduce some important terms and the basic concepts of alternative music notation approaches that make use of graphics. This is necessary to reveal and understand the ideas behind MMG.

First of all, Table 1 introduces frequently used terms, which will be also described in more detail later in the text.

Like many of our contemporary music practices, MMG is primarily rooted in the ideas and works of the musical avant-garde between 1950 and 1970 (Schröder 2010: 151). Back then, many important composers were exploring alternative music notation. Publications of that time show that these approaches generated a lot of controversy. John Cage in the USA (Cage 1969) – and before him Erhard Karkoschka (Karkoschka 1966) in Europe – published widely recognised books, which collected various works of the time and tried to describe these new approaches in music notation. It is important to differentiate two terms, which are unfortunately often used equivalently: graphic notation and musical graphic. As early as 1959, Roman Haubenstock-Ramati coined the term *musikalische Grafik* (in English: musical graphic) when he initiated an exhibition of unusual music notations using graphics in Donaueschingen, Germany (Schröder 2010: 153). György Ligeti describes musical graphics as graphics which have no inherent musical meaning, as they do not use a sign system. Nevertheless, they can convey musical factors and coherences, or work at least as a source of inspiration (Ligeti 1965: 36). Earle Brown's piece "December 1952" (see Fig. 1) is one of the first musical graphics. It is also one of the most cited ones (Schröder 2010: 152).

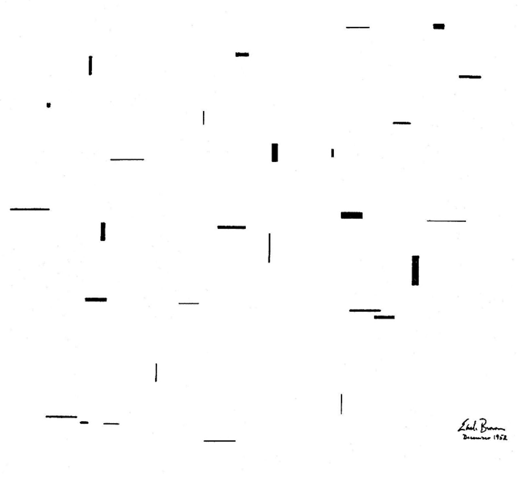
Brown was interested in jazz music and improvisation and was inspired by the abstract art works of the artists Jackson Pollock and Alexander Calder. While looking for new ways to express his musical ideas, he considered the renewal of music notation as imperative. In this context, he discovered graphics as a possibility to incorporate mobility and variability (Brown 1965: 76). "December 1952" is a musical graphic which has a musical purpose only because Earle Brown composed the work and considered it to be a musical work. It can be regarded as a sheer trigger for improvisation. The communication from composer to performer is very vague. There is no indication of how to read the graphics nor what they represent. The graphics are not clearly connected to a specific sound or playing technique. It is by no means

Table 1. Important terms to understand this text.

Term	Explanation
Staff Notation	Western musical notation using staves.
Extended Notation	Staff notation using additional signs and symbols. Often to display extended playing techniques or to include electronic means.
Graphic Notation	Normative music notation using graphics.
Animated Notation	Various kinds of scores communicating music which incorporate animation.
Musical Graphic	Interpretative graphics with a musical purpose.
Visual Music	The use of musical structures in visual images. Visuals are often generated according to a musical piece, not as a means of music notation.
Musical Motion Graphics (MMG)	Animated musical graphics using the so-called artistic visual communication model.

defined whether a black line depicts one note or a cluster of notes. How to interpret the graphic is not defined. The mobility and variability Brown referred to are a paraphrase for what Severin Behnen calls the flexibility of Motion Graphic Scores (a term used by Behnen to describe music notation using video) (Behnen 2008: 1). Composer Mauricio Kagel worked extensively with various alternative notation approaches and used a different terminology, though this aimed at the same context, namely *determinierte Mehrdeutigkeit* (in English: determined ambiguity) (Kagel 1965: 55). Despite the periods in which they originated, their different design and appearance, the longing for variability, flexibility and ambiguity is common to all graphic approaches for notational purposes.

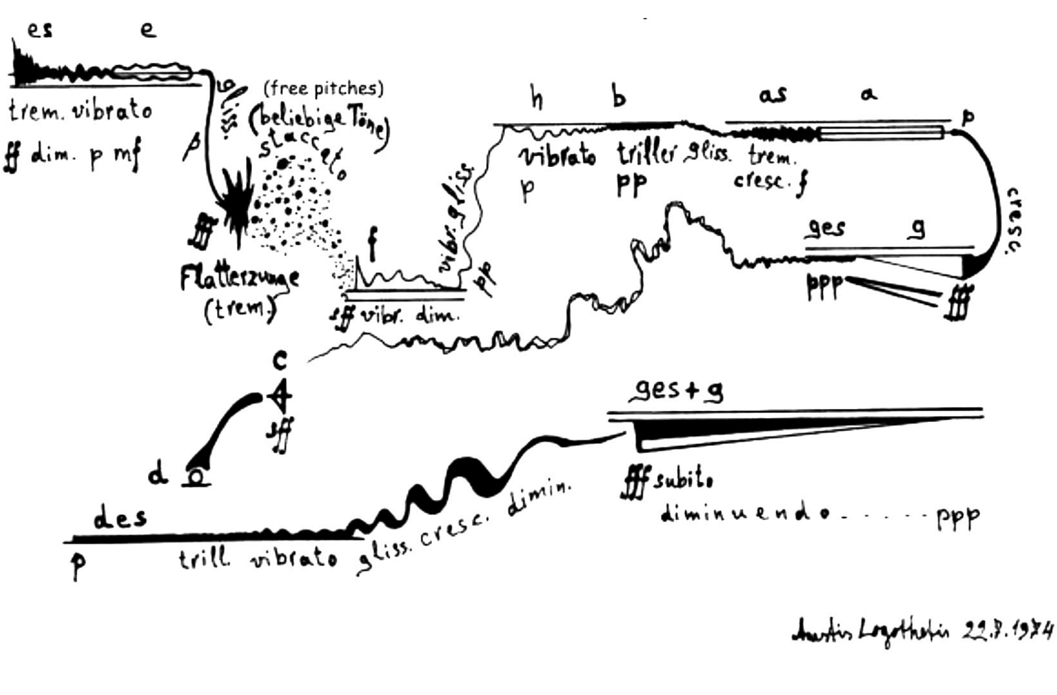
Figure 1. Musical graphic "December 1952" by Earle Brown (O'Connor 2017).



From the 1970s onwards, composers seemed increasingly to lose interest in graphic notation. According to Julia H. Schröder, visual artists developed ideas further as "… their interest in the individual handwriting manifesting itself in musical graphics is greater than that of composers, who were concerned with the establishment of a new, normative graphic canon" (Schröder 2010: 153). Although composers were experimenting with different approaches (using musical graphics, graphic notation and hybrid forms of music notation including staff notation), no new syntax, or broadly recognised sign system, was developed. This meant that no agreed set of rules, like western staff notation, where graphics have a defined meaning, was established. Every composer or artist was working with graphics in a musical context in his or her own artistic way. The ambiguity of graphic notation and a misconception of the visual communication processes underlying graphic notation approaches, which I will describe more in detail later, made many composers lose interest as time went on. The composer Anestis Logothetis is an exception because he succeeded in establishing a normative graphic canon, at least for his own work, and used his system of pitch symbols, association factors and action signals from 1958 continuously until his death in 1994. His works are a supreme example of graphic notation, in which graphics have a defined meaning (see Fig. 2). The communication process between composer and performer is clearly set. For instance, the reading direction is defined. A performer is required to learn and understand the graphics and their meaning in order to be able to perform a piece accurately. Logothetis understood his graphical music notation of symbols and signs as an "aggregate state" of music (Logothetis 1999). To understand graphic notation as an "aggregate state" of music, like the aggregate states of water for example, is a striking image which also refers to communication. Music exists in several transition states. For example, in the mind of the composer while working, or as a visual manifestation (a musical score), or in the mind of the performer, or, of course, as physical sound waves (changing air pressure and frequencies), or ultimately in the bodily experience of perceiving a music performance. This sequence could also be regarded as an artistic communication process. Compared to classic music notation, the first part of the process – the transition from one aggregate state to the other, between composer and performer – is not strictly defined in musical graphics and only sometimes in graphic notations. It is the same in MMG. Music can be depicted in various ways and can thereby also manifest itself in various states of solidity and accurateness.

Even after many avant-garde composers ceased to work with graphic notation, the desire to apply alternative notation never entirely disappeared. There was some interest, also among visual artists, which is very well documented in Theresa Sauer's 2009 collection of graphic notations called *Notations 21* (Sauer 2009). This book can be regarded as a direct successor to the abovementioned *Notations* by John Cage (1969). Both are collections of the very different approaches to graphic music notation of their time. Furthermore, the Audiovisuology project and book (Föllmer 2010) shares comprehensive insights

Figure 2. A typical graphic notation score by Anestis Logothetis (Logothetis 1974).



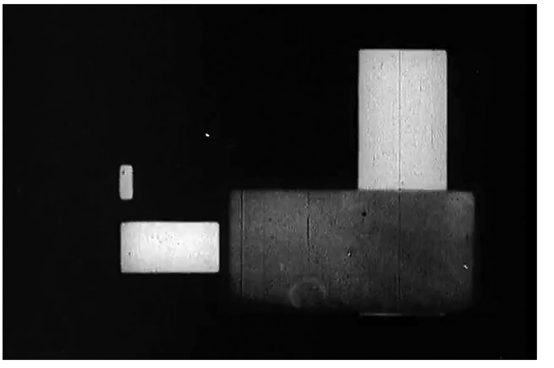
into the history and practice of alternative music notation and the coherences of sound, music and image since the 1950s.

