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**Electroacoustic Orchestration**
Timbre, Space and Sound Material Organisation

Skriftlig reflektion inom självständigt arbete
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to “The Family”...
Electroacoustic music was born in the 20th Century as an alternative, integrative and parallel music to the instrumental repertoire. From the second half of the last century until now, new technologies have been developed very rapidly. This has helped to increase the ease and the possibilities of creating electroacoustic pieces for composers. Today, just with a laptop the studio is portable, unlike the studios in Cologne, Milan and Paris in the early stages of electronic-acousmatic music.

As a composer of electroacoustic music, I'm interested in understanding which characteristics of classical orchestration can be used in electroacoustic music after these years of its development. In specific, which aspects of orchestration can be used as powerful techniques in acousmatic music? The aim of this study is to create connections between the conventional acoustic orchestration practice and electroacoustic orchestration by using a transfer technique.

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1 Frank Zappa

2 Transfer: with this word I want to indicate a method of transferring techniques, thinking and composition methods from the normal instrumental approach to the electroacoustic one. By referring to this word, it is important to say that there are not official or pre-created rules. The border between objectivity and subjectivity is also very thin.
How can these aspects be “translated” into an electroacoustic context, and what are the most effective paths to follow in order to create works that are new and idiomatic to the electroacoustic medium? Another goal of this research is to deepen my knowledge of the subject of orchestration and to give a personal and subjective interpretation of the topic in a different context as acousmatic music is with respect to instrumental composition.

Stockholm, 15 March 2019
I. ON THE ACOUSMATIC

1.1. Origin

The term *acousmatic* comes from the age of Pythagoras. At that time, students were divided in two categories: advanced students (*the mathematicians*) and new students (*the acousmatics*). The first ones were allowed to see, they used to represent figures on the sand to, for example, demonstrate theorems. The second ones instead were allowed only to listen, since they were not yet mature enough and should not have been influenced by the visual aspects and proxemics of the teacher. Accordingly, Pythagoras used to teach from behind a curtain that prevented them from seeing him.

Western metaphysics is based on the relationship between cause-effect. For example, by knocking on a table, we can see the gesture and hear the sound generated as result of the percussive act. Any type of music or sound can be part of the acousmatic field in which the listener does not see the cause of a generated sound but can only perceive the sound as an aural effect.

Indeed since the creation of the phonograph and the possibility of reproducing sounds without musicians, we are accustomed to acousmatic music through vinlys, radio, cassettes, CDs, mp3 and now with music streaming platforms.
1.2. Acousmatic Music

In the field of electroacoustic music, acousmatic music (also known as tape music) represents a music style per se. This genre focuses more on the spectral characteristics of sound than musical notes, more on the motion and the movements than tempo and measures and sometimes more on the transformed sounds when the source is not clear and/or hidden. This kind of music is also played in concerts in a different way than instrumental music. The piece is prerecorded on a physical support and it is reproduced nowadays with a computer and an audio system (stereo, quadrophonic, multichannel, etc.). This is in contrast with the live performance where the music is produced at that very moment on the stage. So, for example, we could say that to listen to an acousmatic music concert, it is like to be in a symphony concert hall, where the musicians are replaced by the loudspeakers under the supervision of the sound technician and/or the composer in person. This role can be also very important, especially when the concert is held in an acousmonium\(^3\).

\(^3\) Acousmonium: (an “orchestra” of loudspeakers) it is an audio system for music diffusion invented by François Bayle in 1974 and used in the beginning mainly at the GRM in France. The original system was made by 80 loudspeakers different in size and technical aspects. At the beginning the loudspeakers were put only in the front, like an orchestra on stage and then all around the audience. Usually, the loudspeakers are divided in couples (Left and Right). A stereo audio signal is sent (split off in L and R) from the mixer board, which is managed by the interpreter, to the loudspeakers. The interpreter decides how many and which loudspeakers should receive the sound in every moment, by his personal taste and different techniques to highlight every part of the piece. Since the number of output channels is more than two, the interpreter decides where to distribute the sound in the geometric structure made by the loudspeakers. This can be made in a static or dynamic way. In the latter case, it is possible to create real movements of spatialisation live. The audience can experience then a true sound immersion. We could compare this to an experience at the movie theatre in a surround system. The new frontier now is to create musical domes of loudspeakers where the immersion experience is expanded in three dimensions (X, Y, Z).
Since the beginning of acousmatic music, a fundamental difference from instrumental music has been the fact that it does not rely on a score for its production. This important subject has been object of study for several composers, in order to find a way to represent with a score this repertoire. Still there is no unique and globally accepted score to represent this music, especially in all its aspects. It is true although that, now with the usage of DAW⁴, it is possible to visualise the music piece and its development on the *timeline*⁵, which could be compared (at least as representation of a sequence of events in time), to the classical score.

One of the most important aspects of an acousmatic piece is the sound itself, with its timbre, spectrum and *spectromorphology*⁶, while other aspects such as melody, musical meter and traditional harmony, are secondary. The sound material can be originally generated by musical instruments, voice, different physical items created by humans and nature sounds. The sound sources are recorded and then organised, edited and mixed to achieve the compositional idea. Another way is to create sounds artificially with sound synthesis. In both cases, the sound material can be treated and organised by the composer and this process can be called as “organised sound”, an expression used for the first time by the French composer Edgard Varèse.

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⁴ Digital audio workstation (DAW): “is an electronic device or application software used for recording, editing and producing audio files. DAWs come in a wide variety of configurations from a single software program on a laptop, to an integrated stand-alone unit, all the way to a highly complex configuration of numerous components controlled by a central computer.” [website] en.wikipedia.org/wiki/Digital_audio_workstation [accessed 10 April 2019].

⁵ Timeline: it is a way to represent on a DAW, in chronological order, the sequence of a several sound events.

