



ACADEMY OF MUSIC AND DRAMA

Composition methods related to chemistry and biology

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Abstract

This master thesis presents three different methods of composing music with some processes, concepts and models from the fields of chemistry and biology, in which I have researched theoretically and practically in order to obtain and to generate the musical knowledge for this work.

Historically, one of the ways of obtaining and creating musical material and musical networks has been the connection of music with other fields, such as literature, sculpture or maths. For this reason, this thesis presents the way of obtaining material from two connected fields: chemistry and biology.

As a composer, I have explored each composition method through the analysis of different pieces, its relation with music elements and the way of composing music with the connections between biology or chemistry and music.

Key words

Music composition, composition methods, biology, chemistry, Crystallization, DNA, Brain Activity.

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Chapter 1: Introduction

1.1 *Why have I written about the topic of this thesis?*

During the history of music, a lot of composers have looked for inspiration from other perspectives. Through connecting music with other fields, composers have obtained different sources of information for pieces. This type of connections started with taking inspiration from other fields of culture such as literature or sculpture, as well as observing and recreating some behaviours of the human being. This way of obtaining inspiration from other disciplines has been developing to other fields of culture, science, humanity and society.

I have been interested in connecting my music to other fields in my career such as literature and sculpture. Nonetheless, this thesis has been written about composition methods related to chemistry and biology for these reasons:

The most important reason for me is to improve my knowledge about composition and methods to compose music. For this reason, I suggest every composer to improve their knowledge about music and society during the career.

Another reason to select this topic has been the point of obtaining more sources of information about compositional methods. In my musical career, I have always had the goal of discovering new material in terms of sound, methods, theory or inspiration and, for this reason, this topic has always motivated me to have more knowledge.

The last reason is to have more knowledge about the possibilities to connect music and science. Before starting to research about these compositional methods, I knew some of those. For this reason, this thesis has been the intention to know more existing compositional methods related to chemistry and biology.

Due to personal connections with other fields of knowledge in my family, I chose to research about possible connections between music and science. For this reason, this thesis is focused on researching the created methods about biochemical concepts or processes.

1.2 What I wanted to achieve at the end of the thesis?

Before starting to write this thesis and, in order to clarify the concepts that should be explained, I ask to myself some questions related to the topic. The question was about the information, goals, material and knowledge that had to be achieved at the end of the thesis.

The first goal has been to improve my musical and composition skills with researching composition methods related to chemistry and biology. With this goal I wanted to explore each method from different perspectives, both from the biochemical perspective and composition perspective.

Next, another aim has been to know more compositional methods related to chemistry and biology. I have researched about the musical concepts of each method, the different understanding of a same method related to chemistry and biology.

The third goal has been to investigate the composers that have explored each method and the different ways of using the concepts and processes related to chemistry and biology. Each of the composers that have been explored in this thesis has based the pieces on similar or different concepts.

Then, one important goal has been to compose pieces with the composition methods researched in this thesis, in order to explore the methods and to create my own way of composing with the methods. I have explored each method investigated in the Independent Project through composing different pieces.

1.3 How have I obtained the information?

The information that is explained in this thesis has been obtained from different sources of information, due to the differences and similarities of the concept features.

In order to obtain information about the biochemical concepts and processes researched in this thesis, I have read selected articles, books and web pages about biochemical concepts. For this reason, I have had to learn about chemical and biological concepts in order to understand the methods.

The second group of sources of information is focused on the composers and the methods used, created and explored by them. The material of this second group has been obtained from articles, books and web pages about these composers or about the methods of

composition. Furthermore, in order to clarify the concepts or the ideas of the composers, this thesis includes quotes by the composers and the writers of the articles and books.

Finally, the information about the pieces that I have composed and my impressions about the process of composing the pieces and my thoughts about the concerts and recordings of these pieces. Moreover, this thesis includes graphic examples to exemplify the ideas developed, as well as the scores of the pieces.

1.4 How is this thesis structured?

The chapters that explored the composition methods have a similar structure. The first step is an introduction of the topic of the chapter, in order to introduce the biochemical context and, the most important, the musical context of the concept. This introduction gives to the reader and the researcher some information about the chapter and about the background of it.

The second step has been to investigate the concept in the field of chemistry and biology. For this reason, the second part of the chapter include the necessary information about the terms, concepts and processes in order to understand them in a non-scientific context.

The third step has been to research about composers that have explored each composition method. In this part, there are similarities and differences about how each composer has used the concepts and how each composer has understood the process.

The fourth step has been to compose a piece with the methods developed by the composers and researchers but from my own ideas. That is, I have composed some pieces taking some concepts from the research but in order to create my own method.

Finally, the last step has been to establish the main lines about each composition method taking into consideration both my own method and the methods investigated in this Independent Project.

1.5 Using external data in music composition

The three composition methods developed in this thesis base their musical parameters on external data. Parameters from biochemical concepts, models and processes are used in order to generate musical material. Specifically, they are used in order to create structures, rhythmic patterns, musical gestures, dynamics and pitch material.

