



Audio portraits of musical instruments

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Abstract

This thesis presents a number of electro-acoustic pieces by Nikolaj Kynde, so-called audio portraits of musical instruments. Apart from an analysis of three finished pieces and one piece in progress, the term “audio portraits” is defined and discussed. The ability to describe and record instruments is further discussed in relation to the writings of Pierre Schaeffer and Suk Jun Kim. Finally, in relation to the discussion, the composing, production, and spatialization in the pieces are explained.

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1 Introduction

This thesis will be presented in three parts; firstly, a part including some conceptions of the instrument and sampled music. Secondly, a presentation of my thoughts on composing, and lastly, a description of each of the four pieces in my series of audio portraits of musical instruments.

The musical instrument is an almost universal part of human culture. The earliest objects made for the purpose of producing sound is dated back 67,000 years. The musical instrument has undergone a long and twisted evolution into a broad range of instruments with different abilities, limitations, timbres, ranges spanning from infrasonic to inaudibly high frequencies. In this thesis I will focus on a series of works written with samples of modern orchestral instruments. Each of my pieces can be seen as a study of one single instrument delving into the personality and the special abilities of the instrument.

Since all the pieces are made as fixed media pieces I am positioning myself in another tradition, the one of sample music. I will present some of Pierre Schaeffer's thoughts on sampled music and show examples of how he has worked with musical instruments in his pieces. The way the audience is intended to listen to the music has a huge impact on how music is written, and a short discussion on listening modes relating to my works is also included.

In the second part I will present my thoughts on my compositions related to the theory I have given, including how I select and reflect on recorded materials and how I use the computer to process sounds to enhance features of instruments. The possibilities that exist today in recording and post production of fixed media pieces provide a vast amount of options to alter the sound and I will discuss some of the solutions that I have chosen in comparison with the works of Trevor Wishart. The performer, or lack of performer, is of course an aspect of presenting recorded material, and this will also be discussed along with my ideas on form and space.

Finally, I will give a thorough analysis of three of my pieces in relation to the thoughts presented. I will end with a conclusion and an overview of my piece *192 Violins* for the Wave Field Synthesis System. This piece is an exploration of the concept of geometrical spatialization, a concept that is also present in several of my other works.

2 The Instrument and its character

The Instrument has a long history; the earliest example of a musical instrument is a 67,000-year-old flute. The flute is already a fairly highly developed instrument when compared to percussion instruments and researchers assume that drums of different sorts have existed long before that (Grame, 2013). Over time, instruments have developed into an acoustically advanced standardization. Today we have, in the western world, a symphony orchestra of around 20 to 50 highly developed instruments, depending on how they are counted. Even though two instruments of same sort can vary a lot in quality, each type of instrument has some clear definitions and ways of behaving. Range, tuning, material, tempering and shape are parameters largely without variation. This has allowed for a standard repertoire and a certain tradition for where and how these instruments are used. I am well aware that the role and the way of playing instruments are constantly questioned and challenged by composers, but I still dare to say that any instrument carries historical ballast that gives reason to talk about a standard way of performing or the personality of that instrument. A vast amount of instruments have been developed since the standardization of the orchestra, many relying on external electrical amplification. In this thesis I choose not to focus on these instruments since they are lacking standardization and history due to their late development.

2.1 The Characterization of an instrument

An instrument can be characterized by several parameters: First of all, the physical appearance: What material is it made of? What does it look like? How is it excited? These parameters are of little importance to an audio portrait, but are valuable assets to help determine elements in the next category: How does the instrument sound?

The instrument's sound is highly dependent on its material and size. Each instrument will also have its own resonance characteristics. This is important to realize in the post-processing of a single instrument, but can not be considered a picture of the instrument group as a whole. One double bass for instance may vary considerably in resonance characteristics from another.

Historically, there has been a lot of focus on describing instruments in terms of pitch

range, like the illustration from Rimsky-Korsakov's *Principle of orchestration* in figure 1. The description, even though widely used, is obviously very one-dimensional. The illustration does not mention the many timbres and dynamic differences between the particular notes in the range of the instrument, nor does it hint at different techniques. Of course it was never Rimsky-Korsakov's intention with this figure to give a complete and absolute description of the instrument and during the course of the book he does describe all of the facets of the instruments necessary to write music within a certain style.

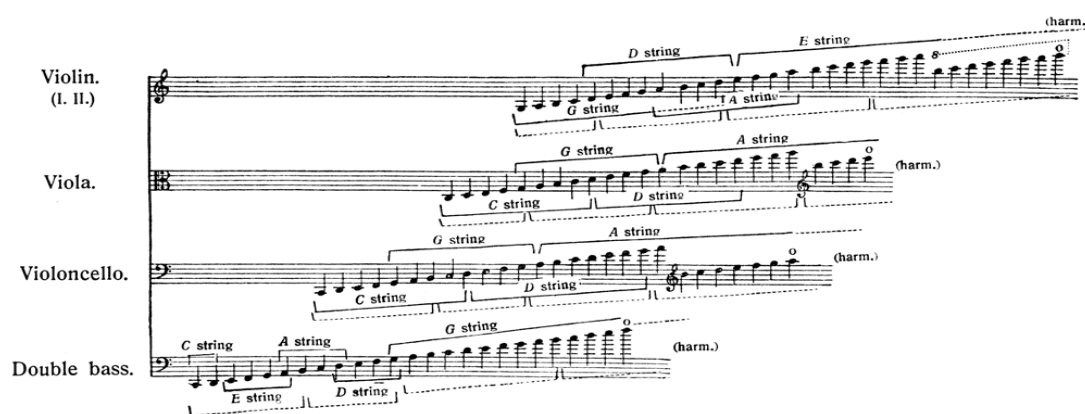


Figure 1: The range of the string family according to Rimsky-Korsakov's principles of orchestration

One could imagine a diagram depicting spectrograms of every chromatic note over the entire range to show the spectral differences. However even this diagram would be inadequate, since there are almost infinite different ways of playing any pitch on any instrument. An attempt to describe the dynamic range of an instrument is equally pointless since it is completely dependent upon the instrument, the pitch and the player. Rimsky-Korsakov's attempts to explain dynamic ranges are always relative and referring to a special and implied way of playing instruments. For instance he writes on dynamics:

Wood-wind instruments, in forte passages, are twice as weak as the horns, 1 Horn = 2 Clarinets = 2 Oboes = 2 Flutes = 2 Bassoons; but, in piano passages, all wind-instruments, wood or brass are of fairly equal balance. (Rimsky-Korsakov, 1964)

This can not be - even though highly applicable if you write a romantic work for orchestra - considered very exact science. In conclusion, a finite description of the sound of an instrument seems only possible within a narrow genre and will in any case be inadequate or subjective.

A last approach to characterize an instrument is to look at its history and what role it

has had in music until the present day. What are the special abilities of the instrument and how does it differ from similar instruments? An analysis as such is more related to humanism than to an exact science and is highly dependent on the person that does the analysis. I have in my pieces used sounds relating to the instrument's special abilities, history of performance and tuning, as well as concepts relating to the pure physicality of instruments as objects. I will discuss the analysis of specific instruments in a later chapter.

3 Sampled music and its meaning

To a large extent my compositions are based on recorded material, therefore I am positioning myself in the tradition of sampled music.

Sampled music has a long history; from the first cumbersome works of Pierre Schaeffer and Halim El-Dabh, until today where a large amount of the music of any genre can to a certain extent be called sampled or contain sampled material.