⁶ Spectromorphology: “is the perceived sonic footprint of a sound spectrum as it manifests in time. A descriptive spectromorphological analysis of sound is sometimes used in the analysis of electroacoustic music, especially acousmatic music. The term was coined by Denis Smalley in 1986.” [website] en.wikipedia.org/wiki/Spectromorphology [accessed 10 April 2019].
1.3. Pierre Schaeffer and the *Musique Concrète*

Pierre Schaeffer was the first avant-garde composer who used the term "acousmatic" in correlation with his experimental works based on the manipulation of pre-recorded concrete sound sources. Because of this, he is also recognised as the father of *Musique Concrète*\(^7\). This music is based on the recording and manipulation of concrete sound sources, and it is different from the *Elektronische Musik* which was born in Germany in Cologne's studio (1951) and then in Italy with the *Studio di Fonologia di Milano* (1955). *Elektronische Musik* was based more on the usage of electronic devices, such as oscillators, to generate sound material to achieve compositional aims. Schaeffer considered this music as heritage of the *serialism*\(^8\), conceived and realised by algebraic methods and processes. In this sense, *musique concrète* wanted to be the exact opposite, a music built of real everyday life sounds with the aim of extracting the essence of every sound taken from its normal context and brought in the inner space of an artistic sound work. This approach is different than the conventional music approach based on notation on the music sheet. In this way, the abstract rules of music theory are left with a concretisation of the organised sound material.

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*Musique Concrète*: officially born October 5, 1948 with the *Concert de Bruits* (concert of noises) transmitted by the French radio RTF. This consists of a collection of five compositions created by Pierre Schaeffer in the same radio studios. The studies n.3 and n.4, respectively *Étude Violette* and *Étude Noire* are made by using a prepared piano (for the first time in history), which in the recording was played by Pierre Boulez. The other études are *Étude Aux Chemins de Fer* (n.1, train and train station sounds), *Étude Aux Tourniquets* (n.2, toys and percussion sounds) *Étude Pathétique* (n.5 piano, voice, harmonica, tableware and a boat).

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\(^8\) Serialism: “In music, serialism is a method of composition using series of pitches, rhythms, dynamics, timbres or other musical elements. Serialism began primarily with Arnold Schoenberg's twelve-tone technique, though some of his contemporaries were also working to establish serialism as a form of post-tonal thinking.”

I have coined the term *Musique Concrète* for this commitment to compose with materials taken from “given” experimental sound in order to emphasise our dependence, no longer on preconceived sound abstractions, but on sound fragments that exist in reality, and that are considered as discrete and complete sound objects, even if and above all when they do not fit in with the elementary definitions of music theory.⁹

### 1.3.1. Sound Object

The fundamental concept of concrete music is the emancipation of the sound from its own source. In the *Traitè des Objects Musicaux* (1966)¹⁰, Schaeffer creates a classification of sound objects by focusing on three aspects: pitch, duration and intensity. He talks about sound objects by considering a sound a phenomenological entity, extrapolated from the reality in which the sound itself is produced. Schaeffer proposes *reduced listening* as acousmatic practice, where the listener focuses only on the sound properties of a sample without thinking about the source. This procedure is connected to the ancient word *epoché*¹¹ as used by Husserl, where the listener must approach the fruition of “the new” and “the object” as a unique experience, by suspending every type of judgement. To induce

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¹¹ “Epoché is an ancient Greek term typically translated as “suspension of judgment” but also as “withholding of assent”. The term was popularised in modern philosophy by Edmund Husserl. [...] Husserl elaborates the notion of ‘phenomenological epoché’ or ‘bracketing’ in Ideas I. Through the systematic procedure of ‘phenomenological reduction’, one is thought to be able to suspend judgment regarding the general or naive philosophical belief in the existence of the external world, and thus examine phenomena as they are originally given to consciousness.” [website] en.wikipedia.org/wiki/Epoché [accessed 10 April 2019].
the listener to do so, for example Schaeffer used the Closed-Groove (or Locked-Groove) technique, where every fragment is copied several times on the same vinyl to create a loop; after repetitions of the sound, the listener will focus more on the sound properties and less on the source.

In fact, Pythagoras’ curtain is not enough to discourage our curiosity about causes, to which we are instinctively, almost irresistibly drawn. But the repetition of the physical signal, which recording makes possible, assists us here in two ways: by exhausting this curiosity, it gradually brings the sound object to the fore as a perception worthy of being observed for itself; on the other hand, as a result of ever richer and more refined listenings, it progressively reveals to us the richness of this perception.¹²

Among the other techniques used, before with vinyls and then with magnetic tape, there are two other important ones: manipulation of sound envelopes and reverse playback techniques. The former becomes important when Schaeffer realises that by cutting the attack from a bell sound, the sound sample becomes similar to an oboe sound. Because of this experiment he understood that the timbre of a sound relies not only on its harmonic spectrum but also on other characteristics such as the attack.

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1.3.2. Sound Object Classification

Pierre Schaeffer creates different categories of sound objects. Shown below, a schematisation of the main characteristics that will be helpful during the development of this dissertation. For an in-depth study, it is suggested to check the original treatise: *Traitè des Objects Musicaux* (1966).

Schaeffer creates a macro-subdivision of sound objects by two main properties: pitch / freq. range (*mass*) and duration (*facture*). Furthermore, he classifies different types of sound objects.