One option with external data could be to recreate an image or process in music, creating that image or process in the audience. In this project, external data has not been used in order to recreate concepts, images or feelings, like a deep sleep or a visualization of the crystallization process. That is not the purpose of this project, even though it could be a good option for future researchers in connection with this Independent Project.

This project is focused on using external data as a generator of musical material for the composer, not for the listener. In order to compose my pieces, I have used concepts from the fields of biology and chemistry in order to create compositional aspects of my pieces, not to recreate a feeling or an image.

For this reason, this thesis presents the following concepts related to generating material: inspiration, as the process of doing something creative; analogy, as a comparison between the concepts, models and processes and music; connection, as the relation of different features; information, as the specific features of the concepts, models and parameters.

In conclusion, my intention with this research is to provide composers with more tools in order to create music, and the way of obtaining these tools has been the connection between biochemical parameters and music material.

Chapter 2: Crystallization

2.1 Introduction to the concept of Crystallization

During the history of music, there are a lot of example about the relation of music to other fields. On the one hand, many composers have looked for inspiration in other fields of the society such as literature, sculpture or history. On the other hand, many composers have investigated concepts from other fields in order to establish connections with music, and in order to obtain different sources of musical material.

One of the fields that have been explored by the composers has been the field of science. This chapter exposes the connections of the process of crystallization to music and, concretely, the analogies that these composers have established in order to compare their music or method to the process of crystallization.

The composers that have been researched in this chapter have used the concept of Crystallization in order to establish analogies between their music and the concept. That is, the concept of crystallization has not been used in order to generate musical material or inspiration.

The concept of crystallization, for the composers of this chapter, has been used in order to explain their methods of composition, in order to clarify their processes.

I have taken into consideration the concepts used by the composers, but using the concept of crystallization in a different way. In other words, the crystallization process is the inspiration for my piece, while for the composers researched in this chapter the crystallization process appeared later in order to explain and clarify.

2.2 The process of Crystallization as a biological process

The concept of crystallization is defined as the process by which a chemical is transformed from a liquid solution to a solid crystalline state. In addition, the concept of crystallization is divided into three parts (the initial state and the two events):

1. Initial state. In this state we find the different molecules that will be part of the whole process.
2. The nucleation process. The molecules are grouped in a definite and stable way until reaching the critical size of the cluster.
3. The process of crystal growth. Clusters that have reached critical cluster size begin to increase in size.

The crystals found in these three parts have different shapes and sizes, since, depending on the conditions, one process will be predominant over another. In addition, in the concept of crystallization is also the phenomenon of polymorphism, which is that a compound can exist in multiple crystalline structures with different physical properties.

2.3 The process of Crystallization in music

2.3.1 Edgard Varèse

The most related composer to the concept of crystallization was the French composer Edgard Varèse (1883-1965). In order to relate the idea of crystallization with Varèse's work, in the lecture given at Princeton University in 1959, the own composer exposes his idea of crystallization and its relation as analogy to his music. In his thesis *The influence of scientific concepts on the music and thought of Edgard Varese*, John D. Anderson quotes Varèse about the concept of crystallization as an analogy of the cell variation technique, but he never looked for influence from the concept of crystallization:

Conceiving musical form as a resultant, the result of a process, I saw a close analogy in the phenomenon of crystallization. It seemed to me the clearest answer I could give people who asked me how I composed, was to say, 'by crystallization.' This summer I thought perhaps I had better talk to a specialist about this idea of mine to be sure my parallel was scientifically justified. I consulted the distinguished mineralogist, Nathaniel Arbiter. My idea intrigued him, but he said he wanted to think it over. He phoned a few days later quite excited with his findings, which he wanted to show me. When I arrived, he was surrounded by scientific books on crystals from which he had gleaned the following for my benefit. (Anderson 1984, 93)

After analysing several articles and researches written by specialists, there are some aspects that can define the main concepts of the idea of crystallization in the pieces written by Edgard Varèse:

1) Form

E. Varèse understood form as something that has to be filled, something that is a result of the manipulation of some musical processes such as rhythms, textures, timbres, pitch elements and the juxtaposition of motives. These manipulations are produced by music operations like projection, verticalization, rotation, compression and stretching.

In his article *The Virtuality of the Compositional Model: Varese with Deleuze*, Luc Doebereiner presents a quote said by Varèse about form. For him, form is not a pre-established concept,

but it emerges from a developing: The misunderstanding has come from thinking of form as a point of departure, a pattern to be followed, a mould to be filled. (Doebereiner 2014, 274)

2) Pitches and harmony

P. Jaffe suggests in his *Edgard Varese's orchestral and ensemble works History, theory and conducting analyses* that: His vertical sonorities are distinctive. Often pitches are discretely partitioned within unordered subgroups; partitions involving horizontal motives occur as well. (Jaffe 1989, 168). That is, there are some sounds that are present in different subgroups of material that create a specific harmony.