Recently, alternative music notation has undergone a renaissance. Various papers and professional literature have appeared. The December 2014 issue of *Organised Sound* (Wyse; Whalley 2014), books such as Christian Dimpker's *Extended Notation* (Dimpker 2013), the 19.3 issue of *eContact! Online Journal for Electroacoustic Practices* dealing exclusively with the Notation of Sonic Art and Digital Media, and of course contemporary music practice reveals a growing interest in the field. TENOR, the International Conference on Technologies for Music Notation and Representation,[2] has been held annually since 2015. Its name already indicates that this time the focus has been widened to include digital technology. The outcomes of this conference show clearly that new technologies continuously find their way into music performance, especially in relation to music notation together with all its manifestations, such as gesture notation, screen scores, various forms of extended notation, or live generated scores.

With the advent of digital technology, mingling audio and video, music and image, graphics and notation has become easy. MMG is rooted in video art, animation and graphic design. Animation, motion graphics and video art in connection with the rise of the computer facilitated the development of all kinds of animated music notation. When looking back in history, there are many influential artists, researchers, inventions and works to be found that have had an impact on the way we design and perceive motion graphics and animations today. Just a few select examples will help to give an impression of this development. Without those works and the methods and techniques they were using, contemporary visual and video art, as well as music notation using video like MMG, would not have been possible.

At the beginning of the twentieth century, Dadaists and Futurists experimented with film and abstract graphics. Hans Richter was one of most significant figures of that time. His film *Rhythmus 21* (see Fig. 3) from 1921/23 uses black and white squares and deals deliberately with rhythm and musical counterpoint (Betancourt 2013: 61). However, *Rhytmus 21* is by no means any kind of musical graphic or even a graphic music notation. It is a silent movie, where the appearance, motion and modifications of graphic objects were arranged according to musical parameters, especially rhythm.

Figure 3. Screenshot from the film *Rhythmus 21* by Hans Richter (Richter 1921)



Oskar Fischinger, an organ maker, engineer, filmmaker and painter, invented new techniques for abstract films. He can also be considered to be one of the fathers of visual music, as he used musical structures in visual imagery (Sito 2013: 13). Although music and image are strongly connected in visual music, and musical composition techniques are used in its creation, it is important to understand that graphics in visual music are often created according to an already existing musical work. Graphic notation, musical graphics and MMG respectively work inversely: the graphics are composed first, and after that the music is performed according to the parameters given in the score. Therefore, visual music is by no means a kind of music notation and works in visual music are not musical scores. In 1941, John and James Whitney built an optical printer and a machine to create "synthetic sound" for their 8mm films. A novelty was their idea to use the optical track on films to directly record sounds. For example, 12 pendulums with light bulbs, corresponding to the 12-tone scale, swing over a film to expose its optical (sound) track (Betancourt 2013: 107). John Whitney also used analogue and later digital computers to create his films, and can be considered one of the fathers of computer animation. Schröder points out that visual artists since the

2 http://tenor-conference.org/ (accessed March 4, 2016).

1970s have creatively developed alternative notation (Schröder 2010: 153). Composers, however, tended to continue working specifically with variations of graphic notations. Again, Theresa Sauer's compendium *Notations 21* reveals a detailed overview of what happened in the field of graphic notation from the late 1960s onwards and presents the enormous variety of approaches (Sauer 2009). In the context of this article, and in relation to how MMG works, which will be described later in detail, it is also important to examine the merger of animation, motion graphics and music video. Since the 1970s, very different connections of sound or music and visuals have come into being, widening the scope of how visuals and music can be connected. Interactive art such as David Rokeby's "Very Nervous System" explores human motion and sound creation (Kwastek 2010: 171), while Jens Brand's award winning "Global Player" uses "computer calculated changes in the distance of satellite orbits and the earth's surface as acoustic data" (Föllmer 2010: 305). It almost plays the earth like a vinyl record. VJing (meaning the live generation and manipulation of video material) and music video have shaped our everyday culture, including film, art, advertisements and, of course, music itself (Keazor 2010). In recent decades, music and visuals have become even closer than the Whitneys could probably have imagined. Hervé Vanel claims: "In the age of digital media, music and visual art are truly united, not only by the experiencing subject, the viewer/listener, but by the artist" (Vanel 2009: 59). In this context, the possibility for artists to purchase tools – a computer, software or other electronic means for their work – has been a prerequisite for further development in the field. Vanel also refers to the fact that the strict division between the different art forms has become more and more blurred through the computer and the artist's work in the digital domain. It has lowered the boundaries for composers to practically explore the visual side of music. I would like to go even further by claiming that working artistically with bits and bytes, which offers all the possibilities of programming and inter-changing data, literally encourages blending your working material in one way or another and (re)using software tools in very different contexts.

2. Live Electronic Music

To avoid misunderstandings, I would like to start with a definition of what live electronic music is in the context of this paper. A version of the Wikipedia article on live electronic music from 2016 includes one interesting aspect:

> Live electronic music (also known as live electronics and electroacoustic improvisation) is any kind of music that can include the use of electroacoustic instruments, various electronic sound-generating devices, and computers, but which generally excludes the use of pre-recorded or sampled material.[3]

The latest Wikipedia article states:

> Live electronic music (also known as live electronics) is a form of music that can include traditional electronic sound-generating devices, modified electric musical instruments, hacked sound generating technologies, and computers. Initially the practice developed in reaction to sound-based composition for fixed media such as musique concrète, electronic music and early computer music. Musical improvisation often plays a large role in the performance of this music.[4]

According to these two versions, live electronic music is often improvised. When comparing the Wikipedia article with two of the most frequently cited books on electronic music, *The Cambridge Companion to Electronic Music*, edited by Nick Collins and Julio d'Escriván (Collins, d'Escriván 2007), and *Electronic and Computer Music* by Peter Manning (Manning 1985), one can agree that this definition is valid. However, according to the way live electronic music is described by Manning, Collins and d'Escriván, we need to include the possible use of acoustic instruments and the option to add pre-recorded or pre-composed material to the live generation of sound (Manning 1985: 187; Collins, d'Escriván 2007: 38). None of the three sources distinguishes precisely between popular and art music. Collins and d'Escriván, in particular, often use references to developments in popular music. For the sake of clarity, especially regarding my own compositional approach, I prefer live electronic music in the context of MMG to be

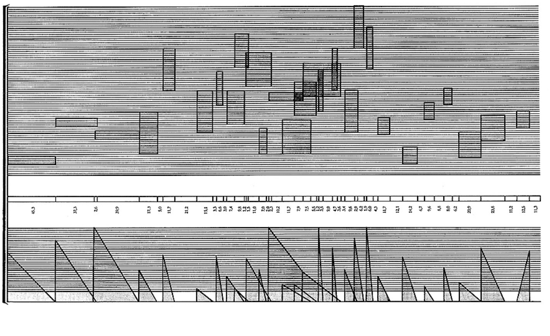
3 Wikipedia, Live Electronic Music, https://en.wikipedia.org/wiki/Live_electronic_music (accessed March 2, 2016).
4 Wikipedia, Live Electronic Music, https://en.wikipedia.org/wiki/Live_electronic_music (accessed February 26, 2018).

defined as follows: live electronic music, as a division of electronic/computer music, is an art music which includes the use of acoustic instruments and the utilisation of any kind of live generated and manipulated sound, as well as the use of pre-produced or recorded sound material.