### MASS → Sound Object Frequency Range

<table>
<thead>
<tr>
<th>1• TONIC: fixed and identifiable pitch</th>
<th>2• COMPLEX: fixed pitch not identifiable</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Pure Sound/Tone (synthetic, i.e. sine wave)</td>
<td>• Nodal Sound</td>
</tr>
<tr>
<td>• Tonic Sound (harmonic timbre, i.e. instrument)</td>
<td>• Groove Sound</td>
</tr>
<tr>
<td>• Groove Sound (non harmonic timbre, i.e. mechanical)</td>
<td>• White Noise</td>
</tr>
<tr>
<td></td>
<td>• Coloured Noise</td>
</tr>
</tbody>
</table>

| 3• VARIABLE: organised variable pitch | |
|--------------------------------------| |
| • Slow sound, continuous, extended (i.e. siren alarm) |
FACTURE → Duration Energy

1. CONTINUOUS:
   held sound

2. PUNCTUAL:
   impulse

3. ITERATIVE:
   repetition
Types of Sound Object

1. Well balanced/tempered:
   music notes

2a. Redundant:
   excessively banal
   or regular

2b. Homogeneous:
   identical
   and repeated

3. Eccentric:
   complex
   - Accumulation (prolonged with micro-sounds)
   - Cell (fragment taken from a track)
   - Sample (continuous but disorganised)
   - Fragment (short fragment of a music note)
   - Big Note (short variation of a music note)
   - Pedal (loop of a repeated cell)
   - Texture (overlapping of prolonged sounds)

4. Variations:
   sound organisation
   - Motif (experimental sound objects)
   - Group (modular agglomerated of music notes)
1.4. Technological Listening

While for an audience not familiar with electroacoustic music, the challenge with reduced listening is to focus on sound objects, for a prepared and expert audience, the additional challenge is to ignore the technological aspect of a composition. In this case, the listener shouldn’t focus on trying to understand technologies (softwares, plugins, effect, etc.) or techniques used to create particular sounds or dramatic effects in the piece. Therefore, the approach should be to give up one’s curiosity of discovering the mysteries behind the realisation of a particular music piece, and not succumb to technological listening.

Technological listening occurs when a listener “perceives” the technology or technique behind the music rather than the music itself, perhaps to such an extent that true musical meaning is blocked. Many methods and devices easily impose their own spectromorphological character and cliches on the music. Ideally the technology should be transparent, or at least the music needs to be composed in such a way that the qualities of its invention override any tendency to listen primarily in a technological manner.14

1.5. The listener

The listener and his/her interpretation of the sound work are fundamental in the composition process. Before all others, the composer is the first listener himself/herself. He or she is the first who becomes “hostage” to the piece and the connected experience. Despite this can be an efficient test, it can not be denied that there are some intrinsic obstacles; first of all the

factor of intense familiarity of the composer with the material, which is a result of a work process very close to the piece and prolonged in time. Thus, there is a substantial difference between what the composer hears and what the audience does. The composer, after several listening sessions during the making of process, is able to listen and perceive every single detail in-depth, while a normal listener at a concert has less time to elaborate all the information presented.

The experience of music is a cognitive response to a perceptual reaction. Music directly touches emotions and associations; intellectualisation is a side-effect. Traditional musical languages adhere to familiar grammars. This familiarity acts as a framework for setting up small surprises. [...] In creative electronic music, where the grammar is not familiar, the surprise often consists in finding familiarity.

In case of a negative feedback from the audience after a concert, the task for the composer could be to understand if the “problem” is because of the listener or for a lacking of the work. For this kind of analysis, often a period of distance from an own composition is needed, to be able to have a more objective point of view. Furthermore, in terms of reduced listening, the listener might have only one chance to do it, which of course is not enough to reveal all aspects of a composition. What a listener can perceive, sometimes it is mainly the first more superficial layer of a piece with the biggest impact. To get deeper into lower layers of listening, other listening sessions might be necessary. This is what actually happens to the composer with the chance of infinite listening times of the same piece. This act is a

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strong weapon that at the same time can be good, by having a chance of going into details, but it can be also bad when the bigger picture, the macro-form and sense of the piece get lost by focusing too much in little details. So, by exploring the piece in all its layers with several listening sessions, it is important to not forget that this can bring to a perceptive distortion of the piece itself.

The encounter between the listener and the music piece, represent a fundamental step for the culmination of the life cycle of an artistic work. This brings a new and fresh objective vision to the music that can emancipate itself from the limited paternal view of the composer in relation to his/her own work. This moment is very delicate and risky, because the composer becomes witness of an event where his/her work could come out in different ways. In a best case scenario, the piece reaches the aims imagined by the composer with possibly positive unexpected surprises. In the worst case scenario, the piece doesn't achieve the aims and proves to be ineffective and not coherent with the composer description. Thus, it has to be remembered the importance of the program notes of a concert, which can condition the audience by creating expectations that are expected to be satisfied.

In general, all types of constructive feedback can be very useful for a composer, to get richer by also knowing better him/herself and his/her music to approach new works.
2. SPACE

2.1. The Concert Space

Space, in electroacoustic music, is a fundamental topic for a composer and it cannot be ignored, since it is also part of the composition process itself. In the acoustic repertoire, the space management has been studied and explored by several composers (mainly during the 20th Century) which used to give particular indications to the musicians on how and where to sit on the stage or in a concert hall. However, this is not a practice that marks the acoustic compositions in general. In a common configuration, usually all the direct sounds come from the instruments of the performer/ensemble/orchestra sitting on the stage, so the audience is reached mainly frontally by the direct sounds, besides the reflections of the sound bouncing on the walls. In an acousmatic concert, it is instead very common to place the loudspeakers in different parts of the concert hall, with the aim of surrounding the audience as much as possible. The ideal hall for acousmatic music would be a dry room with a low reverberation levels, such as the new Lilla Salen Hall at KMH - Royal College of Music in Stockholm. Unfortunately these places are still rare, a lot of the times the concerts are held in theatres or concert halls built mainly for acoustic music\textsuperscript{16}. Since these concert halls were built to amplify the sound of instruments or voices, with a certain amount of reverb, here comes an important problematic for a composer: how to deal with the electroacoustic space and the virtual space of the piece. Thus, the composer should think on an hypothetic place where his or her piece could be played and try to adapt the mixing also from this

point of view. Furthermore, a different audio system, different brand and number of loudspeakers, different places, can condition a lot the execution. These are all aspects that a composer needs to think about during the mixing stage.