3) Analysing the structure

The composition technique used by Edgard Varèse related to crystallization, in which the final form is the result of the process of manipulating musical material, generates difficulties to assign a specific structure to his pieces. P. Jaffe affirms that is difficult to find the connection between a finished piece and varying temporal projections:

Indeed, the whole notion of a musical work being “finished” or “complete” eventually seems at odds with the technique of varying temporal projections (a technique Varese used so often in composing his music. Considering that Varese was the first to travel the path he chose; it was perhaps inevitable that he struggled from the 1930's till the end of his life to complete his compositions. (Jaffe 1989, 168)

4) Musical material

In Varèse's works related to the process of crystallization there are some concepts about musical material that were defined by the own composer. The concepts of musical material and its developing were defined with analogies in order to explain its way of application. The term “rock stratification” was used to define the process of balancing musical material, while the term “crystals” for clarify the process of developing infinite forms.

5) Titles of his works and its relations to science

Another aspect that defines the relationship between Edgard Varèse and the field of science was its election of titles for his pieces. Once again, he affirms that there is no influence of science before starting to composer, but there are a lot of similarities between science and his music:

I often borrow from higher mathematics or astronomy only because these sciences stimulate my imagination and give me the impression of movement, or rhythm. For me, there is more musical fertility in the contemplation of the stars and the high poetry of certain mathematical expositions than in the most sublime gossip of human passions.

However, there are no planets or theorems to be looked for in my music. Music being a special form of thought can, I believe, express nothing but itself. (Dannenbring 1990, 72)

6) Stasis moments

There are some moments in Edgard Varèse's works that contain intervals generally small. For Wehmeyer, these moments could be considered part of the concept of crystallization in his piece *Density 21.5*:

These passages show what Varese might have meant by crystallization as a compositional principle: around one tonal step, other similar steps crystallize and out of the newly arrived molecules, larger crystals are formed. The alternation between pendulum groupings (stasis) and the escapes of the climbs constitutes the progress of the piece. (Dannenbring 1990, 109)

7) Connections of groups of notes: symmetry, projection, rotation, expansion

The groups of notes that could be found in the piece *Density 21.5* have different kinds of connections. In order to classify these connections, M. Dannenbring writes four types of connections in his *Varese's Density 21.5 Interpretation and synthesis of existing analyses*: symmetry, projection, rotation and expansion.

- Symmetry: In a group of three notes, the middle tone of these is equidistant to the extreme notes.
- Projection: transference of a group of notes to one register of pitch to another.
- Rotation: one part causes one or more parts forming a succession of events.
- Expansion and contraction: opening and closing the spatial boundaries.

2.3.2 Jean Sibelius

In the pieces composed by the Finnish composer Jean Sibelius (1865-1957) is possible to find the concept of crystallization. In the research made by Timothy L. Jackson called *Observations on crystallization and entropy in the music of Sibelius and other composers*, the author defines the idea of crystallization in Sibelius' pieces with a metaphor written by Heinrich Schenker: Nebula spirals solidify and become stars. Music, born from the original irrational state as if from a neural spiral, and made ever denser with diminution, grew into a star in the heavens of the spirit. (Jackson 2007, 175)

Following the research made by Timothy L. Jackson, the concept of crystallization is an effect created by "anticipating" the definitive tonic arrival. That is, the crystallization of the tonic as a metaphor to get the heroic. Furthermore, the concept of crystallization,

specifically entropy as the failure of crystallization, is thought as the transformation of order into chaos.

Timothy L. Jackson explains in his research the elements that describe the concept of crystallization in Jean Sibelius' symphonies. For this reason, the Fourth Symphony presents the concept of crystallization in this way: "I hypothesized that *På verandan* (Viktor Rydbergs) is related to the Fourth Symphony, which also unites metaphors for "crystallization" -the creation of life in the first movement with its dissolution in the last." (Jackson 2007, 176)

Moreover, the Seventh Symphony presents the concept of crystallization and its relation with entropy, concepts that fascinated to Jean Sibelius: "My observations will suggest that these intertwined narratives of "crystallization" and "devolution" or "entropy" inform a Sibelian "meta-narrative" culminating in the Seventh Symphony." (Jackson 2007, 176)

Finally, the concept of crystallization in the pieces by Jean Sibelius had another kind of connotation related to the terms exposed before. Timothy L. Jackson suggests that there is a transformation when the concept of crystallization has a beloved woman: "Additionally, when the "goal" is a beloved woman this crystallization process may have psycho-sexual connotations of "yearning" or "longing" for the beloved." (Jackson 2007, 177)

2.3.3 Chou Wen-Chung

The composer Chou Wen-Chung was born in China in 1923 and moved to the United States in 1946. His composition style can be defined as "a contemporary expression of the principles of traditional Chinese aesthetics", and he looked for a confluence of the cultures in order to create the own style of his students.

Chou Wen-Chung was Edgard Varèse's student and copyist in the United States. Furthermore, when Edgard Varèse passed away in 1965, he completed some of Varèse's unfinished works and arranged some piece to record it. For these reasons, the influence of Edgard Varèse in Chou Wen-Chung was very high, and this quote said by Chou Wen-Chung talks about it: "For fifteen years, Varèse demonstrated to Chou what it means to be a true artist. Chou, through his dedication and support, helped Varèse to carry through on his unfinished projects and revive his creative spirit."