3.1 Schaeffer and the concrete music

Pierre Schaeffer's work (first with gramophone and later with tape recorders) laid the foundation of sampled music. Even though he became more known for his pieces using non-instrumental materials, he did conduct experiments with the instruments as sample material. In his book *In Search of a Concrete Music* he explores a number of possibilities that are today doable with the click of a mouse. Half speed playback, backwards playback and looping are amongst the “discoveries” which he made. Also he dreamt up what we today know as a sampler:

An organ with each key linked to a turntable that would have appropriate discs put on it as required [...] in theory we get a mother instrument capable of replacing not only all existing instruments but every conceivable instrument. (Schaeffer, 2012)

He soon realized that rather than replacing existing instruments the turntable created a new sound, a new interpretation of the instrument. He did not make a distinction between environmental noises and musical instruments, but instead called them all “sound complexes”. In his initial try-outs with instrumental *Musique Concret*, his approach was more experimental than systematic. For his piece *Etude aux Tourniquets* he asked his friend Gaston Litaize to compose a number of small motifs for pitched percussion with the intent of sampling the motifs into a full-scale composition. However, rather than using the motifs directly, he took unrelated bites and bits to create something different.

Ignoring the score, I took short pieces, preferably from all the “odd moments” of the performance. Then the whole process of concrete music took place: Transformation of

these fragments by varying speed, timbre etc..(Schaeffer, 2012)

The importance of the quote above lies in the reference to the “odd moments”. Schaeffer realized here that the musical material of the odd moments were equally as interesting as the “correct” recordings. The sampling of music allowed for orchestration not only of the correct notes, but also of the errors. This created a new way of relating to the sound of musical instruments. Errors were just another way of sounding.

Schaeffer's ideas on sound's relation to the source are contradictory. In his later writings he refers to the phenomenon of reduced listening that frees the “sound object” from its source and tries to encourage this type of listening in his music. At this early state however he says about his *Etude Noire*:

I asked Pierre Boulez to record a series of chords in different styles [...] on a given theme, I can by manipulating this “sound stuff”, construct groups that will still have something in common with the initial sound, but without being recognizable as clearly. (Schaeffer, 2012)

3.2 Different modes of listening

Using samples in music does undoubtedly raise a discussion on how to listen, and maybe even more importantly, how the composer wishes the audience to listen. While Schaeffer was keen on the idea of reduced listening (listening to the sound as itself without relating it to any source) other composers have been interested in more narrative approaches where the music tells a story with the objects recorded. For instance, Suk Jun Kim contrary to Schaeffer suggests that the act of imagination often applies when an everyday sound occurs in electronic music, he writes:

Separating musical from everyday listening [...], raises a thorny question in electroacoustic music listening because electroacoustic music often invites listeners back to the everyday world through the capturing and suggestive presentation of everyday sounds. (Kim, 2010)

Further he argues that the composer can use imaginative listening as a method of guiding the listener through a piece as he agrees with John Young:

If sounds in electroacoustic music have, to a varying degree, a recognisable everydayness to them associated with their realism, then realism, and the degree to which composers desire it and listeners perceive it, could possibly serve as a framework through which key features of electroacoustic music composition and listening might be mapped. (Young, 2007)

A further extreme in the act of guiding the listener through compositions by means of images lead us on to the field recordings of Hildegard Westerkamp, (I dare to argue that music based on field recordings is a type of sampled music). In her piece *Kits Beach Soundwalk* (1989) the listener is guided by a calm voice throughout the piece, being told what he is listening to, how it is processed and how it is changing. The piece can be seen as a demonstration of how much the imagination can create the listening experience. Listening to this composition without imagining seems almost absurd.

The discussion on reduced listening versus imaginative listening changes when the recorded material comes from musical instruments. Let's look at two examples: The tone of a piano and the sound of footsteps. If the listener hears an unprocessed recording of one tone of a piano it is difficult for him to reduce the sound to a sound phenomena. The relationship between the sound and the source, a piano, is very obvious in almost any situation compared to the sound of footsteps, which could very well in one situation, invoke the image of feet, but in another situation sound like a drum or a noise generator. In the first example, the sound of a piano recorded by a close microphone does not refer to a larger image. In the latter the listener will at the same instance he recognizes the footsteps as footsteps, imagine what shoes are worn, what surface is walked on and in what environment. If there is a sound of crackling leaves in the sample, the listener is almost certainly imagining a forest, moreover if he hears a hard asphalt-like surface, the whole piece is imagined as taking place in a city.

The musical instrument does not carry these kinds of connotations since it is, in of itself, a medium. The listener's ability to picture sounds and build narratives depend on the sound's ability to relate to one and another in an everyday way, Suk-Jun Kim argues:

The everydayness of the sounds emboldens [the listeners] to 'picture' what they are hearing as they take cues from the way the sounds sit, move, integrate, disintegrate, or generally relate to one other. (Kim 2010)

The natural movement and relation to the source is thus fundamental to the listeners ability of imaginative listening. One note from the piano has no “everyday” relationship with next note, nor does the relationship evoke any image apart from the piano as an isolated object. An instrumental piece can thus remain abstract and non imaginative, even though each and every source is recognizable and referring to an object. The instrument itself is not referring to a place or a movement.

The human voice is placed somewhere in between the instrument and the everyday sound. It does obviously carry information about the speaker, but not necessarily more than that. In Trevor Wishart's marathon composition *Encounters in the republic of Heaven*, with the subtitle *All the colours of speech*, he works with the music of the human voice. Even though the human voice is commonly used as an instrument in itself, what we know as singing, he is preoccupied with:

Large scale features of human language, the rhythm, the melody of natural speech and above all sonority of individual speakers' voice. Or as he also calls it, A snapshot of the diversity of human life. (Wishart, 2010)

His way of achieving this is to superimpose different voices, to stretch particularities of a special voice, to merge one voice into another or to make unrecognisable clusters of voices, etc. At no point during the 80 minute piece he is moving the listener's attention away from the voice. Thus the voice becomes a phenomenon of it own, isolated from the person speaking and the meaning of the words. It is important for Wishart to be able to isolate the voices from their spaces. He is excluding indications of surroundings by *systematically eliminating blemishes* and dissolving the space by advanced pannings and thereby achieving *a strange sense of everywhere* (Wishart, 2010). Wishart's “snapshot of human life” is related to my audio portraits of instruments in the sense that also I am searching for the defining aspects as well as the sonority not of the voice, but of individual musical instruments.

4 The Audio portraits

The classical orchestra has a broad variety of sounds in terms of timbre, pitch and level. Instruments are played together and the sound is perceived as a whole - the music, not as a number of separate instruments producing sound. For instance if four musicians are playing the first string quartet of Beethoven, the sound is perceived as a string quartet by Beethoven rather than two violins, a viola and a cello producing sound. The orchestra is thus usually not the object of attention, but the medium that creates the subject, which is the music.

In my work I am looking for methods to make the instrument itself the subject and the centre of attention. When I write instrument I do not think about the actual physical object, but rather the sound of the instrument. These sounds may refer both to the historical connotations of the instrument and its pure physical properties and everything in between.

4.1 Three modes of performance

Every instrument has a number of ways to be performed on, each way resulting in different levels of physicality ranging from the abstraction of tradition to the instrument as a pure physical object. I realize that the following three categories are not absolute, but rather mutable. Of course it is possible to group sounds differently, however this is the distinction I am making.