2.2. Different Musical Spaces

It is important to differentiate the types of space a composer has to deal with\(^\text{17}\).

I. The *acoustic space* is the physical space where the music is played by musician using instruments or voice without electroacoustic medium. This space can be indoor or outdoor.

II. The *electroacoustic space* (defined as the *external space* of the piece) expands the acoustic space by using electronic devices. Here the loudspeakers become the new sound source. It is important to remember that a loudspeaker can not be compared to a traditional instrument, since it tends to be a neutral source, not identifiable with a specific timbre (although every loudspeaker has its own technical properties, its proper shape and its own material), with a wide frequency range and reproducer of all type of sounds (concrete, synthetic, instrument recorded, etc.). Furthermore, through the loudspeakers it is possible to: divide the space from the sound source, focus more sounds in the same spot, distribute the same sound source in different places at the same time or break up a sound by placing its components in different spots.

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The electroacoustic space, beyond being used by acousmatic music, it can be considered also in a mixed work with instruments and electronic music or in a live electronics\textsuperscript{18} performance.

III. The \textit{virtual space} (defined as the \textit{inner space} of the piece) is the space created by the composer inside the piece itself, no matter the physical place of the execution. The best way to understand the characteristics of this space is by listening the piece in a location lacking of acoustic space. It is not possible to create virtual space without digital plugins during the creating and mixing step of a work. So, from the loudspeaker both the primary (direct sounds) and the secondary (indirect sounds) are played. With the information brought by the latter, our auditory system is able to recreate the space where the sounds are virtually placed and moved inside a composition. Thus, as already said before, the necessity of having a dry acoustic space to use better the expressive potential of the virtual space, puts in a very delicate condition the realisation of acousmatic concerts in traditional concert halls. They have usually a pronounced acoustic personality which inevitably overlaps the inner space of the work. Sometimes, to avoid this problem, a piece can be conceived for a \textit{binaural}\textsuperscript{19} listening for headphones. Another way (also cheap) is to have outdoor concerts which although brings other problems such as eventual noise pollution.

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\textsuperscript{18} Live Electronics: the elaboration and production of sounds in real time, during a live performance on stage.

\textsuperscript{19} Binaural Recording: it is a 3D recording method which aims to optimise the recording for a headphones listening, with a high fidelity of acoustic perception information on a 360° space field. From this point, acousmatic composition for binaural system, it's characterised by an accurate spatialisation work of all the sounds in the inner space and their movements. Headphones listening permits to have also more precise identification of the sounds in a 360° virtual space.
By considering the *acoustic space* and the *virtual space*, there is also an important perceptive difference for the listener: in the former, what the eyes see correspond on what the ears hear (dimensions and architecture of the hall) while, in the latter, the ears can get fooled from a simulation of different sonic environments that the eyes can not see. Furthermore, in a audio surround experience, often can also fall the relation that associate a sound with a loudspeaker. The loudspeakers, beyond diffusing all the single sounds, also provide information of the virtual space, for example using reverbs, echoes, delays, etc., which our auditory system perceives and by that it tries to collocate all the sound events in the right acoustic perspective. Therefore, the intelligibility of a composition depends a lot from a good interaction among the *inner space*, the *external space* and the *acoustic space*.

2.3. Interpretation

The performer is so important for a successful reproduction of the piece when it is played in an *Acousmonium*, where the spatialisation is made live, during the concert. Here, all the techniques have to be used at their best to reach and support the compositional thinking of a piece. When the interpreter and the composer are not the same person, a wrong interpretation could alter the meaning and intention of a work, as in an interpretation of scored music by any instrumentalist. But, if a traditional instrumentalist can work on his/her personal interpretation by focusing on dynamics and tempo, the acousmatic performer can focus more on the aspects of dynamics and space.
Since the tempo in an electroacoustic piece is immutable, the acousmatic interpreter has to fulfil with the space, what a traditional musician can express with the tempo. Therefore, through dynamics and space, the acousmatic interpreter can give perspective to sounds, break their monotony and static nature, move closer or further some sounds or group of sounds and create expectations. Some sounds can be positioned in particular spatial zones while others can move independently around the electroacoustic space.

Different from this is the new trend of building sound domes around the world, at the moment in the bigger centres for electroacoustic music, such for example the one in Lilla Salen Hall at the KMH - Royal College of Music in Stockholm. These domes can be conceived as three metal rings, as support for the loudspeakers that surround the audience, which is sitting in the middle. All the loudspeakers are put along the circumference of the rings with a equal pace. These systems are used in perfect combination with Ambisonics technology.

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Ambisonics: “is a full-sphere surround sound format: in addition to the horizontal plane, it covers sound sources above and below the listener. Unlike other multichannel surround formats, its transmission channels do not carry speaker signals. Instead, they contain a speaker-independent representation of a sound field called B-format, which is then decoded to the listener’s speaker setup. This extra step allows the composer to think in terms of source directions rather than loudspeaker positions, and offers the listener a considerable degree of flexibility as to the layout and number of speakers used for playback.” [website] en.wikipedia.org/wiki/Ambisonics [accessed 10 April 2019].
3. ELECTROACOUSTIC ORCHESTRATION