Due to this relation between Chou Wen-Chung and Edgard Varèse, there are some influences in the works of Chou Wen-Chung related to the concept of crystallization. Eric C. Lai presents this relation in his book *The Music of Chou Wen-Chung*:

In order to liberate sound from its physical limitations, Varèse developed the idea of “sound mass”. The form of a composition (crystallization) is produced by “the growth and interaction of sound-masses in space through a continual process of expansion, projection, penetration and transmutation.” The symmetrical disposition of intervallic structures and the “continual process of transformation and interaction of layers of sound, each with its own sonic attributes but derived out of the same nuclear idea” that are the essential to Varese’s music also appear in Chou’s works. (Lai 2009, 39)

These quotations explain the idea of form as well as the transformation of the musical material and its relation to the process of crystallization:

Chou’s notions of form can be traced back to Varèse’s ideas, especially those of “crystallization” and “melodic totality”. By utilizing both the traditional norms and his new approaches to form, Chou has created music that is unconventional and innovative. (Lai 2009, 93)

Chou’s treatment of form, especially in regard to musical development and transformation, can also be traced back to Varèse. For example, the interaction between linearity and verticality, in addition to producing a formal balance of spatial equilibrium, contributes to the music’s “dynamic” growth. (Lai 2009, 37)

These quotes that explains the way of using the concept of crystallization by Chou Wen-Chung and its relation to Edgard Varèse were written by Eric C. Lai in his book *The music of Chou Wen-Chung*, a book that shows a research of the author about the works of the composer.

About the process of crystallization and the way of developing the musical material, Chou Wen-Chung wrote these words in his publication: *Varèse: A sketch of the Man and his Music*.

The consequence of an interaction caused by the expansion and the splitting of an idea into “different shapes or groups of sound constantly changing in shape, direction, and speed, attracted and repulsed by various forces,” rather than “a mould to be filled. In addition, his view of entire composition as “a melodic totality” – “not a line with harmony and counterpoint, but the whole thing moving as a line”-resembles Chou’s analogy between musical motion and calligraphic brushwork. (Lai 2009, 38)

2.3.4 Ayal Adler

In his thesis *Analysis of Crystallisation*, the composer Ayal Adler (Israel, 1968) analyses his piece for large orchestra called *Crystallisation* (2001), a piece based on the concept of

overall process that affects to form and texture. For this piece, Ayal Adler took inspiration from some quotes said by the composer Edgard Varese:

I became interested in “overall process” as the basis for composition and form in 1999. That year, I wrote the piece *Voyages* for a medium-size orchestra. I attempted to create, in the listener, the illusion of a journey through two different perceptions of time, one dynamic and the other static. (Adler 2003, 3)

Therefore, the elements that form the piece *Crystallization* are inspired by the process of crystallization and Ayal Adler’s understanding.

Crystallisation is a piece for large orchestra with a duration of approximately 15 minutes, written by Ayal Adler in 2001. The thesis that contains the piece explains the formal structure, pitch organization, rhythm and texture of *Crystallisation*.

Related to the concept of crystallization, the thesis exposes some concepts about musicals elements:

- Planning. The form of the piece, pitch and sonorities are decided by the composer before starting to compose.
- Combination. Different techniques such as overlapping and liquidation are used in the process of composing to merge one texture into another.
- Basic elements. Different textures, as well as sonorities and transformations of material, are created with the basic elements of the piece.
- Freedom. The element of freedom is used with the musical elements and concepts explained above. That is, there are different ways of obtaining and using the musical material, but these ways are not rules: “However, in the actual process of the composition I allowed myself some degree of freedom in the evolution of subsections and textures”.

Finally, in the conclusions of the thesis written by Ayal Adler, the composer exposes some thoughts about the concept of crystallization and crystals in his piece *Crystallisation*:

The term crystallization refers to the process of forming crystals. The “overall process” within the piece is thus, a gradual progression towards *Crystallisation* and then a gradual disintegration of the crystalline-like structure. (Adler 2003, 28)

A crystal is a repeating array. Its atoms are aligned in a repeating pattern, i. e. the crystalline lattice. The most important property of the crystal lattice is symmetry. (Adler 2003, 28)

2.4 Composing with the method: *Crystallized* (2019), for ensemble

After studying the concept of crystallization in music, and its definition and development as a chemical process, the next step that has been taken in this independent project is the composition of a piece by the author of this research, which is based on the composition process of crystallization.

Crystallized is a piece composed at the end of 2018 for improvisation ensemble, framed within the first semester of the Master of Fine Arts Programme in Music with specialization in Composition, at the University of Göteborg. It has a length of 6 minutes and 40 seconds, and its premiere was on Saturday, January 19, 2019 in Katakomberna (Göteborg).

The external structure of *Crystallized* was based on the three processes that form the chemical process of crystallization: the initial state, the nucleation process and the process of crystal grow. Therefore, the parts of which the external structure of *Crystallized* is formed are the following:

Section	crystallization process	Length
Section 1	Initial state	0'08" - 2'15"
Section 2	The nucleation process	2'16" - 5'27"
Section 3	The process of crystal growth	5'28" - 6'40"

Table 1 The structure of the piece *Crystallized*.