The traditional way:

Meaning the way an instrument is traditionally allowed to sound within the framework of the orchestra by the end of 19th century. The framework of the orchestra is, as earlier mentioned, a border that especially within the last century has been broaden a lot, which is why I use the turn of the 19th century as a marker. Also Rimsky-Korsakov's book *Principles of Orchestration* is from this period. All techniques and ranges mentioned in the book fall within the traditional way.

The accidental way:

Like with Schaeffer's "odd moments" I like to compose with the errors or accidents, in which case I have to produce them. Errors tend to demonstrate some of the physicality of the instrument. The way the instrument tends to sound if a skilled player does not keep it strictly in control. There are three ways to provoke errors by the performer:

- Chance, like a broken string, an object stopping the horn, a forgotten spit valve etc. This is often more related to the instrument itself than the performer.
- Letting an amateur play the instrument. In this way a natural misbehaviour is achieved, like alternating tempo in fast passages, change in intonation, a bow or a stick might hit the wrong place, etc.
- Ask a skilled professional to play extremely difficult passages, like working in extreme registers, extreme tempi, difficult jumps, etc. The errors occurring are often similar to the ones of the amateur, however, in much more impressive phrases. To me the errors of a professional musician can really show the instrument as an untameable beast, that no matter how controlled it might be, always can show a hidden side of itself.

Extended techniques:

Extended techniques are an attack on the instrument with a non-traditional approach. This is often an extremely effective way to show the physicality of the instrument. Even so much that the instrument becomes unrecognisable to the listener. The extended techniques are an equally questionable term as the traditional ways, but for now, let us define extended techniques as all ways of producing sound from an instrument not covered in *Principles of Orchestration*.

In each of my pieces, these three ways of playing occur.

4.2 The speaker and the computer

According to the Merriam-Webster dictionary, an instrument is *a tool or device used for a particular purpose*. In the core definition of the word an instrument is thus seen as a tool with a purpose different from itself, an object or a medium.

For me it is important to emphasize the instrument as being the subject and not the medium, thus I have found it necessary to disconnect the sound entirely from the instrument

itself. I use the computer and the speaker as my medium and keep the instrument away from the performance. This way I have an airtight distinction between my medium and my subject. Figuratively speaking, I am using the speakers as a canvas to paint the instrument, rather than exhibiting the instrument itself. Whenever I refer to the *subject*, I talk about the instrument in question.

Furthermore, in the distinction between medium and subject, I get rid of the performer. The performer is problematic in a portrait of an instrument. Since most performances tend to be about man taming the instrument rather than the instrument itself. I want, by no means, to present virtuosity by man in my pieces, but rather to show the instrument detached from the performer and what is performable with it.

The computer gives me the possibility of altering a sound to my liking. I can create my personal version of the instrument, present my interpretation of the instrument, and superimpose the instrument on backgrounds that make the subject stand out or transform it in to abstract representations of the subject itself. It is by the computer I move away from the pure phonographic realism, towards my representation, which distinguishes the subject completely from its surroundings.

4.3 Four functions of the computer

I distinguish between four different functions of the computer:

Simple editing:

Simple editing is including more or less all the processing techniques mentioned or discovered by Pierre Schaffer in *In Search of a Concrete music*. Simple editing allows for isolating single sound events and playing them at any moment over the duration of the piece. Also it allows for continuous variation of playback speed (playback rate is often used in the digital domain), and amplitude (fades and cross fades). As it will be shown, these techniques are, even though simple, a corner stone in my work.

Processing:

Here, I think about any kind of digital or analogue effect that alters the original recording. I further distinguish between two different kinds of processing:

1) Pre-processing, which is basic equalisation and compression. It is, in some sense, “inaudible” processing, that only makes the subject fit better to its new medium, the speaker. Pre-processing mostly includes equalisation, noise reduction, and compressing/gating. I also use it to clean up unnecessary noises in order to *seek direct contact with sound material, without any electrons getting in the way*, (quotes?) as Schaeffer (2012) puts it.

2) Post processing, which are clearly audible processes such as filters, delays, modulators and spectral editing etc., processes that has a function in the musical form.

Pre-processing is used on all sounds in all pieces. Post processing is often used to show the instrument from a new perspective after the original sound has been presented. A further discussion on the different techniques can be found in the description of my pieces.

Synthesized representations:

Synthesized representation has an overlap with processing. It is a sound that consists of electronically synthesized sounds, but referring to the original sound of the subject. Either by being obviously similar in sound quality, or by copying parameters from the subject, like envelope or pitch.

These can be introduced as a movement from the original sound of the subject on to its representation or opposite, from representation to subject. It is an effective tool to point out some contrasts or behaviours. Trevor Wishart (2010) uses this technique in his pieces to contrast the clean recordings of voice; his *sounds abstracted from the speaking voice [is] deployed more like musical instruments*.

Abstract sounds

The Abstract sound is the one that is completely synthesized and doesn't relate in any direct way to the subject. These sounds usually function as a background or a contrast to the subject in order to make distinct qualities stand out. I am very careful with using pure synthesized sound unrelated to the instrument. A dominant abstract sound can fast turn the listeners attention away from the instrument, the subject, making the piece about the synthesizer rather than the subject. Abstract sound does, however, occur in some of my pieces.

4.4 On space and spatialization

Space is for me one of the most important elements in composing with sampled music. There are three instances of space present at the same time: the space of the recording, the space of the processing, and the space of the performance (the concert hall). Where the first two are truly compositional elements, the later is, usually only to a limited extent, for the composer to decide. I have composed my last two pieces with the Schoenberg Hall at the Royal Conservatory in mind, not suggesting that, that hall is the only possible venue for my pieces. My compositions are by no means site specific. All of my pieces are for multiple channels on separate speakers. *The 7 trombones* is for five channels arranged with two speakers in front two in back and a centre front speaker. *Grote Trom* and *The Triple bass* both have eight channels evenly distributed in a ring around the audience, the classic “Sonology speaker orchestra”.

Since I'm trying to present the instruments on their own, as subjects not relating to a person or a space, I am never interested in the sound of the space of the recording. Thus, while recording my samples I always try to diminish the effect of the space as much as possible. I achieve this by carefully placing multiple microphones as close to the instrument as possible and making the room as dry as possible. This method is common practice in popular music, instead of trying to create a spatial stereo image as is seen in many classical music recordings.

This again give me a feeling of Schaeffer's direct *contact with the sound material* (Schaffer, 2012). The close microphone technique also allows me to amplify various places on the instruments for various purposes, as will be seen in the later discussion.

The “dry” sound material allows me - if we for now set aside the reverberation of the hall - to create my own space for the instruments. This leaves me with the question; what space does fit: 1) The instrument, 2) The form of my pieces? I work with two different types of spatialization: *One speaker to one subject* where each speaker has a static source that each has some distinct function in the piece. These roles can be a specific pitch, a special rhythm, or a different kind of processing applied to the material. In this way, each speaker has a very defined part in the piece, and the final piece is mixed in the room rather than in the sound file. I consider this a kind of orchestral approach where one could imagine 8 instruments sitting

around on the balcony, each playing their voice. I try to always have the leading role played in the centre front speaker. This speaker has a privileged position due to its implied proximity due to its positioning. The centre speaker radiates sound directly at the audience with (optimally) no phase difference between the ears of the listener.