2.1 Notation of Live Electronic Music

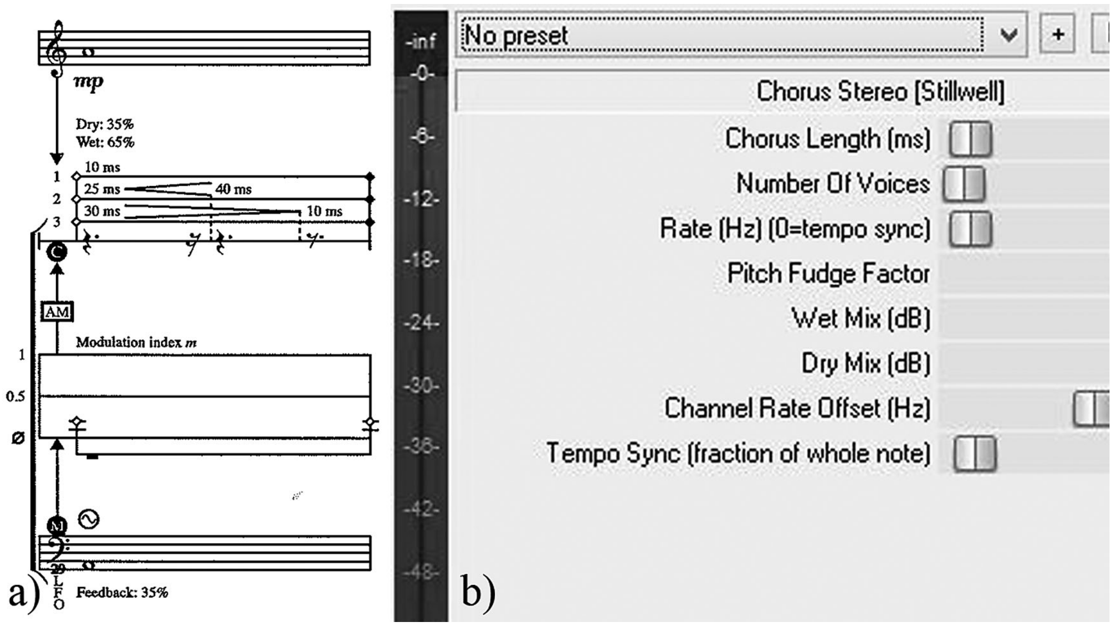
As indicated in the Wikipedia article about live electronic music, as well as from my own experience, live electronic music is sometimes improvised. However, there are pieces where the electronics are notated. Several examples can be found in the second part of Dimpker's *Extended Notation* (Dimpker 2013). As will be described in more detail later, these notations are rather indications and do not encompass the full range of sound source, sound generation and manipulation. From a composer's perspective, not being able to appropriately communicate ideas, especially regarding electronics, to the performer(s) via conventional music notation is a fundamental problem. There are of course approaches to notate electronic sounds. Stockhausen's "Studie II" from 1954 (Stockhausen 1956) is an example of a very exact notation of electronic sounds, which also indicates that the desire to retain electroacoustic music (besides recording it) is as old as electronic music itself. However, the score of "Studie II" is comprehensible and easy to read only because it deals with sine tones (see Fig. 4). It communicates the appearance and length of tones over a timeline. The sheet music gives precise instructions as to how to re-create the work. One can imagine how far more complex the score would look – or even if it would be possible to create such a score – if one were to add various sound sources, different sound synthesis techniques or an additional acoustic instrument.

Figure 4. Stockhausen, "Studie II" – page 15 (from Stockhausen 1956).



A more current example of the notation of electronic means of sound production is to be found in the book *Extended Notation*, in which Christian Dimpker "depicts the unconventional" to establish a coherent and consistent notation system for extended instrument playing techniques and (in the second part of the book) even for electroacoustic music (Dimpker 2013: 210). By analysing common practice, i.e. the use of scores, he handles all the major sound synthesis techniques, audio processing and sound recording. Although his depiction is very detailed and a huge help for composers of contemporary music, it is not adequate in a live electronic music context. In one example, a chorus-effect is added to an unspecified instrument (Dimpker 2013: 286). For such a rather simple effect, the suggestion for a notation (see Fig. 5a) seems to be rather complex and not easy to read at first sight. Even so, it does not cover all the possible chorus-effect parameters. For instance, an indication as to whether the chorus is mono or stereo is missing (see Fig. 5b). In the case of a stereo chorus, the indication of the time offset of each channel would also be necessary, as this would change the sound significantly. Another problem is that there are actually various chorus-effects available with various parameters that could be changed, either as a software plugin or as a physical effect pedal. They vary in terms of sound quality, usability and effect parameters. *Extended Notation* also neglects the possibility of creating sounds in a completely different manner from that depicted in the book. The simplest example would be the use of whole effect racks in a digital audio workstation. A more complex approach would be to program individual effects or even whole software instruments using programming environments such as Max/MSP, Pure Data, SuperCollider, Csound, or similar (Roads 1996: 569). There are coding events where the programming of the music is done live, or concerts using "circuit bending", where circuits within electronic devices are customised to create sounds (Collins, d'Escriván 2007: 51). It is difficult to visualise how such complex methods of sound generation and music making could be depicted, along with the notation of the acoustic instrument, in a clear and comprehensible music notation system with a clear set of rules. There is a need for an equally

Figure 5. Chorus effects, a) in *Extended Notation* (p. 286) and b) in Reaper software.



adequate representation of electronic sounds, comparable to the representation of acoustic instruments in staff notation. In "Studie II", the chorus effect example and – not least – the possibility to create highly individual approaches in sound generation clearly indicate that adding additional signs to staff notation is barely adequate to cover the various possibilities for generating and manipulating sound. Already in the 1960s, composers realised that staff notation was not capable of representing the almost infinite spectrum of electronic sounds (Karkoschka 1966: 83).

The lack of an adequate score to establish a communication stream between composer and performer has implications on the performance as well. The question of how the acoustic instrument and the electronic instrument can synchronise their playing needs to be tackled. A simple approach would be to indicate acoustic cues. For instance, a trill could indicate the start of a certain section of a piece. However, this possibility is rather impractical, as it only works with pieces that contain deliberately composed cues and this constrains the compositional freedom significantly. The use of stopwatches is well known in contemporary music, as for instance in John Cage's famous piece "4.33". Ladislav Kupkovič's graphic indicates in his piece "…" for bass clarinet alone that each of the presented seven systems should last exactly 45 seconds (Karkoschka 1966: 119). Hermann Nitsch's *musik für die 38. malaktion* (Essl 1998) is a more recent example. Practice shows that performers would like to avoid the use of a stopwatch while reading a score, as it restricts their playing and is simply inconvenient. A more elegant way is the use of score following techniques. This technique was perfected at the Institut de Recherche et Coordination Acoustique/Musique (IRCAM) in Paris. They state: "Score following is the real-time synchronisation of a live musician playing a score with the score itself and decoding of expressive parameters of the musician on the fly". Composers connected to IRCAM, including Pierre Boulez, utilised this technique (Cuvillier 2014). Although instrument playing can be synchronised exactly with the computer, there is one major drawback. It requires software to execute accurate score following, and this software needs to be compatible with the software and techniques for sound generation used in the piece. The software has to be able to communicate. When, for instance, an analogue modular synthesiser is used for sound generation, the synchronisation might even be impossible. Without compatibility there can be no score following. The problem of the synchronisation of instruments is a symptom deriving from the lack of a proper notational communication platform. The techniques just mentioned are no more than work-arounds which tackle the symptom but not the core problem.

2.2 Perception of Live Electronic Music

Generally, abstract art music such as live electronic music is often not easily accessible and understandable. The famous electroacoustic composer Francis Dhomont claimed that there is a "poor attendance at our concerts". In this context he discusses the audience's inability to assimilate and identify with the constantly changing electronic music repertoire (Collins, d'Escriván 2007: 194). Live electronic music often seems awkward and not easy to access, especially for the unfamiliar listener. William Forde Thompson tackles the problem from a psychological perspective and indicates throughout the entire book *Music, Thought and Feeling: Understanding the Psychology of Music* that contemporary music often lacks the potential to be easily identified with, understood and enjoyed, as the familiar musical features of rhythm and harmony are missing (Thompson 2009). The lack of these features is omnipresent in live electronic art music. Another issue – and maybe the most important one – is the performance of electronic music itself. First, the genesis of electronic music usually remains hidden in a device, regardless of whether it is a modular analogue synthesiser, a computer or any other electronic device. For the audience, how and why the music unfolds the way it does is often elusive. Additionally, the physical actions on an electronic device which are required in order for the sounds to be heard do not necessarily correspond to the sonic result. A little turn on a small knob can have a huge impact on the music, as for example when changing the overall amplitude of a sound. On the other hand, pushing several controllers may have a very subtle impact e.g., when they are connected to rather insignificant parameters of one single sound effect. For the audience it may not be clear how much of the music is "made" by the performer and how much by the computer. Furthermore, computer music often lacks the expressiveness of a classic music performance. Performance practice shows several approaches that try to address this, such as, for example, the use of interfaces. There are various controllers with knobs, slides, and switches to control sounds. Also, patch panels for live patching cables on analogue synthesisers have seen a resurgence in recent years. The gesture control for music systems has been used and researched for over 20 years now. Apart from the use of rather out-dated devices like a Wii controller or a MIDI glove, there are more sophisticated possibilities for using motion capturing tools such as cameras to analyse human gestures as well as motion detection to trigger events and change the control parameters of electronic music, as described by Frederic Bevilacqua, the head researcher of the Sound Music Movement Interaction team at IRCAM (Bevilacqua 2015). This might enhance the general expressiveness of the performance, as the audience can see that a performer is doing something. Nevertheless, for the audience, it is almost impossible to figure out the connection between a gesture made while operating a device and the sound. In summary, it can be stated that the issues in composing and performing live electronic music derive from its lack of an adequate musical notation, especially for electronics, and from the challenges in synchronising acoustic and electronic instruments and its characteristic inexpressive performance, in which the genesis of the electronic sounds remains hidden.

From the very beginning fifteen years ago, all my approaches, my composed studies and pieces aimed to establish a common ground for all participants involved in the process of composing, performing and perceiving live electronic music. The major objective was to create a neutral ground, a way to communicate music, where acoustic instruments and computer instrument are represented equally and as intuitively as possible. In the following section, I propose Musical Motion Graphics (MMG) as a compositional method and tool to tackle the challenges of live electronic music described above and to establish a basis for an equal musical communication of all parties involved.

3. Visual Communication Processes

The key to comprehending MMG and to using it in artistic practice lies in communication processes, as described in communication theory. There the main elements of communication, sender, receiver and message, have been defined in the

Shannon-Weaver model (Shannon 1948). Schematically a communication process works in the following way: a message is encoded and sent from source to receiver using a communication channel, and then the receiver decodes the message and gives a feedback. In a musical context the source would be the composer, the message is the encoded music, the channel is the visual object (i.e. the score), and the receiver decoding the message is the performing musician (see Fig. 6). Regarding the performance of the music, the communication process is not creating a loop of sending, receiving and feedback as is common in human communication, as for instance in a conversation. In music notation, the feedback is not directly addressed to the sender. It is rather creating a new communication process which manifests in the complex process of performing and perceiving acoustic phenomena (Truax 2001).