3.1. Introduction

The desire of deepen this aspect of the electroacoustic composition, comes after a transfer project that I've done during my last year of my Bachelor's Degree in electroacoustic composition. The piece that I created by then (*Mobyrei*), was the result of the application of this method to some of the *Pictures at an Exhibition* of M.Musorgsky in the orchestrated version of M.Ravel. During the process of this work, I've been able to understand the potential of organising the electroacoustic material with an orchestral thinking\(^\text{21}\). The transfer (porting) process, without being regulated, represents an important composition method itself. From the original orchestral pieces, to the acousmatic final product, it is clear that the result is a brand new piece, but with particular characteristics kept from the original piece, for example the structure, the form and the dynamic evolution. During this process, the recurring question was: which would be the best way to “translate” some of the original components to the new electroacoustic context, by keeping a coherent meaning? For example, one of the biggest problems was: how to interpret an *ostinato* rhythm (a type of gesture which is not very common in the acousmatic repertoire, where usually composers tend to avoid recognisable rhythmic forms, grooves or isorhythmic figures), a theme or a melody? This last aspect was a very big obstacle, since acousmatic music usually doesn't concern the usage of

melody, harmony or other components characteristic more of tonal music. By being in an atonal context, it was very hard to find solutions to adapt the original version to the electroacoustic one. From here, I started to think on which components could be kept in a passage from an orchestral theme to an electroacoustic one. This journey has been interesting in an attempt to extrapolate new composition techniques from the process. In particular, by trying to apply this process to the orchestration, I started to realise how an electroacoustic discourse could be more complex and complete. From this point I started to ask myself questions such as: which characteristics of an instrumental orchestration can be considered efficient in an electroacoustic orchestration? Which is the correct way to interpret and translate them? While doing this research, I started to formalise all my thoughts and creating rules and techniques, with the long term aim of creating a proper method. I felt very interested by this last point also because often the composition knowledge of techniques and styles in our field, it is passed down more in an oral way from teacher to student, or learned by listening sessions. There are not many books conceived as a manual, especially there is quite zero material about electroacoustic orchestration, while there are several manual of classical orchestration.

3.2. Work Session Organisation

How to organise the work session it has been another obstacle to deal with. Usually, in orchestration, there are some characteristic set-ups for a score. In music scores, all the instruments are represented in sections, following the “classical” order. In some particular cases, it can be also indicated special sitting solutions. During the history of music, both the orchestral
score and the sitting disposition have changed. The score organisation has been chosen mainly by conductors' necessity, while the disposition on the stage has been chosen mainly by composers. Without having the same worldwide approved organisation of acousmatic pieces on a DAW and, without having documents from all composers about their “digital scores”,

<table>
<thead>
<tr>
<th>Woodwinds</th>
<th>Traditional Orchestra</th>
<th>Electroacoustic Orchestra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flute I</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Flute II</td>
<td>I b</td>
<td></td>
</tr>
<tr>
<td>Oboe I</td>
<td>II</td>
<td></td>
</tr>
<tr>
<td>Oboe II</td>
<td>II b</td>
<td></td>
</tr>
<tr>
<td>Clarinet I</td>
<td>III</td>
<td></td>
</tr>
<tr>
<td>Clarinet II</td>
<td>III b</td>
<td></td>
</tr>
<tr>
<td>Bassoon I</td>
<td>IV</td>
<td></td>
</tr>
<tr>
<td>Bassoon II</td>
<td>IV b</td>
<td></td>
</tr>
<tr>
<td>Horn I</td>
<td>I</td>
<td></td>
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<tr>
<td>Horn II</td>
<td>I b</td>
<td></td>
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<tr>
<td>Trumpet I</td>
<td>II</td>
<td></td>
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<tr>
<td>Trumpet II</td>
<td>II b</td>
<td></td>
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<tr>
<td>etc.</td>
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</table>

*Fig. 1 - Daw organisation_A*
there is no common practice and every composer is totally free to organise his/her session independently. In this method, starting from the classic orchestra score, I tried to obtain three examples of how it could be organised a DAW session.

In the A example in fig. 1, there is a direct connection with the traditional orchestral score. There are electroacoustic sections, as instrument sections, each with a different colour to make subdivisions clearer. It is important to say that this subdivision is not concerning the usage of transformed instrument sound samples for acousmatic purposes. This is only a way to facilitate the composition approach during the translation from orchestration knowledge to the electroacoustic practice. I find this comparison very useful as a starting point to think about sound sections, single sounds, gestures, sections behaviour etc. Therefore, if for example an instrument has its own articulation, timbre and idiomatic characteristics, also a sound sample can have the same type of parameters. Thus, with this way of thinking, it is not really important anymore to associate every single sample with a single new track (as it is usually common to do). For example, the same track can have different elaborations of the same sound source or more sounds with similar characteristics. This conception can also bring a better digital “economy” and a better (and easier) management of the usually high number of tracks. But this requires a better focus from the composer to have all the tracks under control, with their automations.

Concerning the space, the direct connection with the symphonic orchestra, would be for example to assign to every single track a fixed position in the inner space, as to recreate a fake stage in a virtual space. However, this method brings big limitations. Furthermore, another consequence would be
an extreme fixed spacial frequency disposition in the stereophonic (or multichannel) mix. For example, if we would decide to pan the low frequency sounds to the right (as the double bass section in the symphonic orchestra) and the high frequency sounds to the left (as the violin section in the orchestra), it would result in an extreme predictable space-timbre configuration and potentially a bigger fatigue for the left ear of the listener.
(especially in a high loudness level of a concert). A more effective way could be to create couples of similar tracks, to make different decision every time on how to handle the entire stereophonic space, for example balancing the left and right channels with similar frequency range (intensity and role) samples.

Another hypothetical solution could be the one in the B scheme in fig. 2, where from the traditional orchestra score there is a semi-break. In this example, the sections are still present, but they are organised by a timbre distinction or a physical material source. These sections based on the material of the sound sources could be correlated to the different characteristics of mass created by Schaeffer.

The third example C in fig. 3, looses totally the connection with the traditional orchestral score, by creating a new organisation based only on the frequency range of every sound sample without having any section. Of these three hypothetical ways, I found and still find the A method as the best for me. This helps me to keep a good connection with the traditional orchestra practice.

3.3. Obtained Orchestration Techniques

Here follows a series of techniques obtained after reading and consulting some of the most important orchestration manuals. I've tried to integrate these techniques in my last compositions. Obviously is not possible to create an iron subdivision of all the techniques, since often different aspects are involved at the same time.