The other type of spatialization is the moving source or *one pitch one position*. In this spatialization, fixed tones in pitch are still static, portamentos are moving according to their length and pitches. I draw a map of the concert hall and place pitches as points around in the space. Afterwards, I let the sound travel between the points according to the pitch of the sound. The result is symmetrical movements and geometric shapes in the room representing different chords. This can be an amazing strategy to underline form elements. Both strategies have an ability to surround the listener with the sound of the instrument, as in Wishart's words, "*Immerse listeners in a community of human voice*", or instruments in my case. This happens without simply playing back the same sound from all speakers, but creating a vividly changing sound, that even though abstract in terms of space, still remains very true to the source. In one case an outwards spiral movement is made by slowly introducing reverb while decreasing the level, to simulate increasing distance. This can also be away of "fading" sounds out. Reverb effects seem to work excellently in small studios, although in a big hall like Schoenberg hall, the large existing reverb seems to make the added reverb less noticeable.

4.5 The Process

Each of my pieces has gone through a similar process. After choosing the instrument a careful examination of the subject is made; what special characteristics and attributes does it have, what can it do and not do, and how does it work? Afterwards, a number of experiments are made with samples, typically taken from the internet. With these experiments in mind I create a score in order to know exactly what I want to record from a performer. Sometimes it has been necessary to come back for more files or revise the score after the recording sessions. The material is then processed and edited to my liking. Then additional material is created, and everything is put together according to the score. The scores are usually not exact to the second, but works mostly as a guideline for the composition. It is, to a larger extent, a tool to have an overview of the piece, rather than a manuscript. The scores remain sketches for my own use, however I have typed out one score that can be seen in appendix 1.

My scores are always in three parts lasting in total approximately ten minutes. Each part is describing some aspect of the instrument's personality. I do not try to tell a story or narrative in my pieces. There is no natural beginning or end, taking the listener from one state of mind to the next. My goal is to present an instrument as I hear it, and nothing else. I try to isolate one different way of performing the instrument in each part. Deleuze (2003) argues that

Isolation is the simplest means, necessary though not sufficient, to break with representation, to disrupt narration, to escape illustration, to liberate the figure

Even though Deleuze speaks about the painting, I argue that the same holds for music: earlier, I have already discussed that musical instruments are, to a lesser extent, at risk of becoming a narrative more than everyday objects. But by isolating the instrument and putting it up against a backdrop that is completely unrelated to its natural surroundings, it seems completely free. This is another reason that the positioning of sound, my spatialization, has to be abstract and symmetrical rather than natural and realistic.

The processing itself also has a function of isolating not the instrument itself, but specific attributes of it. By blurring out some details of the sound of an instrument, or by replacing them with abstract instances, all of a sudden other modes become clear. The synthesized representations almost always have this role of isolation.

5 Four audio portraits

5.1 The 7 Trombones

The 7 trombones was the first of my portraits of instruments and laid the foundation of the series of pieces. The choice of the trombone as sample material came naturally as a beginning, due to my many years as a trombone player.

Originally, I intended simply to experiment with a form where I could show other people my fascination with the trombone and its peculiarities, without having the physical instrument and the limitations of a performer. The whole piece was made as a fixed media piece, with recorded samples of the trombone arranged and manipulated with a computer afterwards.

5.1.1 The Glissando

In a certain sense, this piece has been developed over many years. My original fascination with the trombone, and the reason I chose to play the trombone at the age of 6, was to a large degree, the glissando. The effortless movement from one tone to the next, and the sudden emphasis on the movement from one note to another, still fascinates me. Whenever I play or hear a glissando, I am still as intrigued as I was when my father dragged me to ragtime band concerts, and I thought the trombone sounded like a funny elephant. Upon getting my first computer at age 14, I composed a small piece that would play every time the Windows operative system would open. It was recordings of myself playing three glissandi on top of each other. One going from D down to Bb, one going from D up to F and a last one stable on D. In this way I made a movement from the single tone D to the Bb major triad over the course of 5 seconds.

It was Natural to remake the composition with the techniques I had gained both in editing and recording during my stay At ESMuC in Barcelona. This movement is, with a few changes, the entire first four minutes of the piece.

Upon my experiments and tests to make this new version of my “Windows start up sound”, I realised that I myself was not the right trombone player nor was my trombone

suited for the kind of sounds I imagined. I used the opportunity of being in a music academy surrounded by musicians and having access to professional studios to install myself as an engineer rather than a performer. The results were much more to my liking and I have continued this procedure in my later pieces. I realised that I had much more control in the control room than when I had to play myself, not unlike Piere Schaeffer's discovery:

You can not be two places at once. I must choose between the studio and the sound booth. This is where I finally took refuge. [...] I operate through intermediaries. I no longer manipulate sound objects myself. I listen to there effect through the microphone. (Schaeffer, 2012)

This way of making music did, however, also require a certain amount of preparation. Since I could not just create new material whenever I wanted, I had to know exactly what I wanted for my piece before I started the recordings. I decided to come up with a few more ideas before bothering a trombone player.

5.1.2 The fool and the divine

Another concept of the trombone, or another part of its personality is what I call “the fool”. The trombone is commonly taken for a funny or even silly instrument. I have already mentioned the obvious comparison with the trunk of an elephant, but maybe the classic “sad trombone sample” [sound example 1] is an even better example. In my playing, I have usually tried to get away from this association, but in this piece I decided to embrace it, by making a whole part of the piece dedicated to funny speaking elephant sounds. In the score you will see the dialogue on which the sounds are built. It's an argument between 5 trombones, in each their own speaker. The text in the score [see appendix 1] is in Danish and it is not meant to be understood, nor is the listener supposed to think of it as an argument between trombones. The text is only to illustrate my thought process during the making of the piece. The whole part should, as with the first part, be thought of as a mode of the trombone.

Another aspect of the trombone is the majestic or the divine. I try to embrace this in the third part of the piece. When I say divine, it is highly due to language confusion. The word σάλπιγξ (salpigx, an ancient nature horn) that is used several times in New Testament is commonly translated into “trumpet” in English translations (like in REV 8,2). In the Scandinavian and German languages however it is translated into trombone. Thus in the Danish language “trombones of judgement day”, “trombone angels” and “trombones of

Jericho” are common expressions. The name of the piece is derived from the seven “trombones” of judgement day.

The last part of the piece is a majestic gesture with the trombone emerging out of the noise into a chord and further in to a single pitch with long solid tones. It’s a movement from the flat spectrum to a single complex tone pointing towards a supreme ruler.

I decided to make the movement from the fool to the divine in such away that the “argument” of the trombones, became more and more complex. Meanwhile, the sound of each trombone became spectrally more and more simple, until there were only sinusoidal clusters left. These clusters would turn into noise and the “divine” trombone sounds would merge out of the noise.

My first attempt on making the trombone sounds spectrally more simple was to use phase vocoding and bin reduction. I soon realized that this method had a too specific sound, that didn't match up with the sound world I hoped for. The phase vocoding sound took over the sound picture and took attention away from the trombone, the subject of the piece. I decided instead on pitch tracking the movement of each of the recorded trombone phrases, and then applying a band-pass filter on the material and gradually raising the Q over the course of a minute until there was only the ringing of the filter left. This process had a more analogue feeling to it and rendered better with the trombone sounds. The pitch tracker showed to have some errors, which I ended up ignoring. The errors only made the material more vivid and alive and matched well with the uncontrolled fast movements of the trombone. When the Q was at maximum, the input of the filters was gradually changed to pink noise and then the Q of the filters, still following the trombones, was brought down again to a level so the result would be an unstable low-pass filtered noise. This noise was then, using gradually multiplication of the spectra (morphing), morphed into the trombone sounds.