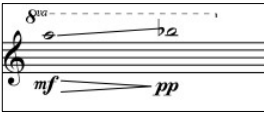
At the beginning of the piece, which is created without having a preconceived form, are all the tissue of cells that are developed through various processes of composition. This section ends when the first motif created by the grouping of the cells (2'16") appears. (Fig. 1)

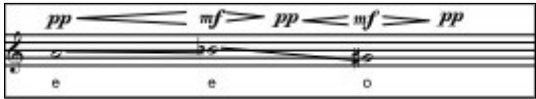
Figure 1 displays 12 musical staves, labeled G through R, arranged in a 4x3 grid. Each staff illustrates a primary musical motif from the first section of the piece 'Crystallized' in its 'Initial state'. The motifs are as follows:

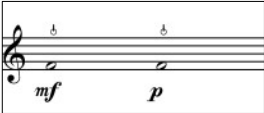
- G:** Treble clef, quarter notes, dynamic *mf*, includes a triplet of eighth notes.
- H:** Treble clef, sixteenth notes, dynamic markings *pp*, *mf*, *pp* with a crescendo/decrescendo hairpin.
- I:** Treble clef, sixteenth notes, dynamic markings *pp*, *mf*, *pp* with a crescendo/decrescendo hairpin.
- J:** Bass clef, quarter notes, dynamic markings *pp*, *mf* with a crescendo/decrescendo hairpin.
- K:** Treble clef, quarter notes, dynamic markings *p*, *mf*, *p* with a crescendo/decrescendo hairpin.
- L:** Treble clef, quarter notes, dynamic *mf*.
- M:** Bass clef, quarter notes, dynamic markings *pp*, *mf*, *pp* with a crescendo/decrescendo hairpin.
- N:** Treble clef, quarter notes, dynamic markings *pp*, *mf*, *pp* with a crescendo/decrescendo hairpin.
- O:** Bass clef, quarter notes, dynamic markings *p*, *mf* with a crescendo/decrescendo hairpin.
- P:** Bass clef, quarter notes, dynamic markings *p*, *mf* with a crescendo/decrescendo hairpin.
- Q:** Bass clef, quarter notes, dynamic markings *mf*, *p*.
- R:** Treble clef, quarter notes, dynamic markings *mf*, *p* with a crescendo/decrescendo hairpin.

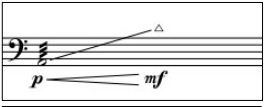
Fig. 1 Primary material of the First section of the piece *Crystallized* "Initial state".

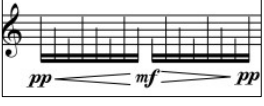
The second part of the piece begins with the appearance of the first motif formed from the grouping of several cells of the first section. From that moment, the piece is formed by two groupings or main motifs, which are presented in different ways in the different instruments of the piece, exemplifying the process of nucleation or grouping of cells in a stable manner. (Fig. 2)

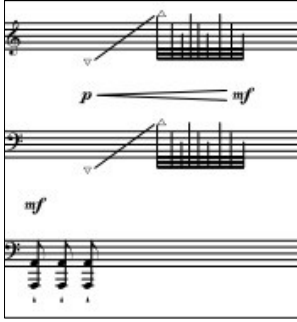
A  

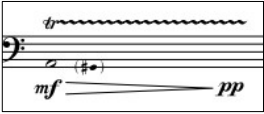
M1 


C 

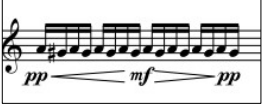
D 


E 


M2 

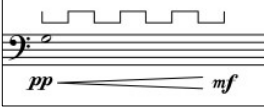
F 

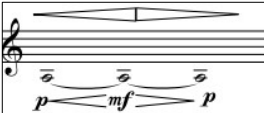
G 

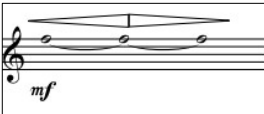
H 

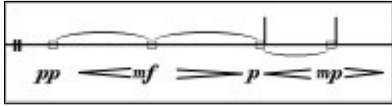
I 

M3 

J 

K 

L 

M4 

The diagram illustrates the compositional process for the second section of the piece *Crystallized* "The nucleation process". It shows how initial motifs (M, N, O, P, Q, R) evolve into more complex forms (M5, M6).

- Motif M:** A single note with dynamics *pp*, *mf*, and *pp* indicated by a wedge.
- Motif N:** A three-note motif in treble clef with dynamics *pp*, *mf*, and *pp*.
- Motif O:** A single note with dynamics *p* and *mf*.
- Motif P:** A single note with dynamics *p* and *mf*.
- Motif Q:** A two-note motif in bass clef with dynamics *mf* and *p*.
- Motif R:** A two-note motif in treble clef with dynamics *mf* and *p*.

Arrows indicate the development of these motifs into:

- M5:** A complex motif in bass clef, derived from M, N, O, and P, featuring a series of notes with dynamics *pp* and *mf*.
- M6:** A complex motif in treble clef, derived from Q and R, featuring a series of notes with dynamics *mf* and *p*.

Fig. 2 Material of the Second section of the piece *Crystallized* "The nucleation process".