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22 For the complete list of consulted orchestration manuals, refer to Manuals in the Bibliography.
3.3.1. Dynamics

Dynamics are such a fundamental aspect to keep in mind during the creation of a work. This parameter can bring life to a music piece. For example, during the transfer process mentioned before, I realised how
dynamics are important in the orchestrated version of *Cattle*\(^{23}\). The dynamic evolution is strictly connected to the idea of the cart pulled by oxen that move from a far distance to a closer one and then leave. This idea is very efficient and in the electroacoustic field it can be implemented with spatialisation movements.

**Doubling**

This is a basic practice to increment the dynamic level. Starting from the instrumental concept, this doesn't have to be strictly connected to music intervals obtained with the equal temperament system, especially for tonic mass sounds. One way to double would be to use (vertically) two or several copies of the same sound sample and then change the pitch of every single one. It is possible to work with semitones or cents to adjust the intonation of every single sound and to reach a good orchestral volume (interpreted as

\(^{23}\) *Cattle*: the 4th movement of *Pictures of an Exhibition*, work composed by Modest Mussorgsky.
a quantity of tracks that sound simultaneously). This overlapping increases the general intensity (dynamic) but it modifies also the general timbre as result of all partial timbres. In combination with this, it is useful to work also on filtering\textsuperscript{24} the audio sample, in order to limit the spectral extension, based on the assigned role of the sound itself into its orchestral section. Not to be forget, it is also the different perceived loudness of sounds. For example, some concretere sounds, at the same dynamic level, can result “thicker” (with more energy) or “thinner” (with less energy). To make a comparison, for example we could find this difference in a \textit{f} of an horn compared to a \textit{f} of a violin.

**Terraced Dynamics**

This technique can be achieved by summing gradually some electroacoustic orchestral sections. After deciding the orchestra sections subdivision (see paragraph 3.2.) it is possible to decide how to overlap the sections, to increase the total dynamic without working on the volume automation\textsuperscript{25} of every single track. This practice brings also a complexity in the general timbre. Thus, this technique should be used with attention to not thicken the general timbre towards a heavier listening.

\textsuperscript{24} Audio filter: “is a frequency dependent amplifier circuit, working in the audio frequency range, 0 Hz to beyond 20 kHz. Audio filters can amplify (boost), pass or attenuate (cut) some frequency ranges. Many types of filters exist for different audio applications including hi-fi stereo systems, musical synthesisers, sound effects, sound reinforcement systems, instrument amplifiers and virtual reality systems.” [website] \url{en.wikipedia.org/wiki/Audio_filter} [accessed 10 April 2019]

Automation: The term is identified with the technology that uses control systems (such as logic circuits or computers) to manage machines and processes, reducing the need for human intervention. It is carried out for the execution of repetitive or complex operations, but also where security or certainty of the action is required or simply for greater convenience. In the DAW there is the possibility of processing different parameters through the use of automation. One of the many, for example, is the intensity-volume parameter of a sound wave.
Connected dynamic changes

This passage represents a gradual movement of the dynamic range, using for example different orchestral sections without having a severe gain or drop of intensity. Between the departure group and the arrival group there is a third group which has the transition function. This technique is also very efficient to combine the dynamic change with a timbre change, to reach an effect close to *morphing*²⁶.

![Diagram of connected dynamic change](image)

*Fig. 5 - Connected dynamic change*

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²⁶ Morphing: it consists in the fluid, gradual and seamless transformation between two differently shaped sound images, which can be concrete sounds or synthetic sounds.
Crescendo with timbre fusion

This technique aims to create a crescendo by reaching also a complex timbre, by using different single timbres or entire sections. The pictures, represent three hypothetic situations following this idea. In fig. 6, a first group makes a linear crescendo from $p$ to $f$ using a specific time (x-axis).

Fig. 6 - Crescendo with timbre fusion_A

A second group, make the crescendo using the same time but in an exponential way. This example has both groups starting and arriving on the same dynamic targets.
In fig. 7, the behaviour of the first group is the same, but the second group makes a linear dynamic change from \( pp \), so from a lower dynamic level, to the same target \( f \). This dynamic evolution presents a steeper profile.

In fig. 8, the first group is unchanged, the second makes an evolution from \( pp \) to \( f \) in an exponential curve, by using only half the time. This solution is more aggressive and vivid compared to the other two. This technique can be found for example in my piece *Echoss* at the end of the first section, from 02:50 to 03:00.
Fig. 8 - Crescendo with timbre fusion_c
3.3.2. Figure - Background

This technique is connected to one of the most important laws of the gestalt\textsuperscript{27} theory\textsuperscript{28}. This indicates, as the necessary condition to understand any image, the possibility for our perceptive system to distinguish the figure from the background and vice versa. The background has a relevant importance, it never disappears completely from our vision, and influences the perception of the figure. However, these two elements can not have the same attention at the same time, usually it is possible to focus alternatively on one aspect or on the other. The figure is what we perceive as the main and closer aspect, while the background is what appears to us secondary and more distant.

In music there is a parallelism between the contraposition of figure-background and melody-accompaniment. The melody is alway at the centre of our attention while the accompaniment can have a secondary function in the same way that the background is on a second level as compared to the figure. In acousmatic music, this contraposition can be considerably implemented by using the virtual space of a piece. Thus, for example, it is possible to assign to the figure a first frontal mixing layer and to the background a place further back in the depth of the mix. The management of the relationship of figure-background in space, could be divided actually

\textsuperscript{27} Gestalt psychology: from the German Gestaltpsychologie, psychology of form or representation, it is a psychological current focused on the themes of perception and experience that was born and developed in the early twentieth century in Germany (in the period between the years ten and thirties), to continue its articulation in the USA, where its main exponents had moved during the period of Nazi persecution. Founders of Gestalt psychology are usually considered Kurt Koffka, Wolfgang Köhler and Max Wertheimer who were certainly the main scientific promoters and theorists of this research current in Psychology. Their psychological studies focused mainly on perceptual and reasoning / problem-solving aspects.

in three different layers. In fig. 9 it can be noticed the background made by two different levels: the dashed orange layer, which could be defined as semi-background and, the dashed red layer which can be simply defined as the background.