The unnatural long glissando in the beginning and the end was achieved only by cross fading small overlapping pieces of glissando into one long glissando. The glissando in the beginning from D to Bb was alone put together from 20 different pieces. This was made possible by the trombone player Maria Torre's extreme precision in playing.

5.1.3 Geometrical spatialization

The trombone piece was also my first exploration of space as a form element. What I have called the geometrical spatialization (see appendix 2). In the beginning of the piece when the melody shifts from one tone, the D, to the B-flat triad (red), the spatialization also shifts from one point in the room into a triangle standing with D in centre front and B-flat and F on each of the two rear speakers. The shift into a parallel chord one quarter tone below (blue), also creates a parallel triangle opposing the first one in the room between the left and right front speakers and a virtual point between the two rear speakers. The long movement from the two B-flats towards the B-flat triad one octave below the existing triad (green) shows as a circle, movement surrounding the two triangles, until they end at the same position as the original first B-flat triad. There is an opposite movement by the end of the piece, when the B-flat triad moves back to the one tone, D.

5.1.4 Evaluation

Even though I today consider *The 7 trombones* the least successful of my audio portraits, I was surprised by my ability to put highly conceptual thoughts into action. In earlier pieces, I had problems creating sound that would match my initial idea, and the process where often related to more or less random procedures, creating sounds to my liking that was then put together. *The 7 trombones* was my first piece, where I felt a sense of control from the beginning to the end of the creation process, which resulted in what I think is a much more mature and confident piece, than I had ever made before. Upon premièring it, I was surprised at the result of a number of form decisions. The initial glissandi seemed all of a sudden to short, and the speaking part to long.

The piece was realized in an 8m², sound dampened studio, and many of the more delicate effects that worked well there were smeared out by the reverberant hall. Especially, I realized that if I wanted to use reverb as an effect, I would have to overdo it noticeably for it to work well in a large hall.

Most importantly, I realized that even though I had a lot of tools on the computer for manipulating the audio, the original recording had an enormous impact on the final result, and should not be neglected. I took some of my experiences with me to my next piece.

5.2 Grote Trom

By the end of my stay in Barcelona, I had the possibility to engage in my first larger recording project. I did a recording of the piece *En 2013 toutes les 4 secondes...* by Jean-Luc Fafchamps, for percussion, which had a repeating pulse on a symphonic bass drum every 4 seconds. My original intention was to make a processed and spatialized version of the piece. While working with the material I soon became more and more interested in the sound of the bass drum itself. The gut shaking boom and the long tale of resonance, the fact that such a big instrument has such a limited range of sound. All of it fascinated me so much that I decided to make a piece in the same style as my trombone piece, only for bass drum.

I soon realized that my experience and association with the trombone was much more extensive than with that of the bass drum. Also, my only material for experimentation was one sample taken from the recorded piece of a bass drum struck with a foot pedal. None of my experiments worked out very well and it was not until I heard the bass drum concerto of Gabriel Prokofiev and Michelangelo Lupone's brilliant feedback piece *Gran Cassa* that I really realized the potential of the bass drum. There were two questions of the bass drum that I found particularly interesting to work with: How can the one “boom” be spread out in time and become a musical form? And is there any high frequency material hidden in the bass drum?

To answer these questions, I had my first meeting with percussion player Rubén Castillo, who had specialized in the bass drum. I felt after this meeting that I had familiarised my self enough with the bass drum to create a score for the piece.

The answer of the first question turned out to be easier than I had hoped for. I tried with different methods for extending the tale of a single hit on a bass drum. I tried with cross fading as in the “7 trombones”, time-stretching, and mixing with a physical model of the bass drum. It turned out that what was closest to my idea was a simple roll on the bass drum. With a bit of EQ and compression, I could make the attacks of the mallet disappear, leaving only the boom-y resonant sound of the drum itself. These long rolls are the foundation of the first part of this piece.

5.2.1 The inescapable bass

Finding high pitch material in the bass drum turned out to be a much larger quest than I had expected. Before my meeting, I had one proposal, to experiment with hitting the rim, getting the high pitched metallic sound. I soon realized that even though I liked the metallic sounds, the entire resonance of the drum followed after like a shadow. It was a part of the bass drums personality that was impossible to get rid of. Upon recording, I worked with two microphones: a bass drum microphone for the low frequencies on the back of the drum, and a cardioid condenser microphone to pick up high frequencies and the hit on the skin on the front. For the high frequencies, I experimented a lot with taking out the bass drum microphone and record extremely close to the mallets of the performer. This turned out much more successful, even though I had to EQ quite a bit afterwards in order to achieve the sound that I had initially hoped for. I realized that the bass resonance is such an important part of the bass drum, that the artificially high-pitched material was almost unrecognisable as a bass drum.

This concept, of an inescapable bass, I used as inspiration for the next form section. Ruben Castillo presented me with the sounds of the friction of a moist thump or rubber balls on the skin of the bass drum that produced high-pitched sounds. The material varied between sounding like the scream of a seagull to a whale in mating season. The subtle rumble around the resonance frequency of the bass drum was always present. What I experienced was that even though the low frequencies were subtle on each recording, when layered they became very present. While the high (different) frequency material stayed the same level the resonance frequencies of the bass drum summed up to an immense rumble, slowly overtaking the high frequencies, the more layers that were added. In this way the bass drum drowned itself in its attempt to play high frequencies.

In the end I used the hit, the roll, the rim shots and the moist thump sounds to create the whole piece.

5.2.2 Electronic aid

For “Grote Trom” I mainly worked with electronically generated material as a background for the recorded material, a kind of counterpoint to make the bass drum material stand forward. By the end, I also used reverbs and effects as a method of transition and guiding the form.

The first introduction of postproduction is the third hit of the bass drum that is preceded by a row of rabbit hits reaching a crescendo. The hits are followed by patterns of short impulses overlaying the rumble of the bass drum. The idea is that the pulses fill out some of the spectral gaps left by the bass drum in order to make a richer sound, without taking attention away from the subject, the drum. Later, a low frequency noise is added in the mid-range filling out the remaining gaps. This is the beginning of a build up of intensity, ending with a time-stretched version of the initial hit played backwards. The hit makes a sudden stop and marks the ending of the first part with a short silence.

The second part of the piece is a play on expectation. It starts in the centre speaker with the fast metal sounds of the rim, the unexpected sound of the drum. Then 7 more layers, in each their own speaker, are added in slightly different tempi. Then slowly regular bass drum hits are appearing while the rim hits continue. Slowly over the course of 5 minutes, a vocoded version of the rhythms are faded in while the original rhythm is faded out. I used 4 different vocoding-like methods played in 4 different spatial positions. The vocoding was done in SuperCollider by applying 64 parallel band pass filters spaced one whole tone apart over 10 octaves to the original rhythm. The amplitude data from each filter was then applied to 4 different kind of synthesis:

- The same bank of filters filtering pink noise.
- The same bank of filters filtering a steady pulse train at 15 Hz.
- Frequencies of sine waves corresponding to the centre frequency of each filter.
- Frequencies of pulse trains corresponding to the centre frequency of each filter.