Therefore, the compositional processes that have been applied for the composition of the cells that form the second and third section of the piece are the followings:

- Process of Symmetry. Process formed by three notes, of which the central note has the same distance with the two extremes.
- Process of Projection. Transposition of a motif or cell of pitches from a defined register level to another.
- Process of Rotation. Process that involves transformations through inversion, retrogression and retrogression-inversion, in a tonal or rhythmic way.
- Process of Expansion and contraction: Process of expanding or compressing the ends of the pitches of the cells, expanding or compressing the length of the notes.

Once the piece has shown the two main groupings that have been generated from the initial cells, the process of growth of the motifs appears at the end of the piece. That is, this section starts and ends with the growth of musical elements and dynamics of the main motifs. The growth is carried out in the two main motifs, since this way the final form that is produced through the entire crystallization process is exemplified.

This part, dedicated to the expansion of the motifs (which are formed by the grouping and development of the cells and motifs), the two resulting motifs are transferred in the different instruments of the ensemble, with indications of increasing the dynamics at the same time that the seconds advance, in order to expand the same concept, or the same phrase that gives unity to the final form of the piece (to the final shape of the crystal). (Fig. 3)

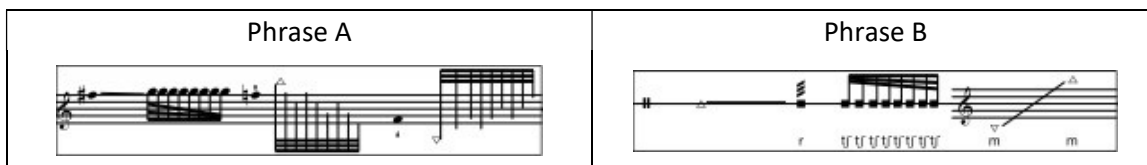


Fig. 3 Material of the Third section of the piece *Crystallized* "The process of crystal growth".

2.5 Definition and explanation of the compositional method of Crystallization

The first part of the Independent Project ends with this point, in which, once the theoretical concepts of crystallization in music and crystallization as a chemical process have been investigated and the author of this research has explored the method through the composition of the work *Crystallized*, the basis of the compositional method of crystallization is established.

The method of musical composition of crystallization can be defined as the composition of a piece based on the establishment, grouping, development and expansion of its cells and motifs, which are those that generate the structure or parts of the piece. Therefore, in the pre-compositional part of the piece there is no preconceived structure, with parts differentiated by contrasts or different tonal focus, but the structure is the result of the movement of the cells and motifs of the piece.

If the three sections that provide the two sub-processes (nucleation and growth) of the chemical crystallization process are used, in the pre-compositional aspect of the piece the composer must be aware that the initial cells that she/he proposes must develop a process of grouping and an expansion process.

Therefore, at the beginning of the piece the composer must provide enough compositional cells to the piece, since the next section is created from its grouping. It is the decision of the composer whether these cells keep a very close coherence or not and, on the other hand, whether they are very contrasting, since the compositional processes applied to the cells and their characteristics are what will characterize the rest of the piece.

It should be noted that the crystallization process that has been explored in this project and in the piece *Crystallized* is not intended to be an analogy or a copy of the crystallization processes used by some composers. This exploration has been carried out through the information obtained through the works in which the composers used the analogy of crystallization and the conceptual basis of the chemical process of crystallization. Therefore, the final result is to establish the ideas of crystallization from the previous analysis and my own composition.

Chapter 3: DNA Music

3.1 Introduction to the concept of DNA

Something present in everybody, something present in nearly all living organism, something that gives us the primordial information: the information of life. This could be a philosophical definition about the concept researched in this chapter: the concept of DNA.

As it is said in the introduction of the first concept, many composers have looked for inspiration, information or connections in other fields during the history of music, and this biochemical concept is not an exception.

This chapter shows and describes three methods of using the concepts of DNA in order to create a network of musical material and musical parameters. These three composers have used the main parameters of DNA in order to generate music in different ways, such as creating analogies between DNA parameters and music, translating DNA images or gestures into music, using characteristic numbers of DNA to create musical parameters.

The pieces composed for the author of this thesis related to the concepts of DNA have some similarities with the methods used by the composers researched, using the information and images in order to create music material, analogies, musical gestures, pitch material, rhythms.

Furthermore, at the end of this thesis there is an interview about the concept of DNA for the composer Maria Mannone. The method developed for this composer is explained in the first part of this chapter, and this interview was a great tool to clarify the process of using DNA concepts in music.

3.2 The concept of DNA as a biological concept

We can define DNA or Deoxyribonucleic Acid as an acid in the chromosomes that gives the functions and structures of the cells. The image of the DNA, the double helix, has the following three parts:

- a) Bases of DNA or Nucleobases. A base of DNA is one of the molecules that has information. Pairs of nucleobases connect the strands of DNA. A nucleotide contains a nitrogen base (and a sugar group and a phosphate group). There are four types of nitrogen bases: adenine (A), thymine (T), guanine (G) and cytosine (C). The order of the nucleobases is what determines the genetic code.