Fig. 9 - Levels of spatial separation A

The fundamental parameters to work with, in order to put sound elements in one of these layers are:
- Reverb (dry = close / wet = far)
- Intensity (loud = close / soft = far)
- Frequency, in connection with filtering (middle-high = close / low = far)
After having created different levels, it is possible to decide which kind of gestures can be assigned to each layer. All this by trying to reach the compositional idea of the figure-background image desired.

![Levels of spatial separation diagram](image)

*Fig. 10 - Levels of spatial separation_B*

An example of configuration can be seen in fig. 10: the figure is positioned on the frontal and central layer, close to the listener. In the semi-background there are some elements of punctual facture, with more reverb and separated in a wider utilisation of the stereophonic image. On the last
level, the background, there are sounds that are close to the continuous facture, as a “glue” band to blend all the levels.

![Fig. 11 - Levels of spatial separation_C](image)

Obviously this is just one of the possible configuration of the virtual space of a composition. For every specific case here would be different approaches to the handling of timbres, movements, resonances and all the other parameters listed above. Furthermore, it would be very interesting to create a contrast between the figure and the background, to differentiate more the characteristics and role of the two, plus also the possibility of
changing and inverting roles could be an interesting solution, as showed in the fig. 11.

3.3.3. Parallel Lines

This type of polyphonic writing, which could be close to the traditional counterpoint idea, is different from the figure-background technique for a series of reasons. First of all, the lack of a predominant figure, therefore a lack of hierarchy among the sound elements and sound levels. Every sound level is autonomous and can be marked by an own rhythm, timbre and position in space. In this configuration, the listener focuses from time to time on every single different sound level, more than looking for a whole picture. The different planes could be divided into two main types:
1 - **Amalgamation**: the sounds have similar timbres and their spectral characteristics are similar.
2 - **Separation**: the sounds have different timbres and their spectral characteristics are different.

In this process, the focus would be from time to time on less monotonous elements which, for example, would be highlighted by more interesting rhythm-timbre configuration, resulting in elements of *priority perception* for the auditory system. The space has of course an important role in this *parallel lines* concept. If, for example, we would decide to assign to every sound element and its development in time, a precise spot in the inner space, we could define this as *polarised spatialisation*. 
3.3.4. Tessitura - Spectrum

Using different sound source samples in electroacoustic music, we could substitute the word tessitura with spectrum, which is preferable when thinking in terms of frequency intensity characteristics. By filtering a sound, it is possible to change the frequency profile of the sound in order to create new spectral shades. As said before, for example, this technique can be used during the doubling practice in the orchestration to cover the entire audible spectrum, if needed.

Reiteration of the spectrum

Both the instrumental orchestration and the electroacoustic one, try to cover the entire spectrum range by using, in the former case, several instruments with their own tessitura and, in the latter, different sound samples with their own frequency range. This concept concerns the possibility to reiterate some gestures and motives along different spectral zones of the frequency range of single sounds or sections.

Glissando

Glissando in music consist in the constant increasing and decreasing of the pitch of a sound. If we would try to interpret this in acousmatic music, the first idea would be to modify the automation of the pitch of the sound sample, to modify it towards an higher or lower pitch in a given time frame. In this way, now days it could fall in a lure to an old acousmatic “language” from the past, with the risk, sometimes, to result in a banal (or worse) ironic sound. Thus, a more efficient method could be to work with a dynamic filter
which moves in a given tempo along the spectrum of a sound, downward or upward. This process can be applied to single tracks or entire sections.

**Orchestral Expansion/Contraction**

With this nomenclature the aim is to indicate the spectral movement of single sounds or entire sections. Thinking of spectral motions, it is possible to individuate two basic ones:

1 - *Expansion Motion* 

2 - *Contraction Motion*

In the first one, the sound elements depart from a central common spectral area, leading to opposite directions along the frequency spectrum. In the second one, instead, the behaviour is exactly the other way around. Starting from these two basic movements, it is possible to create other different types of motion, for example parallel motions towards higher or lower frequencies. This can be associated also with a movement in space to create more interesting changes.

**3.3.5. Timbre - Colour**

This aspect is strictly connected to the previous paragraph since specific timbres are often connected to the spectral band of any sound. If for music
instruments the timbre is not the same along the whole range, we could say that this is valid for concrete sounds too.

Timbre Contrast

in order to create interest and surprise during the development of the piece, it is possible to create strong or weak contrasts with timbres, for example to highlight some important points in the composition. Timbre considerably influences the perception of the orchestral form, therefore it would be appropriate to ration the contrasts by following the compositional idea. If there are many ways to work with the traditional orchestra, with a series of shades and details, with the electroacoustic orchestra these possibilities are higher. Indeed, in the work session, a composer could use infinite sound samples, infinite track and effects; these infinite possibilities can result also in a risk for the composer. With countless analog-digital possibilities, it can be easy to be in a situation which is hard to contain, handle, manipulate and elaborate in a way to reach a finalised music product, with its form, style, personality and coherence. Shown below three examples of possible timbre contrasts.

- **Level 1 contrast**: achieved by using sounds derived from the same sound source, with slight differences of mass and facture.

- **Level 2 contrast**: achieved by using sound samples derived from the same sound family/category with emphasised variation of mass and facture.

- **Level 3 contrast**: achieved by using sound samples from different sound families/categories, with opposite (or very far from each other) mass and facture.
3.3.6. Articulation - Gesture

In the electroacoustic orchestration, it is possible to work on the phrasing and articulation of single sounds, to create *micro-gestures* and it is also possible to create *macro-gestures* by working with more sounds or entire sections. Connected to this, there are all the expression possibilities such as: legato, staccato and superimposition. Often these aspects mix together with sudden or gradual timbre changes.