The idea was to recreate the material, but due to the imperfections of the reproduction method, pitched material was introduced into the very non-pitched percussion sounds. The result is a kind of old-fashioned analogue sound that still undoubtedly carries the characteristics of the bass drum. While the sounds change more and more into this electronic representation, they also start to swirl around the listener faster and faster. With a slow increase of a reverb, it gives a feeling that the sounds drift outwards and disappear somewhere far away. Then the sounds of the moist thump on skin appear with an almost surprising proximity. The thump sound remains unedited to clearly show the mentioned effect of the bass drum “drowning” itself. A drum roll slowly takes over and to each speaker is applied it's

own unique delay time for a comb filter between 100 and 350 ms. None of the filters have any decay, resulting in an increasingly messy and loud swamp of bass frequencies. From the centre speaker appears a final roll, unprocessed, showing the last of the power left in the bass drum to the audience. I asked Ruben Castillo to play louder than possible and in the recording a distinct rattle from the stand is present, along with inconsistencies in rhythm due to the large amount of power put in. The long roll is a quote to the roll of the beginning.

5.2.3 Spatialization

Like the trombone piece, the triangle is a strong element in the spatialization of *Grote Trom* (see appendix 3). The three initial drum sounds (red) are moving from a triangle to a single point in the middle of the room. When the third drum is appearing in the rear left speaker, the layer of pulse and low frequency noise (blue) is moving from a line in the rear towards a line across the room between mid-left and mid-right speaker. The backwards, time-stretched hit (green) moves in a parallel movement from front to middle. The idea of separate movements in separate speakers is also apparent throughout the second and third part of the piece.

5.2.4 Evaluation

The process of creating *Grote Trom* was, to a large extent, a *less is more* approach. I tried, based on my experiences with the *7 Trombones*, to extend the more static parts longer than what I found comfortable myself. This turned out to have a strong and engulfing effect on the listeners, both according to myself, and some of the feedback that I later received on my piece. I was generally very content with the fact that I managed to make this piece suit the Schoenberg hall well. Contrary to the *7 trombones*, I felt that the hall complimented the piece rather than hindered it.

5.3 The Triple Bass

The Triple Bass was my third piece in the series, and I decided to explore the double bass. The double bass had long intrigued me. It seems contrary to its size to be a unnoticed instrument. It occurs in an extremely important role, both in the classic tradition, jazz, and folk tradition. Yet solo pieces are rare, and bass solos in jazz are often the least noticed solo. I found two things that I wanted to focus on with the bass:

First of all, I was, like with the bass drum, fascinated by the size and the physicality of the bass, especially the immense amount of force needed by the player for fortissimo in arco passages, or in the Bartók pizzicato (a particularly strong pizzicato where the string is plucked vertically by snapping and rebounds off the fingerboard of the instrument). I was highly inspired by the forcefulness in Ligeti's atmospheres at bar 40 [sound example 2].

The second aspect I found interesting was the large range of the bass. A skilled player can play a range of more than 5 octaves. The upper three octaves, however, are rarely used since the player has to play harmonics rather than fundamentals of the string. It was these “weak” harmonics that interested me, and the high difference in timbre between the harmonic frequencies and the fundamental frequencies. My interest lies in the contrast between the full resonant sound of the lower string, (especially, the open A string was very strong on the bass I used) and the weak high frequent sounds that do not work properly with the enormous body of the bass.

5.3.1 The form

The entire first part is dedicated to this play of timbre between the electronic representation, the manipulated sound, and the natural sound. First, an electronic representation appears, a simple sawtooth wave modulated slightly added a low frequency reverb to simulate the resonance chamber of the bass. The sound, I found, was successfully placing itself in between the electronic and the acoustic domain. The high-pitched tone enters and sounds somehow even less like a double bass than the electronic representation. In a proportional canon movement, the high-pitched tones spread into different tempi electronically pitch down over four octaves, all in turn ending at the pitch A. When all tones have rested, the actual pitch on the A string is bowed showing the difference in timbre between the two ranges of the instrument. A series of Bartók pizzicati are played with a massive preverb in order to bridge to the next session.

The next session focuses exactly on the Bartók pizzicato; this is performed by a large physical action and thus takes some time before the action can be repeated. In this part, I played with the ability to repeat this sound via delays. When was it a repeated sound of a bass and when did it become a pure abstract rhythm? I packed this in a minimalism-inspired form, where a number of fixed rhythms phased in and out of each other creating ever changing complex rhythms. The eight layers were spread out over 8 speakers. The tones E, A, D, G, the open strings, were spread out in a diamond across the room. On a 45 degree shifted square, the tones B, E, A, D (marked with '), one-fifth above the open strings were sounding (see figure 2).

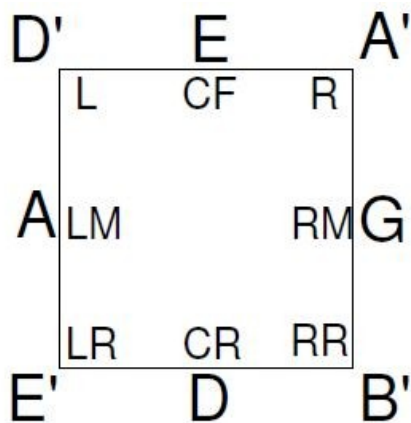


figure 2: The ordering of pitches in the space in Triple Bass

This way, I was trying to emphasize the fourth relationship between strings in the traditional tuning of the double bass. This is one of the major differences from the other instruments in the string family, that is all tuned with a fifth between their strings.

I wanted to make a gradual movement away from the timbre of the double bass before I introduced it again in the last part. At the same time, I wanted to keep the rhythmical pattern and the envelope of the pizzicati. I

decided to introduce a low-pass filter in the feedback

chain, towards the ending of the second part. A small resonance at the cut-off frequency of the filter (between 500 and 10,000 Hz) insured that every time a new pizzicato was played, the tone would ring more at the resonant frequency, until only an almost sinusoidal ringing was still left in the original rhythm. On each speaker, a different cut-off frequency was chosen resulting in a high-pitched, harsh, and dissonant chord by the end of the second half. Different Q-factors were calculated for the different tempi of the rhythms in order to time the length of the bass-to-resonance movement. When all of the speakers are at there most resonant, their loudest, they are abruptly stopped and replaced by the rumble of 8 layers of the double bass playing the open string E on each their speaker arco and fortissimo. The Whole hall is resonating in gut-shaking, continuous bass frequencies, contrasting the abrupt high frequencies in the previous part. This part is very simply showing off the true nature of the bass the low rich tones as powerful as it gets. The composition terminates after about a minute of this one tone.

5.3.2 Evaluation

I had intended each of the three parts to take the same focus in the piece. But since the middle part, the pizzicato part was considerably longer than the other parts, the piece was considered by many of the listeners, one part with a intro and an ending. I like generally to keep the middle part of my pieces a little longer in duration than the beginning and the end, since the listener seems, to my experience, to have more focus the first few minutes and the last few minutes of a piece. By extending the middle part I can enhance the focus, and equal out the awareness of each part. In this piece I might have overdone it a bit. Generally, however, I was very satisfied with the piece, and I felt that I, like with the *Grote Trom*, managed to make the large hall work for me rather than against me.

5.4 192 Violins

The Institute of Sonology has a cooperation with the *Game of Life foundation* about using a Wave Field Synthesis (WFS) system. The system consist of 192 speakers and eight subwoofers, all controllable by a dedicated software that can emulate point sources at any place in the room and thereby create “virtual spaces”. However, the system can also be considered as 192 individually controlled, simple speakers. I am, during the spring 2014, working on a piece using the system in this manner, a non-wave field approach. The whole piece is an exploration of the *one pitch one position* approach mentioned earlier. The idea is simply to spread 192 distinct pitches of a violin over 192 speakers. A skilled player can play a little more than 4 octaves on the violin or 48 distinct chromatic pitches. A further division of four pitches within every semitone results in exactly 192 pitches.