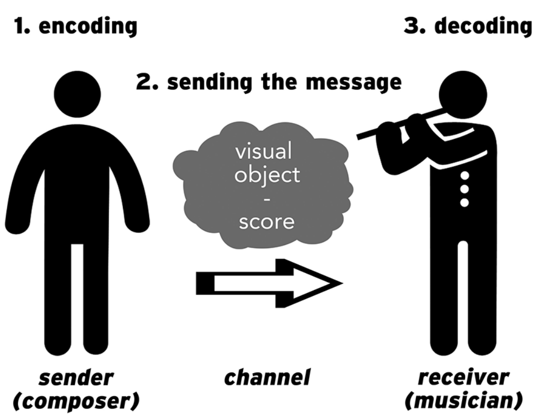
Regarding music notation using alternative graphics, the process of coding and decoding information is also called mapping (Fischer 2014). In an ideal process, the receiver decodes the same content as the source encoded before. In this case the mapping process works without loss of information. Similarly Mazzola, in his text "Semiotics of Music" (Mazzola 1997), refers to Jean Molino and Paul Valéry and their description of the tripartite communicative character of music. He describes three niveaus: "poietic", "neutral" and "esthetic".

> This (poietic) niveau describes the sender instance of the message, classically realised by the composer. According to the Greek etymology, "poietic" relates to the one who makes the work of art (Mazzola 1997).

> This (neutral niveau) is the medium of information transfer, classically realized by the score. Relating to the poietic niveau, it is the object that has been made by that instance, and which is to be communicated to a receiver. But it is not a pure signal in the sense of mathematical information theory. The neutral niveau is the sum of objective data related to a musical work. Its identification depends upon the contract of sender and receiver on the common object of consideration (Mazzola 1997).

> This (esthetic) niveau describes the receiver instance of the message (Mazzola 1997).

Figure 6. General communication process according to communication theory.



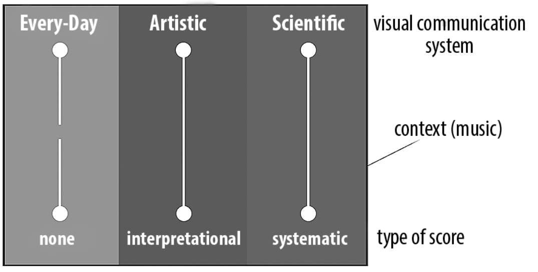
The neutral niveau describes the channel, the score itself. The "identification" and the "contract of sender and receiver" encompass the content of the message, as well as the way in which this message is understood. For instance, in western staff notation the understanding of the message ("contract") is ensured by relying on a system of meaningful signs which have been previously learned by sender and receiver. The question of what kind of "contracts" are feasible and how they come to life leads directly to visual communication theory and processes.

3.1 Visual Communication Theory

In visual communication theory there are three systems which can be the basis of a communication process. Based on the semiotic studies of Charles Sanders Peirce (Peirce 1983), German communication theorist Heinz Kroehl described this very clearly. According to Kroehl, the three major communication systems are Everyday-Life, Scientific, and Artistic (Kroehl 1987). The models are put in the context of music notation in Fig. 7.

The Everyday-Life model refers to real objects that surround us. Kroehl calls it denotative information. Our spoken language defines (often physical) objects which have a name and we can assume that we are understood by others using the same language. The Everyday-Life model is originally of no significance when discussing music notation, because it is not precise enough. To be more precise and to minimise the loss of information during the mapping process, terms would

Figure 7. The three visual communication systems of Heinz Kroehl put in the context of music.



need to be defined accurately. However, these definitions are not used in the Everyday-Life model, but in the so called Scientific model.

In the Scientific model, signs convey meaning according to definitions and rules. Kroehl calls this precise information. Mathematics is such a scientific model. In the Scientific model terms, objects and the coherences between them are clearly defined to create meaning. Regarding music, western staff notation is a system of specific rules, syntax and modes to create meaning. This system needs to be learned and understood to be able to apply it for musical performance. Furthermore, there is a pre-defined connection between sign and sonic result. The Scientific system of western music notation was shaped through the centuries, from neumes in the early Middle Ages to the western staff notation which we know and use today. Someone able to read staff notation knows exactly which key to press on a piano keyboard when reading one specific note (e.g. C4) in a score. Another musician on the other side of the world reading the very same score will therefore press the very same key on the piano keyboard when reading this note. To interpret this C4 as a completely different pitch and therefore pressing any other key apart from C4 would be regarded as wrong. Music scores which use the Scientific model are based on a system. This could be an established system like western staff notation used for an infinite set of works by countless composers over many centuries or the uniquely developed system of a particular composer just for his or her own oeuvre, as in the case of Anestis Logothetis (Logothetis 1999), or just for one single piece, as in the book "Notations" (Cage 1969). The system can be more complex or more simple. In general, for example, the graphic objects used aim at a universal validity, at least within the closed system of the score itself. Within a systematic score which is not based on a common system there are often interacting and reoccurring components which have a predefined meaning. Visually, single components are clearly recognisable. Additionally, the application of these components is also clearly defined by the composer. A music score based on the systematic approach, using the Scientific communication model, tries to reduce interpretation, compared to a musical graphic like "December 1952".

The third communication model is the Artistic. This communication model uses connotative information and works entirely differently from the Scientific (Kroehl 1987). In accordance with the basics of visual communication theory, meaning is generated through interpretation. A photograph, a picture or a drawing cannot be read. They can only be interpreted (Müller 2003). The artistic communication model conveys possibilities. It is not likely that two people, in our case musicians, interpret or understand a message in the same way and play exactly the same sound. The decoding might lead to different results than the sender intended in the coding. Thus, the mapping process is not lossless. The message is rather an invitation for performers to generate meaning by starting their individual mapping process. However, the interpretation is not completely arbitrary as it is contextualised. A red square in an advertising context will be interpreted differently from a red square in a music notation context. In advertising, a red square could be recognised as a brand logo and thereby associated with certain attributes according to the public relations strategy of the company concerned. In a music notation context, a red square could indicate a specific instrument or a special playing technique according to the composer's instructions. Contrary to the Scientific, the Artistic model does not develop a normative canon or any kind of universal validity. Within the context of music notation, it is up to the composer to decide whether and how the mapping process is guided. In the context of graphic notation Mauricio Kagel used the term "determined ambiguity" (Kagel 1965) to describe how composers can set the boundaries for performers. In other words, the composer allows the performers a certain artistic freedom within clearly defined boundaries: within the Artistic model, composers give meaning to graphical attributes within a score while others are left completely open for interpretation. The level of determination is up to the composer. Scores based on the Artistic model are not music notations based on a defined system but interpretational and alternative music representations.

4. Musical Motion Graphics

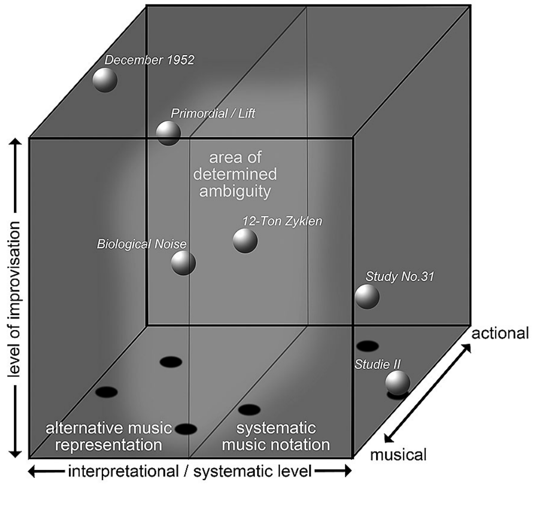
There are several terms describing alternative music notation approaches, including "animated music notation" (Smith 2015), "Plastic Scores" (Behnen 2008: 68) or "screen scores" (Vickery 2012). Additionally, terms and practices are in a constant state of flux, as changes in digital technology have a significant impact on this rather new research area. At the beginning of my research I used the term "motion graphic notation" (Fischer 2013) as I saw my work in the direct succession of graphic notation. Later I adopted "animated notation" (Fischer 2015). However, I needed to revise my terminology and use a modified description according to my findings, especially regarding the visual communication processes, meaning how the message is passed from sender (composer) to receiver (performer) (Fischer 2018). The term "musical motion graphics" (MMG), which is used in this paper, links the terms "music" or "musical" and "motion graphics". MMG is a successor to the musical graphics (graphics with no inherent meaning, rather working as a trigger for improvisation) of the mid-twentieth century, and not of graphic notation (graphics establishing a meaningful sign system). Musical graphics are extended by the term "motion", as animation techniques are applied and MMG always manifests in time-based media. I would like to understand MMG in the following way: "musical motion graphics" is a subdivision of the term "animated notation" (which is understood as an umbrella term to include various ways of communicating music that incorporate animation and movement). MMG uses animated abstract graphics, with no inherent meaning, manifesting in time-based media, mainly video. MMG communicates music, especially the time structure of musical objects and events and their relations, intuitively. MMG bears the potential to act as a trigger for a comprehensive and coherent improvisation process by the performers as well as to give clear instructions of what and when to play to performers and information to the audience.