**Resonance**

This aspect is strictly connected to the articulation of sound samples. Often, it can be an interesting solution where there is a cause-effect sequence, in other words: a connection between triggering and resulting elements. This passage can be obtained in two different ways: drastically, with a clear division between the cause and the effect (fig.12), or continuously with a resonance connection between the two elements (fig.13). The resonance can be created, for example, by using a third sound element, which could be similar to a sound band, to create a smooth connection from point A to B with a direction in the timbre evolution. Not to be forgotten, the reverb (created in the virtual space or the acoustic space of the concert hall) has an important role in this evolution and it can amplify the effectiveness of the music discourse.
Fig. 12 - Cause-effect_A

Fig. 13 - Cause-effect_B
Impulse Sequence

To create a quick development of a sound, it is possible to use a concatenation of sound samples (long or short) without having any interruption. This idea can be close to dovetail joint of the classical orchestration practice, where there is a continuity of a phrase/melody/motif played from different instruments in sequence. It is possible also to use an

![Diagram of impulse sequence]

Fig. 14 - Impulses sequence_A
increasing number of short impulses to have an *incrementation* process, starting from a single impulse (fig. 15). This can be created also as a *multiplication process*, an effect obtained by an overlap of increasing audio fragments in several audio tracks. This can result in an effective opening, as a fast and energetic fade in, to launch what follows.

*Fig. 15 - Impulses sequence_B*
Reiteration with Echo

To work on the real or perceived tempo of a piece, or to create a breathing effect, it is possible to use imitation as an echo process. This is conceived as a delay-echo effect, but without using any plugin\textsuperscript{29}. This process is instead done manually by reiterating a given audio sample for a limited number of times with a regular or irregular time interval. Connected to this, it is

\textsuperscript{29} Plugin: In computer science, it’s an add-on that, included in an audio-video production program, allows you to add audio effects or generate new sounds. The term derives from the English plug, or plug or connector: it is considered a plugin that is virtually inserted into the program that uses it.
important to create a dynamic *decrescendo* to follow the normal weakening of sound reflections in nature. Furthermore, it is possible to place virtually faraway the sound samples in the depth of the mix, using reverb and EQ filters (*KOM* 05.26). This process can be made more interesting if the sound samples are spread in different spots of the space (*Echoss* 00:47).

*Fig. 17 - Reiteration with echo_B*
3.4. Compositions

As mentioned above, there is not a traditional score in electroacoustic music but, for me, the timeline of every single project I worked on, shows some characteristics that can make clearer my personal concept of electroacoustic orchestration. At this point, it might be interesting to see the evolution of the work process, through the creation of the last four pieces: Mobyrei (2016), Echoss (2017), KOM (2018) and Cohærere (2019). Shown below (from fig. 18 to 21) the screenshots of all four DAW sessions. There are some aspects that change, for example the first piece has been made in Ableton Live, while the others have been made in Cockos Reaper. This choice was made for meany reasons, including the usage of the Ambisonics technology. It is possible to see a development of the “instrument” sections and the management of the sections of the structure. Of course, through these pictures it is not very easy to understand parameters such as: dynamic, timing and register, but the organisation of sound samples (horizontally and vertically) is quite clear.

It is possible to listen to these pieces on my Website or on my Soundcloud: https://diegoratto.wixsite.com/diegoratto
https://soundcloud.com/diego-ratto
In fig. 18 it is shown the timeline of *Mobyrei* with the following organisation of my electroacoustic orchestra:

- Blue: “woodwinds”.
- Pink: single sounds added in the B section.
- White: accessory tracks added later on, during the composition process.
- Yellow: “brass”.
- Red: “percussion”.
- Green: special instruments “xilofono”, “celesta” and “harp”.
- Brown: “strings”.

![Fig. 18- Mobyrei (2016)](image-url)
Fig. 19 - Echoss (2017)
In fig. 19 it is shown the timeline of *Echoss* with the following organisation of my electroacoustic orchestra:

- The first 8 tracks represent the tracks dedicated to ambisonics.
- Orange (from 9 to 18): “woodwinds”
- Yellow: brass.
- Orange (26 and 27): “percussion”.
- Brown: “strings”.
- White: accessory tracks, added later on during the composition.
- Fuchsia: accessory tracks in rewire from Ableton Live.
- Track 50, audio recorded from a sample on *Kontakt*. 
In fig. 20 it is shown the timeline of *KOM* with the following organisation of my electroacoustic orchestra:

- Grey: voice samples
- Orange (from 4 to 11): “woodwinds“.
- Yellow: brass
- Orange (from 22 to 25): percussion. Track 21 is used with ambisonics (see the logo).
- Brown: “strings”.

*Fig. 20 - KOM (2018)*
Fig. 21 - Cohærere (2019)
In fig. 21 it is shown the timeline of *Cohærere* with the following organisation of my electroacoustic orchestra:

- Orange: “woodwinds”.
- Yellow: “brass”.
- Purple: “percussions”.
- Turquoise: special instruments, “celesta” and “harp”.
- Brown: “strings”.


4. CONCLUSIONS

I’ve found it very helpful to formalise all my thoughts in this thesis. It is important to give time to think how to explain things that sometimes are not easy to transfer from your mind to paper. This process creates also new ideas and inspirations. I have now new goals that I would like to reach. I’m thinking now to continue this research in a PhD, where I would like to deepen my knowledge in orchestration for electroacoustic music. At the moment, I have many questions that don't have an answer and this makes me curious and motivates me to go one step further. During the last period, I’ve also started to “daydream” about actually writing a piece for acousmatic music and orchestra. That would be very interesting, to try to meld these two worlds and these ideas of orchestration (instrumental and electroacoustic) in the same work. It sounds fascinating and scary at the same time, because I can imagine how big the amount of work could be and time needed and all the problems (concerned the execution) that would need a solution. There are so many aspects of this that I feel I would need to explore to become a better and more complete composer. I think all this is just the beginning of my journey.
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