5.4.1 Arrangement of pitch in the room

Each pitch is being assigned to one speaker, and melodies will, with the change of pitch, also change positions. Melodies can thus be expressed as patterns in the room as well as in a score. In appendix 4, three different modes of the room are presented with three different ordering of the pitches, from the simple low to high ordering, where simple shapes have complex melodies, to more complex patterns with complex melodic structures having simple shapes.

The three models of placing speakers in the room that I am working with presently are all taking some kind of chromatic approach:

Eighth-tone chromatic: Simply ordering the pitches from low to high clockwise around the system eighth-tone chromatically.

Semi-tone chromatic: Ordered semi-tone chromatically on each side of the system, so that each side has four octaves from low to high pitch displaced one eighth-tone on each side.

725 cent row: Ordered in a row of augmented fifth (exactly 725 cents), from low to high, wrapped around four octaves in such a way that whenever a tone exceeds the highest pitch, it is transposed down four octaves. This row of augmented fifth repeats

itself in a series of 192 steps, like the circle of fifths repeats itself in 12 steps.

These are the 3 orderings I have experimented with, and can be seen in the appendix 3. In the model each ordering is represented by three boxes, with a line representing a different melodic movement in each of them. The melodic movements are the same as the pitch ordering of the speakers clockwise. For instance the upper leftmost box is representing the movement of the 725 cent row played back in a eighth-tone chromatic space. Other models could be thought of, creating different patterns.

5.4.2 Three elements of the violin and the space

I want to work with three different elements of the violin: the pizzicato, the glissando and the whispering string.

The pizzicato is a short single event, which can be arranged without problems in the space. I imagine starting with this part, ordering the room in the eighth-tone chromatic mode, letting the tone spin from low to high. After a few rounds, a number of octaves is added creating a turning square in the room. Slowly, I fade out the lowest and highest tones of the space and create a Shepard-tone effect. The space will change while the Shepard tone continues into the semi-tone chromatic space. The space can now be interpreted in two different ways: As a fast moving Shepard tone across the room, or as four different slower Shepard tones on either side of the room.

The second element is the glissando. What I found very noticeable in my first recording session with Violinist Ana Pires, was the difficulty she had in playing continuous glissandi in slow tempi. Playing in fast tempo was not a problem, but when she needed to do a movement over an octave for more than 7 seconds, a number of weird stuttering and creaking appeared from the violin. Intrigued by this sound, I decided to push her a little bit more, and asked her to play it even slower. The glissandi, together with the creaking, are what are going to lay the foundation of the second part of the piece. I hope to be able to clean the sound so I can fade in the creaking to my liking. The listener will be emerged in several moving glissandi over the total range of the violin, some going up and some going down. Meanwhile, the creaking of the violin will be gradually amplified, giving the listener a feeling of being placed in an old wooden ship shaped as a violin. I imagine the space being ordered in the 725 cents row for this part.

The last part is highly inspired by the last part of *The 7 Trombones*: filtered white noise is played on all speakers and the whole part is a gradual movement from the noise to a single tone over the course of the part. The violin has an ability of having a half-pitched, half-noisy sound when played with very little bow pressure. This state is going to be linking between the noise and the one “clean” tone that will end the piece being played back in only one speaker.

The piece will have a duration of approximately ten minutes.

5.4.3 The future

The piece still has to be realized and further consultation will have to be made with Ana Pires in order to finalize the score. The few experiments I have made with the WFS system have proven successful and I hope to be able to realize the piece approximately as written above. I do, however, realize that a vast amount of recordings and ordering of sound material is required in order to finalize this piece.

6 Conclusions

Describing an instrument in an audio portrait is a highly subjective matter. An objective description is difficult, if not senseless, and is of little interest for the compositional process. I have made three pieces describing subjective portraits of the instruments.

The recordings of instruments that I use as a foundation for my pieces are, as far possible, taken out of a real and narrative context in order to present different aspects of the instrument as naked as possible. This has a high influence on my ideas on recording, processing, and spatialization. A fourth, not yet finished piece, *192 violins*, is especially exploring what I call *geometric spatialization*. The listening plays a central role in my pieces, and by using recognizable sounds in a non narrative context, I am placing myself in between reduced and imaginative listening, not unlike Trevor Wisharts piece *Encounters in the republic of heaven*. The three finished pieces have all been played with more or less success within and outside the institute of Sonology, and the last piece will hopefully show some new aspects of my music due to the use of the Wave Field Synthesis system.

7 References

Deleuze, G (2003) *Francis Bacon* (Smith, D.W.) London: Continuum (Original work published: 1981)

Kim, S (2010). *Imaginal Listening: a quaternary framework for listening to electroacoustic music and phenomena of sound-images*. Organised Sound 15(1), 43-53

Rimsky-Korsakov, N (1964). *Principles of Orchestration*. (Agate, A) New York: Dover Publications, Inc. (Original work published: 1922)

Schaeffer, P (2012) *In search of a concrete music*. (North, C & Dack, J) Berkeley and San Francisco: University of California press (Original work published: 1952)

Wishart, T (2010). *Encounters in the republic of heaven*. York: Orpheus The Pantomime Ltd

Young, J (2007). *Reflections on sound image design in electroacoustic music*. Organised Sound 12(1), 1-3

Grame, T.C. (2013). *Musical instrument*. In Encyclopaedia Britannica, retrieved from <http://www.britannica.com/EBchecked/topic/399171/musical-instrument>

Instrument. (n.d.). In Meriam-Webster's online dictionary (**XX ed.**) Retrieved from <http://www.merriam-webster.com/dictionary/instrument>

8 List of sound examples

- 1: Sad trombone taken from freesound.org via user Benboncan
- 2: Exerpt from György Ligeti : Atmosphères. track 2 from 4:17 to 4:38 on Wien Modern, Deutsche Gramophon, 2005, Vienna Philharmonic/Claudio Abbado.
- 3: Seven trombones (2012) Stereo mixdown
- 4: Grote Trom (2013) Stereo mixdown
- 5: Triple Bass (2014) Stereo mixdown