Contrasting my initial approach at the beginning of this research, the term music notation is deliberately avoided in this characterisation. MMG certainly has a music notational purpose. However, its main task is to communicate structure and the relative relations of musical objects over time and with regard to their characteristics. MMG is not a musical notation as has been understood and used in common practice in western music since the middle of the eighteenth century. MMG does not propose a normative canon or even a language of signs and symbols. It is the other way around: the use of symbols, signs, elements of staff notation or any other graphic with an inherent meaning are rejected in MMG due to the mechanisms of the visual communication process, which were discussed in detail in the third chapter.

4.1 Tackling a Typology / Current Practice

The contemporary practice of animated forms of music notation is as versatile as graphic notation was back in the 1960s. My first approach for a typology was presented at the TENOR 2015 conference in Paris (Fischer 2015), a second one was part of my PhD thesis in 2016 (Fischer 2016a). Figure 8 shows the latest version of a three-dimensional coordinate system of that typology, taken from an article published in eContact! in February 2018

Figure 8. 3D-coordinate system to classify animated notations and MMG (Fischer 2018).



(Fischer 2018), featuring example pieces from various composers.

The 3D-coordinate system consists of the following:

x-axis: interpretational/systematic level. First there is a clear distinction between a systematic music notation using the Scientific communication model (see chapter 3) (right half of the cube) and alternative representations with an interpretational approach using the Artistic communication model (left half of the cube). The further to the right, the stricter is the systematic approach and the less interpretational freedom is left within the communicational model.

y-axis: level of improvisation. Of course, there is no clear mathematical method to measure the level of improvisation in music performance. This level can be regarded as an indication of how much effort and own ideas the performer must invest in the interpretation. The interpretational effort is highly dependent on the composer's intention and willingness to indicate direct connections between graphic and sonic parameters. The clearer the composer's instructions, the less interpretational effort and improvisation are required by the performer.

z-axis: musical – actional. Musical means in this context that the score depicts the sound. Actional scores, on the other hand, depict a certain physical action that needs to be executed by the performer to produce a sound. It is also possible that the time structure is depicted, indicating when to execute an action. In other words, the musical and actional poles refer to whether a score concerns the characteristics of a sound (musical) or its conduct (actional).

Area of determined ambiguity: in the middle of the cube is a yellowish area, which reaches only a little into the right, the systematic side of the cube, and about half way into the left, the interpretational side. This is an area where the composer sets certain rules and boundaries for a score, within which the performers are then free as far as their interpretation is concerned.

A typology like this serves as a visualisation of the characteristic parameters of the notational representations of music. It can only be descriptive, as these parameters cannot be measured or calculated mathematically. Practice shows that the more systematic the Scientific communication model used in the score is, the less improvisational effort is demanded; and that the higher the level of interpretation in the artistic communication model, the higher the level of improvisation is.

Examples used in the typology graphic: The following pieces were chosen either due to their degree of familiarity or due to their characteristics showing the limits of the typology.

"December 1952" by Earle Brown (1954) (see Fig. 1)

The score of "December 1952" is one of the most cited when discussing the alternative notation approaches of the musical avant-garde. As mentioned above, it is not a graphic notation but a musical graphic (Schröder 2010). This score uses clearly the artistic communication model. The composer gave only very few hints as to how to read the score, e.g. it would be possible to treat the 2D objects as 3D, according to Brown's interest in the mobiles of Alexander Calder. Inspired by free jazz, Brown himself saw the score as a trigger for improvisation rather than as concrete playing instructions (Gresser 2007). Even within the Artistic communication model, the expression of this work is very vague. The level of improvisation is therefore very high. The instrumentation, the length of the piece, and clearly the music itself is entirely up to the performer(s). It is also unclear whether the score is musical or actional.

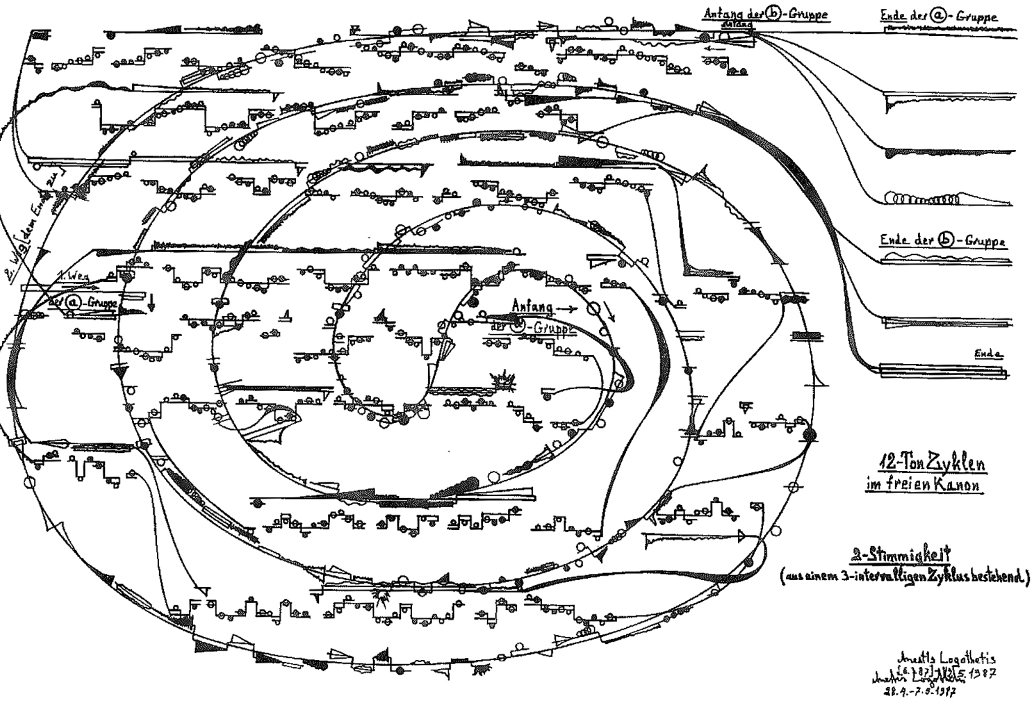
"Studie II" by Karlheinz Stockhausen (1956) (see Fig. 4)

This famous score displays a unique notation system for electronic music. It is a precise manual which explains how to realise the piece, e.g. how and what frequencies to mix to one sound. The score is a visual representation of the sound used. At the same time, it indicates actions, for instance when and how to fade out sounds. The score is musical and actional at the same time. Finally, there is no interpretational freedom for the performer or sound engineer.

***12-Ton Zyklen* by Anestis Logothetis (1987)**

Logothetis developed his own graphic notation system. He differentiates Pitch Symbols, known from western staff notation, which indicate a relative pitch, Association Factors, which indicate loudness, timbre changes and sound character, and finally Action Signals, which display movement graphically to be translated into musical

Figure 9. Anestis Logothetis – *12-Ton-Zyklen* (from Fischer 2018).



„12-Ton Zyklen" 1987

movement (Logothetis 1999). He also uses text. His scores usually combine these symbols and thereby become complex, and require a profound examination to be played correctly. Although his approach is systematic, it still allows the performers a certain freedom of interpretation (determined ambiguity).

Primordial/Lift by Pauline Oliveros (1998)

This piece for accordion, cello, electric cello, harmonium, violin, sampler and oscillator contains two approaches. On the one hand the score reflects Oliveros' idea of "deep listening" in music performance. The score indicates the coherencies of listening and instrument playing while leaving the application of their coherencies up to the performer. On the other hand, there is an indication of time structure regarding two different parts of the piece and the usage of the oscillator. The level of improvisation is quite high. Apart from the oscillator, there is no indication of the sounds themselves. The displayed graphics refer to an ideology of how to perceive and work with sounds and music. This means that the score is rather actional and on the very edge of determined ambiguity.

"Study No. 31" by Ryan Ross Smith (2013)

Over the years Ryan Ross Smith developed his own notation system when dealing with animated notation. His scores use what he calls primitives (irreducible static or dynamic symbols – the dots in Figure 11), structures (two or more primitives in some interrelated relationship – the dots and arches in Figure 11), aggregates (a collection of primitives, structures and their respective dynamisms that correspond to a single player – the circles in Figure 11) and actualised indication (the use of a motion play-head to trigger – the thin lines with numbers at the end in Figure 11). The score is systematic and actional. It tells the performers exactly when to play their instruments and how long its sound should last. According to Smith, the score features "... Animated Music Notation as a particular notational methodology"

Figure 10. First page of *Primordial/Lift* by Pauline Oliveros.