- b) Connections or Rungs (between bases and strands). To make the connections, two bases join between the sugar molecules. There are only four possible combinations of the bases, because a thymine molecule only pairs with an adenine (A-T or T-A) and a guanine molecule only pairs with a cytosine (C-G or G-C).
- c) The strands of the double helix. The description of the structure of a DNA molecule is the Double helix, which consists of strands that wind around each other.

Furthermore, the double helix and its order of coiling are controlled by helicases and topoisomerases, which are enzymes that produce the winding of DNA (overwinding and underwinding). There are two topological problems involved in the topoisomerase.

- d) Concatenation. In the concatenation process two circular DNA strands are linked together.
- e) Supercoiling. In the supercoiling process the double helix is further twisted about itself, forming a tightly coiled structure.

3.3 The concept of DNA in music

3.3.1 Maria Mannone

Maria Mannone was born in Palermo (Italy) in 1985. She studied bachelor's degrees in composition and orchestral conducting at the Conservatoire de Musique of Palermo and a master's degree at RCAM-UPMC Paris. Furthermore, she developed her PhD at University of Minnesota (USA).

This investigation is based on the article *Knots, Music and DNA*, written by Maria Mannone in 2018, and the piece *DNA*, composed by Maria Mannone in 2018. In that article, she explains the background of the compositional method, that is, the theory of musical gestures. Moreover, she describes the compositional method and analyses some extracts of her piece *DNA*.

The method developed by Maria Mannone in her article *Knots, Music and DNA* is based on analogies between the image of the structure of DNA and its representation as musical concepts and aspects. Therefore, the parts of the double helix of the DNA and the topological problems involved in the topoisomerase are represented through musical analogies.

- a) Bases of DNA or Nucleobases. Each nucleobase is represented by a specific interval, pitch and isolated chords.
 - Adenine (A) = minor 3rd (A-C)
 - Cytosine (C) = major 3rd (C-E)
 - Thymine (T) = minor 3rd (B-D) *T is like B in American solfeggio
 - Guanine (G) = major 3rd (G-B)
- b) Connections or Rungs. The composer uses glissandos as an analogy of rungs or connections.
- c) The strands of the double helix. The strands are rendered as melodic lines. There are different types of helix because of the number of strands. Therefore, two strands are transformed into two melodic lines; three strands into three melodic lines and four into four. Furthermore, these melodic lines exchanging and intertwining because of the movement of the lines.
- d) Concatenation. In order to explain the concatenation process, the composer uses superposed sequences, time reduction and the deformation of the patterns to obtain more superposition
- e) Supercoiling. In the musical representation of the supercoiling process, there are musical elements such as melodies with the same structure and dynamic patterns, repeated unison notes and phrases or melodies that return on the same note.

3.3.2 Clara Maïda

Clara Maïda (1963) is a composer from France who studied at IRCAM, in Marsella and Nanterre. Currently she works as a music teacher in France and Germany and investigates some connections between music, neuroscience and genetics.

One of her lines of investigations is focused on the relation between DNA and music. Related to this question, she gets the harmonic structure from the chemical structure of the DNA in order to produce different chords, sonorities or pitch material.

For relating DNA and music, Clara Maïda uses material such as molecular structures of DNA, the double-helix of DNA, and then she produces some layers and different develops of the motifs. All this material is produced in order to have the necessary material before starting to compose a piece.

One of these examples of using DNA material into music is her piece *Via Rupta*.

Another way of obtaining musical material is using the chemical structures of the amino acids to create similar blocks of sounds or harmony. The number of repetitions of each base of DNA or nucleobase is used to create the different durations of sounds.

3.3.3 Peter Gena

Peter Gena (1947) is an American composer and professor at The School of the Art Institute of Chicago. His composition style is based on electronic music and computer-generated music, as well as minimalism. Furthermore, Peter Gena has collaborated with geneticists to create methods of using DNA sequences in his pieces.

As it is said above, Peter Gena collaborated with the geneticist Charles Strom to compose pieces that includes or are based on the genetic structure as sound. In order to produce the musical material, Peter Gena uses a patch on Max/MSP called *DNA Mixer* that scan complete genomes of human or bacterial proteins. For Peter Gena, this is the system to sonificate DNA:

An algorithm was designed to convert the list of sixty-four codons into distinct musical events. Complete genomes of human or bacterial proteins, or viruses are then scanned by a Max/MSP patch, *DNA Mixer*, so that each of the codons is culled from a database table and then played in real-time linear sequence. This process is analogous to the scanning of the mRNA by the ribosomes as it adds amino acids sequentially to make proteins - a process not unlike several cars (ribosomes) on a roller coaster negotiating the identical track (mRNA), but at different locations, speeds, and spacing. (Jensen 2008, 250)

One of the pieces composed by Peter Gena with this kind of using DNA material is the piece *Collagen*, which has material derived from a single DNA sequence. The patch used to read the coded material transform that information into arbitrary sounds that produce the musical material.

3.3.4 Laurie Spiegel

Laurie Spiegel (1945) is an American composer who studied composition at the Juilliard School, and known for her use of algorithmic logics in her compositional development. In some of her pieces she has included elements from the DNA mapping, which refers to the variety of different methods that can be used to describe the positions of genes. It can show different levels of detail.