Appendix 1

Score of *The 7 Trombones*

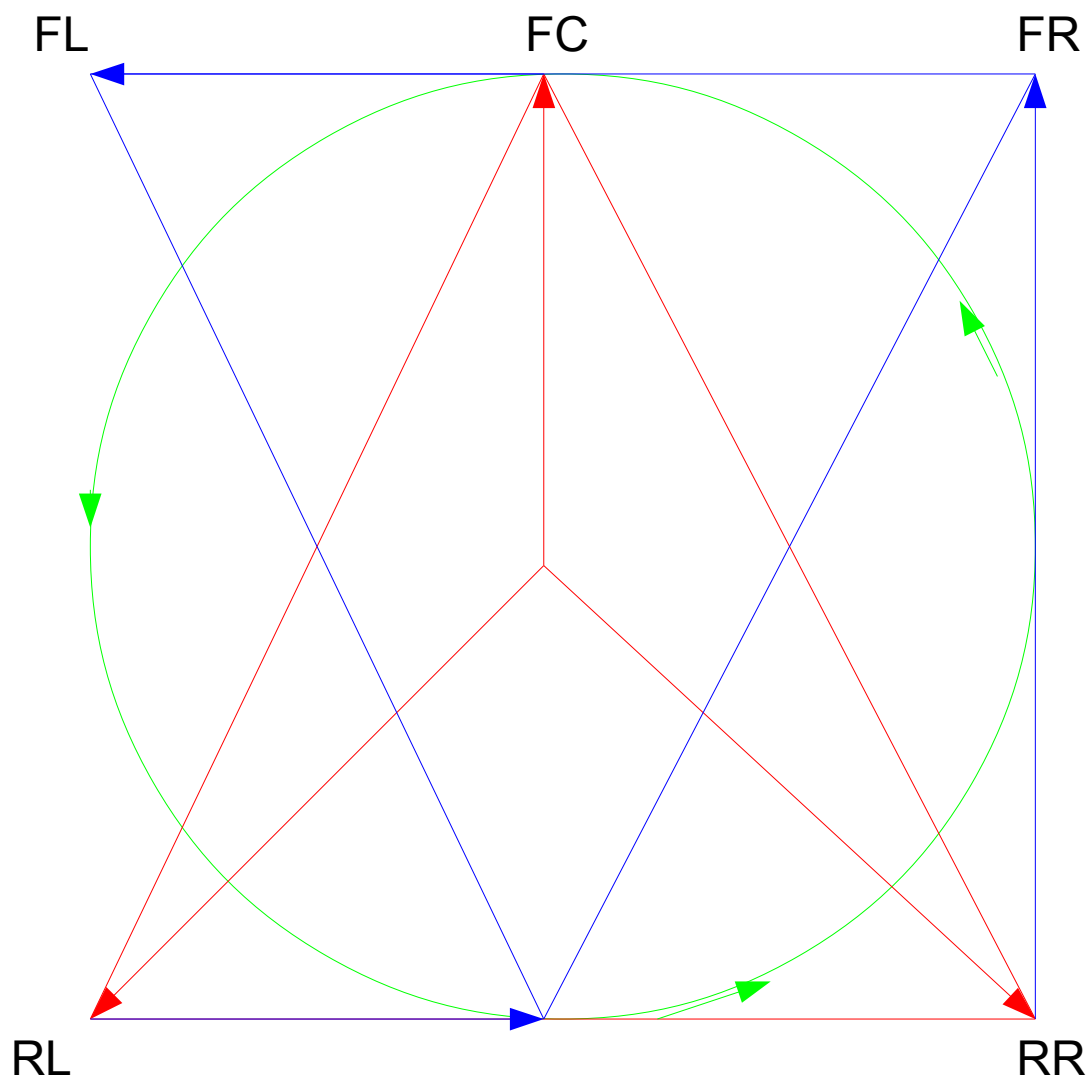
The image displays three staves of musical notation for the song 'The Rose Tree'. The notation is written in a traditional style, likely for a vocal or instrumental melody. The first staff begins with a treble clef and a key signature of one flat (B-flat). The melody starts on a middle C and proceeds with various intervals, including eighth and sixteenth notes. The second staff continues the melody, featuring a series of sixteenth notes and a final cadence. The third staff shows a continuation of the melody, with a final cadence and a double bar line. The notation is clear and legible, with a focus on the melodic line.

[illegible]

Appendix 2

Geometrical spatialization of the intro of 7 *Trombones*

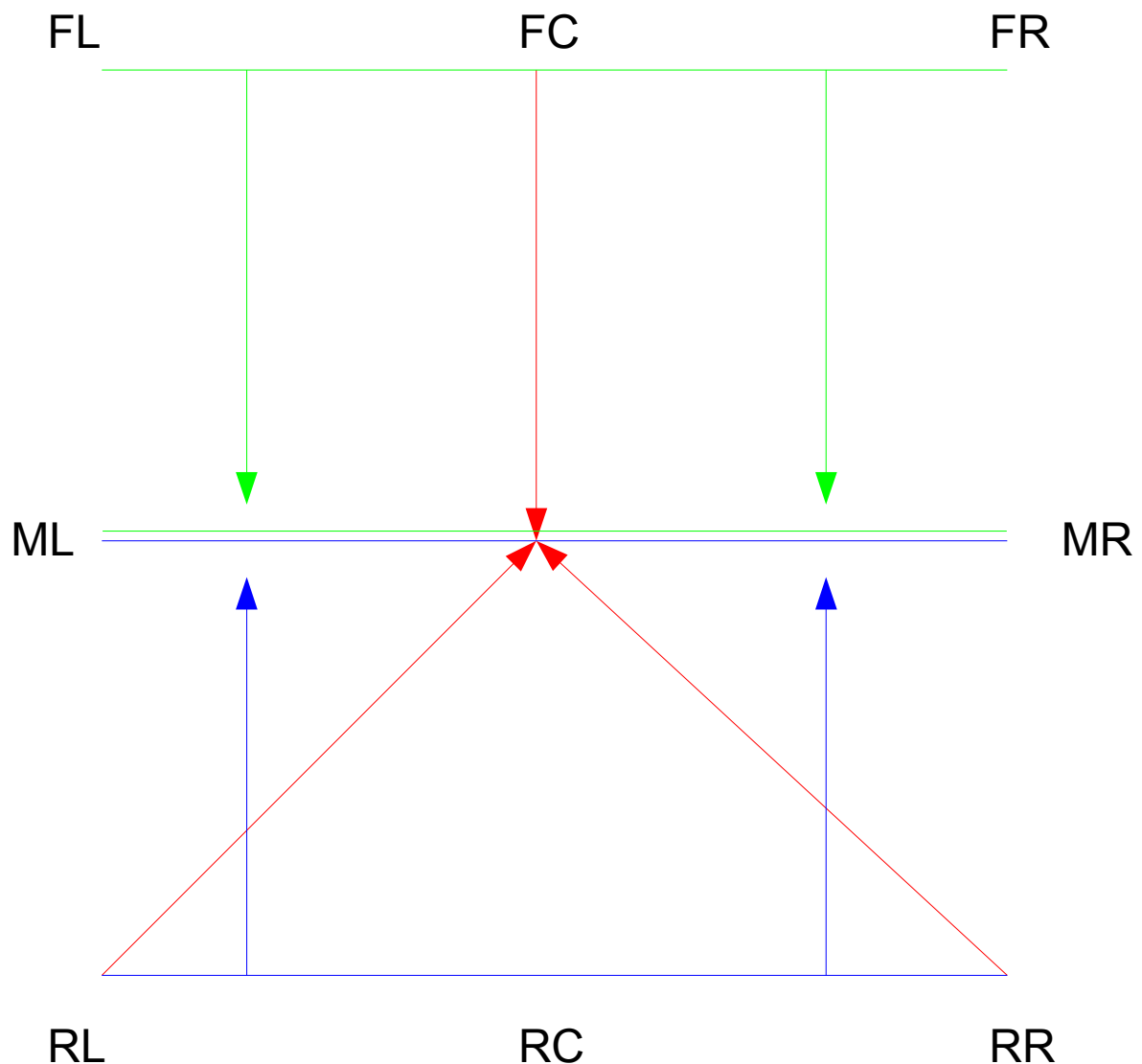
- Movement from D to B flat triad
- Triangle of B flat
- Movement from B flat to low B flat
- Triangle of low B flat
- Movement from B flat to B flat one octave below



Appendix 3

Geometrical spatialization of the intro of *Grote Trom*

- The three initial hits movement
- Movement of the digital pulses
- Digital pulses start and end position
- Movement of time stretched backwards hit
- Start and end position of time stretched backwards hit



Appendix 4

Three modes of the room in *192 Violins*