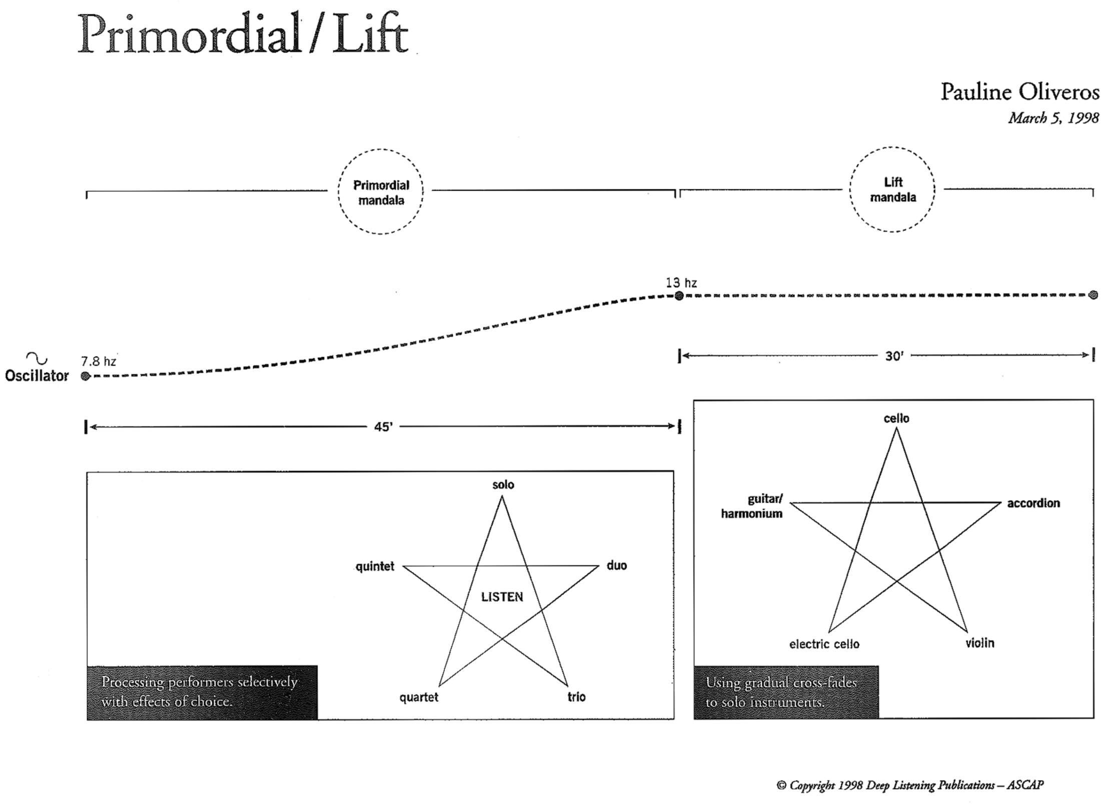
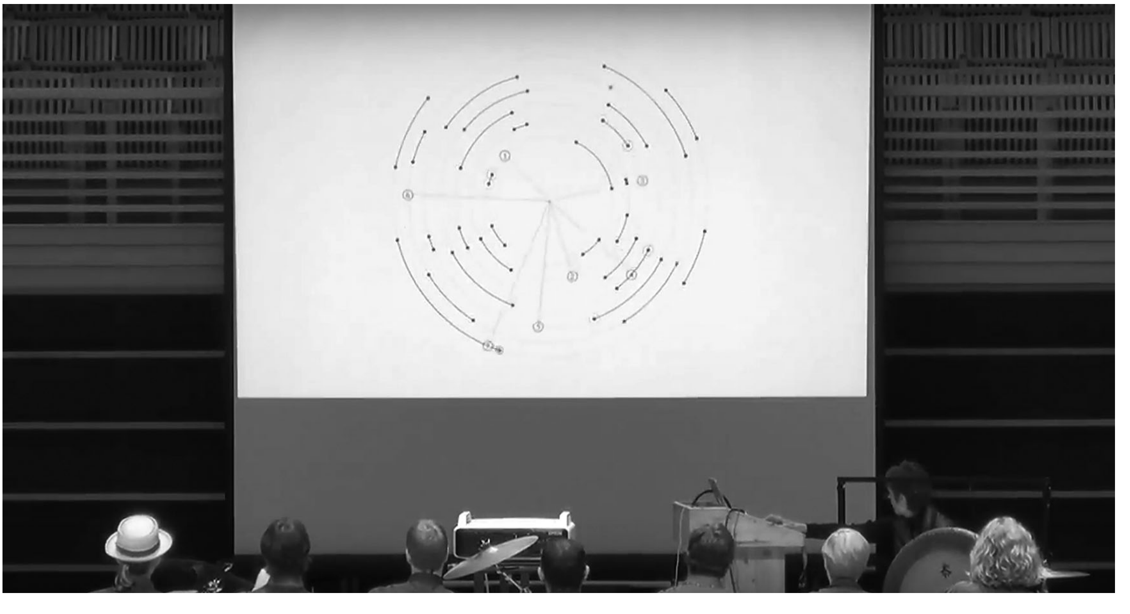
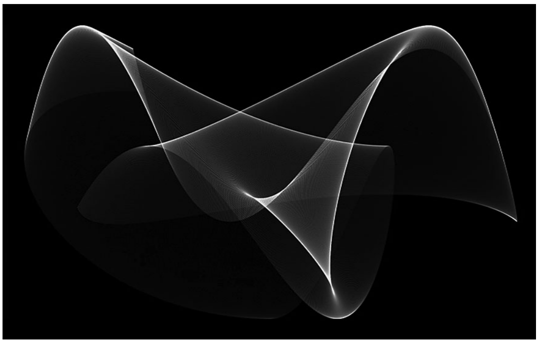


Figure 11. Screenshot of a performance video of "Study No. 31" by Ryan Ross Smith.[5]



5 From Ryan Ross Smith, Complete Studies, http://ryanrosssmith.com/ (accessed March 4, 2016).

Figure 12. Screenshot (0.36 min) of the score "Biological Noise" by Christian M. Fischer.[6]



(Smith 2015). This approach works especially well for pieces focusing on rhythmical structures and their changing over time.

"Biological Noise" by Christian M. Fischer (2016)

This score (see Fig. 12) is an MMG. It was written for electric guitar, effects and live-electronics and uses animated abstract graphics which are interpreted by the performer according to a set of guidelines. As the score manifests as a video, the timing of events and the overall length is determined. There are also guidelines as to how to deal with the score, for instance that the interpretation should be coherent and comprehensible, meaning a visual element should have the same corresponding sound or playing technique throughout the whole piece. On the other hand, the interpretation itself – finding sounds that correspond to the visuals – is left entirely up to the performer. The score creates a space of determined ambiguity for the performer and depicts sounds and music rather than physical actions.

Table 2. Mapping of the three performers of *Brahmavihara* in Pärnu, 9.01.2014.

graphic attribute	sonic / musical attribute	physical action
speed of motion	tempo	
motion in general	phrases, gestures	motion in/on instrument
circular motion	phrases, gestures	circular motion in/on instrument
number of elements	number of sounds	
position on y-axis	pitch	
position on x-axis	panning (electronics)	
motion on y-axis	change in pitch	
motion on x-axis	sounds moving	sound spatialisation, e.g. panning by performer
colour	indicates instrument	
waves/curves	glissando, tremolo, vibrato	
size of elements	dynamics	
lines	long sounds	
dots	short sounds	single events
accent (e.g. by brightness)	accent	
complex graphic	chaotic, random play	
various features at once	chaotic, random play	

6 From c-m-fischer.de (accessed February 20, 2018).

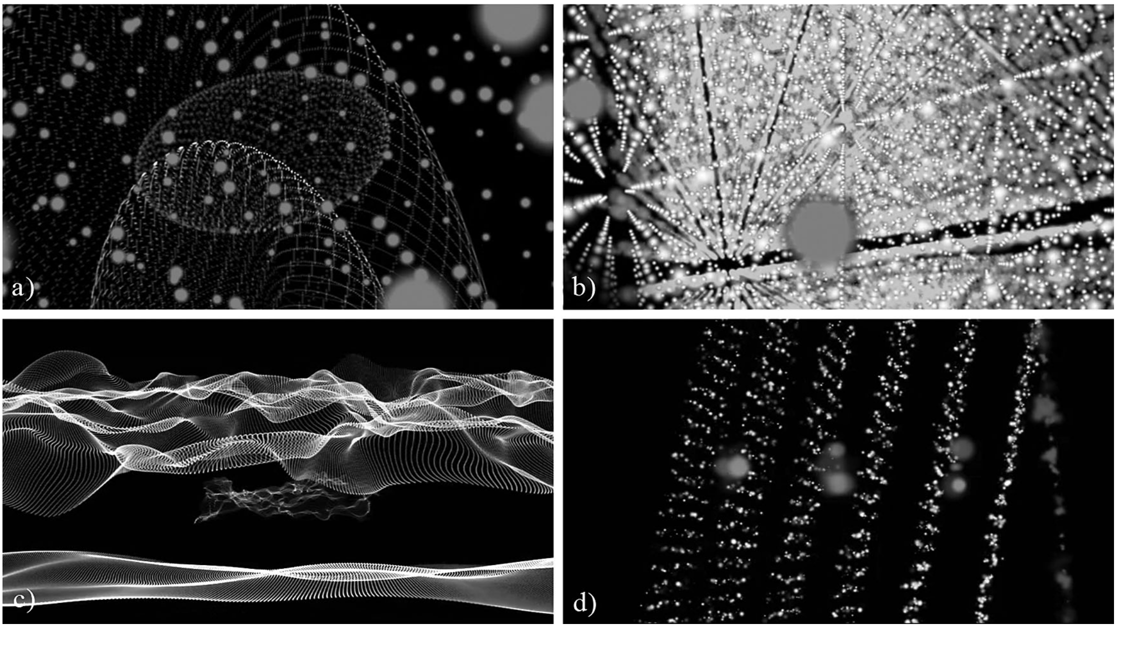
5. Composing using MMG – Example: *Brahmavihara*

Brahmavihara was composed for clarinet, violin and live electronics and premiered on January 9, 2014 at the city library in Pärnu, Estonia, within the Pärnu Contemporary Music Days Festival. Table 2 is a generalised display of the practical mapping processes of the three performers of *Brahmavihara* working with the piece before its premiere. This table should be understood as a generalisation: it is just one possibility of many. There are two mapping processes involved. First is the mapping of the composer when composing the work; second is the mapping process carried out by the performer when interpreting the work. Usually, the desire of the composer is to have both mapping processes as congruent as possible. The table has three columns. The first is the attribute of the graphic. This was translated into sound (second column) or into an action (third column).

The graphics of the piece were generated in Adobe After Effects. The possibility to automate single attributes of a graphical element, to use particle emitters, and to use a timeline and key frames made it a perfect tool for composition, especially with regard to the time structure. My previous experience of other works allowed me to come up with a set of simple principles to be applied during the composition process and rehearsals of *Brahmavihara*: General Validity – the score needs to work for audience, acoustic instruments and live electronics alike; Time-Based Media / Usability – the score uses a video and a regular video player like VLC media player, and performers should be able to navigate as easily as possible through the score; Transparency – the audience should be able to understand the actions of the performers in relation to the video score; Comprehensibility – the score should be composed and performed in a way comprehensible to the receiver (see Fig. 6). Graphics should be designed to support the mapping process. For example, it is comprehensible to make a connection and to map visual noise also known as "snow" or "visual static" with white noise (sound). Once a specific graphical element is mapped with a specific sound, e.g. if a small yellow dot is once mapped with a plucked string on a violin, it should remain this way throughout the whole piece. Whenever a yellow dot reappears on the screen, the receiver knows what to expect and comprehends the actions of the performer.

Brahmavihara consists of four movements. The instruments are indicated clearly by colour: violin – yellow, clarinet – red, and electronics – blue. The score is associative, symbolic, and requires a

Figure 13. Screenshots from the four movements of *Brahmavihara*.



high level of interpretation and improvisation by the performers. There is no play-head, meaning a distinct indication of which graphic to play when (compare Fig. 11). Performers cannot look ahead in the score. The score requires profound involvement to conduct a mapping process. The mapping of visual and sonic attributes and the structure of the piece need to be memorised. As well as being an independent instrument (indicated by the blue graphics), the live electronics need to support the acoustic instruments, especially in passages with a lot of movement and complex visual structures. The key graphical element is moving and changing or morphing objects over time; for example, in the third movement (see Fig. 13c), the mesh changes from a static three-dimensional plane to a rapidly swirling shape. Changes can occur very slowly, or sometimes quite rapidly. The timing and visual design of these changes for all three instruments constitute the main compositional process.

After the performance of *Brahmavihara* the two musicians playing acoustic instruments filled out a questionnaire to gather feedback about the score itself and how they used it. They self-evaluated their performance regarding their individual interpretation of the score. Although they had different ways to work with the score (one musician watched it several times until she memorised her part, while the other worked through it step by step and made some notes for herself), both found the score intuitive and easy to use. Both made their individual mapping. For example, the violinist mapped graphic waves to glissando and vibrato-like sounds, circles indicated the bow circulating on the strings and the distance of objects referred to dynamics. The clarinettist mapped different graphic types to the instrument register and the motion to the tempo. They both stated that their performance corresponded to the score very well and found the third movement (see Fig. 13c) with its wave-like graphics the easiest to play, as it was the slowest and easiest to follow, due to the lack of rapid changes. One performer commented that it was difficult to grasp the range or scale of the graphics. For example, when mapping the size of an object to dynamics, the performer needs to know the minimum and maximum size that this object will have before starting to play. Playing the score at *prima vista* would not be possible. After comparing the audio recording of the work and the scores, I decided that some parts of the piece were too fast and that the graphics were too complex, especially for the acoustic instruments. The violin in the second movement for example (see Fig. 13b) had too many units in too complex a structure. Although we tried to interpret these by looping recorded material several times to generate an equally complex sound structure, the sonic result was not entirely convincing. Regarding the electronics, the graphics were easy to interpret. However, due to the almost infinite possibilities of electronic sound generation, the mapping of visuals and sounds remains vague in comparison to the acoustic instruments. Some aspects could be resolved more clearly. The motion of graphics was mapped with the development of sounds over time, e.g. changes of effect parameters. Size was mapped with dynamics. The visual complexity of a graphic (for instance, when using many elements, as in Figure 13b) was reflected in the sonic complexity of a sound by using granular synthesis to generate sound structures consisting of multiple elements. The overall character of the sounds was clearly depicted within the graphics.

It became clear that the depiction of the electronic sounds might remain vague compared to the acoustic sounds, simply because there are more possibilities to generate sounds electronically. For instance, a single line will very likely be interpreted as one single continuous tone by a violinist. The computer musician will very likely do the same and create one continuous sound. However, the sound creation on the violin will sound like a violin, whereas it is entirely unclear what kind of synthesised or even recorded sound the electronics might use. When there are numerous dots arranged in a turning three-dimensional cube, the violinist needs to find a way to interpret the visual appearance of the graphics as one unit, because the number of dots exceeds the number of tones the violin can play at once. The computer musician could do the same as the violinist and interpret the object as one unit, or (s)he could find a sound for each individual dot and a way to change them according to the turning of the cube. This indicates that the composition and use of graphics means that for the live electronics a profound involvement is required.

After using MMG in several line ups, *Brahmavihara* showed that this kind of score design works best for up to three instruments. MMG is therefore ideal as a tool for live electronic music within the setup in which I intend live electronic music to happen. However, with four or more instruments individually indicated on one canvas, the score needs a completely different setup. Therefore MMG, as introduced in my doctoral thesis, is not suitable for bigger ensembles or orchestra. However, this does not indicate that animated notation techniques are for small ensembles only. There are animated notations for larger groups of musicians using a different approach and displaying techniques such as the previously mentioned "Study No. 31" by Ryan Ross Smith or "The Max Maestro", an animated music notation system for non-professional performers, which was developed within an artistic research project by Anders Lind at the Umeå University in Sweden (Lind 2014). Its simplicity allows performers – even large groups of them – to use it right away. This suggests that it is a question of the individual score design and the technique utilised rather than a problem of animated notation itself.

5.1 Composition Process

It is possible to display any sound or any action in a musical context using MMG. However, practice shows that its strength lies rather in the display of structures, meaning the sequence of musical sections and events in relation to one another. MMG is one possible tool to use when composing and performing live electronic music. My composition process changed drastically along with my involvement in animated music notation approaches. Formerly, I started with the sound material itself. I collected sounds and classified, shaped and arranged them. The process could be compared with the work of a sculptor. Adding and subtracting sound material shaped the piece, while the character of the sounds themselves determined their use, starting sometimes only with a first single crackle of a few milliseconds without knowing where the process might end. The possibility to utilise graphics as a representation for the music changed my approach entirely. Now, I compose visually. First, I think about the instrumentation and allocate a shape or colour to a specific instrument. From the very beginning, the piece as a whole (time/length) exists as a two-dimensional canvas. Single passages do not develop sonically but visually, where objects move within a certain time span and become events. The timing of these events, as well as the design of graphics themselves, follow mathematical rules like the golden ratio, symmetry, the rule of thirds, or more complex strings of numbers. Object relations are also bound to those rules. For instance, there are three circles named "a", "b" and "c". Their size follows exactly the golden ratio where "a+b" is to "a" as "a" is to "b". In this case, "a+b" would be the third circle "c". All three circles start to move at the same time across the screen, but at three different speeds. The adjustment of their speed also follows the golden ratio. Colours, contrasts, ratios, visual arts and design rules are applied on the graphic design of objects as well as on the time structure of events. Design rules, ratios which can be called aesthetic, find their sonic counterpart. In very simplified terms it can be stated that what looks good, also sounds good. During the visual composition of the piece, a mapping with sound is inevitable. Visuals and sounds are inextricably connected by their purpose as a communication tool. In this way the aesthetics of the visuals determine the aesthetics of the sound, and not the other way around, as in VJing or in visual music. The motion of a graphic, which is meant to indicate a slowly sliding pitch change of a violin, is initially evaluated by its visual appearance during the composition process. During my own composition process, the graphics and their change certainly have a sonic representation in my mind. Nevertheless, the translation to music, the interpretation of how the graphic in motion would sound and how it could be played comes second. The graphic design and its evaluation comes first.

For a musical composition process that is based on motion graphics, previous knowledge of graphic design and the software tools to create the video score is highly advisable. There is various software available for animation, motion graphic design and video editing. The software used for the generation of the score will definitely have an impact on the design through the possibilities offered by the specific software, its interface, and the algorithms it uses. Graphics made with software based on vectors will undoubtedly look different from those of a pixel-based software. The use of particle emitters will create an entirely different piece from the use of filmed video material. The overall style and design (visual impression), which are influenced by the software of choice, is the first individual decision of the composition process. The character of the graphics may reflect the essence of the musical work and the compositional approach. The second important aspect is the purpose of the MMG. It can be a piece of art, which is intended to be a source of inspiration for an improviser, or it can be an instructive score indicating exactly when and what to play. The typology presented in Figure 8 indicates the various possibilities. The more actional and instructive the score, the easier it is to execute, as it is based on clear instructions. Another aspect to consider is the readability or, to borrow a more general term from software engineering, the usability of the score, indicated for instance by questions such as whether it offers the possibility to read ahead, enabling the performer to see what graphics to play next; whether the score is a video file that can be played, paused and fast forwarded using a common video player; or whether it is a standalone application with its own interface. In addition, the use of the score on different devices like a PC screen or a small tablet should be considered.

The mapping process is the core of the creation and interpretation of an MMG. There are three separate mapping processes involved in the way the scores were used during my concerts. Foremost among these is the visual design, followed by the composer's mapping, meaning the ideas, sounds and music I had in mind whilst creating the score. It is advisable for composers to make the mapping as reasonable and applicable as possible for the instrument or performer. An animated score, especially an MMG, might be entirely new to the performer. It is advisable for the composer to try to see the score with the performer's eyes. This is mainly a question of human perception and how much visual information the performer can process at the same time. The speed, size, number and complexity of objects are the most important aspects in this context. Secondly, there is the mapping of the performer. The performer's mapping can be supported by additional comments from the composer or discussions during the rehearsal. This support is however not obligatory. For performers, it is advisable to keep the mapping process comprehensible and as consistent as possible throughout the whole piece. On the one hand, this supports their own interpretation of the score as re-occurring elements can be more easily mapped. On the other hand, it promotes the audiences mapping process. This occurs in situ while simultaneously perceiving the music and the score. If the mapping of the performers is not consistent, then the mapping process – or, rather, the expectations of the audience – might be seriously disappointed. The presentation of the score to the performers and the audience is the final aspect to consider. It is part of the composition and the performance and should fit the idea and message of the piece.

6. Conclusion

MMG supports the composer in several ways. It allows the composition of live electronic music, featuring acoustic and computer instruments, by offering an intuitive visual way to communicate with performers. It has the flexibility and the determined ambiguity to be able to represent acoustic and electronic instruments in an equal manner. Designing the score profoundly and elaborately will display the nature and character of the piece. Furthermore, the design of an MMG is an artistic and a very individual decision. The work reflects the composer's intentions sonically and visually for performers and audience alike. Starting a composition by using visual elements for developing structure over time is nothing new for composers and should facilitate the use of MMG in general. The use of time-based media (video) in MMG includes a structure over time *per se*. The termination of a piece is therefore apparently simple. Practice shows that animated notation approaches like MMG can be approached and utilised very intuitively. MMG additionally allows the synchronisation of musical events for all the instruments involved, regardless of whether they are acoustic, electronic or even non-musical sound objects. Stopwatches, acoustic cues, score following or other possible means of synchronising the actions become obsolete, but can still be used if desired. The use of computer-based playback of MMG allows the synchronisation of a video in different locations, e.g. by using tablets and synchronising the replay over a local network. Finally, apart from utilising MMG to support the communication between composer and performer, it can also be presented to the audience during the performance. This has several advantages. MMG can add an aesthetic value to performance. It can enhance the enjoyment of a performance by extending it with a visual component.

While the audience focuses on the MMG, the rather inexpressive performance by the computer musician, which is disconnected from visible and comprehensible sound generation, is no longer of any consequence. Most importantly, MMG communicates music visually. In so doing, the audience can follow the musical structure more easily, and this supports understanding and, finally, the appreciation of the work. The major advantage of MMG is that it encompasses all the described advantages in one single entity.

Sources

Concerts:

PhD concert No. 2: *Brahmavihara*, performed January 09, 2014 at the city library in Pärnu, Estonia, within the Pärnu Contemporary Music Days Festival; Mari Targo / violin, Helena Tuuling / clarinet and Christian M. Fischer / electronics.

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Animeeritud muusikagraafika (AMG) – *live*-elektroonilise muusika edastamine[1]

Christian M. Fischer

Töö käesolevas artiklis käsitletava loomingulise uurimisprojekti kallal algas peaaegu 15 aastat tagasi. Helilooja ja arvutimuusikuna seisin silmitsi probleemiga, kuidas edastada adekvaatselt nii muusikutele kui publikule oma muusikalisi ideid *live*-elektroonilise teose esitamisel. *Live*-elektroonilist muusikat defineerin siin kui elektroonilise / arvutiga loodava muusika üht žanrit, millesse on kaasatud akustilised muusikainstrumendid ja milles toimub elektrooniliste helide loomine ning nii tekkivate kui ka eelsalvestatud helidega manipuleerimine reaalajas. Traditsiooniline noodikiri pole arvutimuusika edastamiseks piisav. Lisaks võib selline muusika mõnikord olla kuulamisel raske mõista. Seetõttu töötasin välja helilooja, esitajate ja publiku vahelise suhtlusplatvormina töötava animeeritud muusikagraafika (AMG), mida artiklis tutvustangi.

AMG põhiideed pärinevad muusikalise avangardi 1950ndate ja 1970ndate aastate vahel rakendatud notatsioonipraktikatest. AMG aluseks on graafiline notatsioon (modifitseeritud noodikiri või muusikalistel eesmärkidel loodud alternatiivne graafika) nagu Anestis Logothetise partituurid (vt. nt. joonis 2) ja eriti muusikaline graafika (pigem improvisatsiooni vallandajana töötav abstraktne graafika), nagu Earle Browni teos „December 1952" (vt. joonis 1). Kuid neid ideid on laiendatud animatsiooni ja liikuvate kujutiste abil.

Karlheinz Stockhauseni „Studie II" (1954) näitab, et soov talletada elektroakustilist muusikat on sama vana kui elektrooniline muusika ise. Alates 1950ndatest toimunud arengus, digitaalse revolutsiooni, helide genereerimise ja nende arvutil manipuleerimise kaudu jõudsid arvutimuusika ja selle võimalused täiesti uuele tasemele. Seega muutus notatsioon keerukamaks. *Live*-elektroonilise muusika puhul saab neid probleeme lahendada (traditsioonilist) noodikirja laiendades (lisades noodikirjale uusi graafilisi sümboleid) või kasutades tehnilisi abivahendeid nagu partituuri järgimine (ingl. *score following*), et sünkroniseerida akustiline ja elektrooniline instrument.

Selliste abivahendite kasutamine ei tulnud mu oma loomingulises töös kõne alla. Pärast probleemi analüüsimist jõudsin järeldusele, et tegu on puhtalt suhtlusprobleemiga. Lahenduse pakkus mu disaini ja visuaalse kommunikatsiooniga seotud taust. Charles Sanders Peirce'i semiootilistele uurimustele toetudes kirjeldas saksa kommunikatsiooniteoreetik Heinz Kroehl (1987) kolme kommunikatsioonimudelit: argielu, teadus ja kunst. Traditsiooniline noodijoonestik kuulub teadusliku mudeli alla, kuna selle lugemiseks ja mõistmiseks on vajalik eelnev reeglite tundmaõppimine. Kunstiline mudel kasutab konnotatiivset informatsiooni ja põhineb interpretatsioonil. AMG kasutab kunstilist mudelit ja seda võib defineerida järgnevalt: AMG on animeeritud notatsiooni alaliik (terminit „animeeritud notatsioon" võib mõista kui katusmõistet hõlmamaks muusika edastamise eri liike, mis kasutavad animatsiooni ja liikumist). AMG kasutab abstraktset, ilma konkreetse tähenduseta graafikat ja see realiseeritakse peamiselt video või mõne teise ajapõhise meediumi kaudu. AMG väljendab intuitiivselt muusikat, eriti muusikaliste objektide ja sündmuste ning nende suhete ajalist struktuuri. AMG-l on potentsiaal toimida nii laiahaardelise ja sidusa improvisatsiooniprotsessi sütitajana mängijatel kui ka täpse informatsioonina publikule ja mängijatele selle kohta, mida ja millal mängida.

Kõige tähtsam protsess AMG rakendamisel on seostamine (ingl. *mapping*). Seostamist võib mõista kui visuaalsetele elementidele akustilise tähenduse omistamist, nt. et punane ruut tähendab viiulikeele näppimist. Niisugune seostamine on individuaalne protsess, mis toimub teose loomisel (helilooja), esitamisel (muusik) ja kuulamisel (publik).

AMG-d on kasutatud ja täiustatud mitmetel kontsertidel. Artiklis vaadeldakse seda protsessi teose „Brahmavihara" näitel. Neljaosaline „Brahmavihara" on kirjutatud klarnetile, viiulile ja *live*-elektroonikale ja selle esiettekanne toimus 9. jaanuaril 2014 Pärnu linnaraamatukogus Pärnu nüüdismuusika päevade

[1] Artikkel põhineb autori 2016. aastal Eesti Muusika- ja Teatriakadeemias kaitstud doktoritööl (juhendaja prof. Kerri Kotta), https://www.ema.edu.ee/vaitekirjad/doktor/Christian_Fischer.pdf.

raames. Esitajatega tehtud intervjuude, küsitluse ja teose videosalvestuse kvalitatiivanalüüsi põhjal töötasin välja optimaalsete seostamisvõimaluste tabeli (vt. tabel 2). Näiteks graafika liikumiskiirus seostati peaaegu üksnes muusikalise tempoga, graafiliste elementide arv aga helide hulgaga.

AMG kasutamine osutas *live*-elektroonilise muusika esitusprobleemidele, nagu töö alguses eeldatud. AMG kui komponeerimise abivahendi peamine eelis on võimalus teost täpselt struktureerida, nii tervikuna kui ka väga väikesteks ühikuteks jaotatuna. Struktureerimine on visuaalselt tajutav ja struktuuri on ka kuuldeliselt kergem haarata. Visuaalse suhtlusvahendina on sama AMG rakendatav nii akustiliste kui elektrooniliste instrumentide muusikute kui ka publiku tarbeks.

Tõlkinud Anu Schaper