One example of using DNA in music pieces is the piece *A Strand of Life* included in her album *Unseen Worlds* (1990). This piece has been composed with a translation of DNA features in a minimalistic way. She used the four Nucleobases of DNA (adenine, uracil, guanine and cytosine) to generate the pitch material of the piece:

A Strand of Life (1990), happened one afternoon while I was sick with a virus. Fantasizing that I could take my own virus by doing so, I decided to map the complete genetic base sequence of a viroid into the musical pitch domain. I didn't have the data for a real DNA virus, but I found complete information on a viroid (which has only RNA) in an old copy of Scientific American ... If you substitute adenine for each A, uracil for each E, guanine for each G, and cytosine for each C in this piece, you will have a self-replicating genetic strand. (Jensen 2008, 247)

This way of obtaining musical material is generated by using the first letter of the Nucleobases words: A for Adenine, C for Cytosine, G for Guanine and U for Uracil). Moreover, this method is supported by using software that translate genetic information into music material.

3.4 Composing with the concept: *Intramolecular* (2019), trio for flute, violoncello and percussion

After the research on the theoretical concepts of DNA and the musical method created by these composers, the next step was to create the own method of the composer and researcher of this investigation.

The first piece of this part of the project is *Intramolecular*, composed in 2019. It is a trio for flute, violoncello and percussion (vibraphone, frame drum and Waterphone). The premiere of this piece was at Högskolan för scen och music (Göteborg – Sweden) on May 10, 2019, by the ensemble Mimitabu. The duration of this piece is 8 minutes.

a) Dynamics and Tempo Marks. Pitch. Double helix analogy

In order to achieve an analogy of the double helix strands, I based the structure of the tempo marks and the dynamics on the double helix concept. The dynamic structure of this piece is based on the movement of one strand, which starts and ends at the same point, and has the same distance from the middle to the extreme points.

In order to achieve an analogy of the double helix strands, the composer of this piece based the structure of the tempo marks and the dynamics on the double helix concept. The

dynamic structure of this piece is based on the movement of one strand, which starts and ends at the same point, and has the same distance from the middle to the extreme points. (Fig. 4)

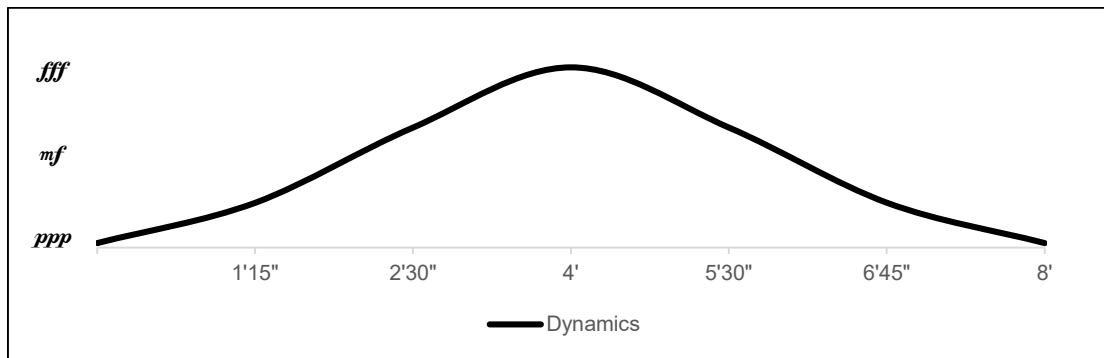


Fig. 4 Dynamic structure of the piece *Intramolecular*.

Furthermore, the movement of the strands gives the DNA analogy in order to obtain the overall dynamic structure of the piece *Intramolecular*. (Fig. 5)

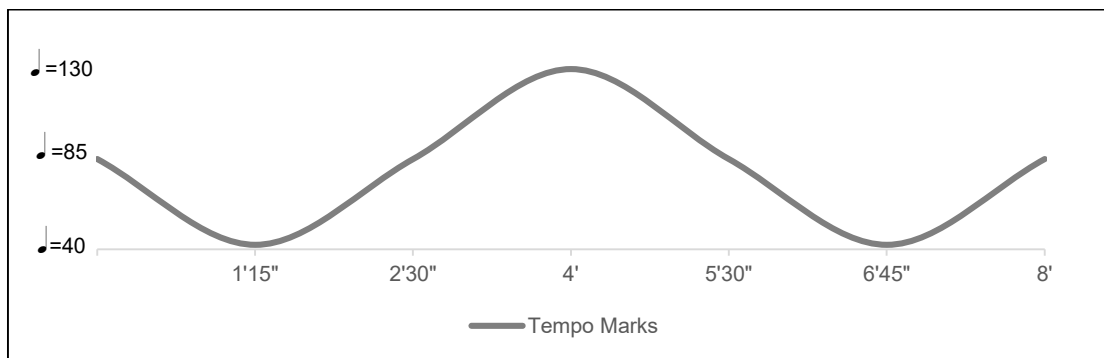


Fig. 5 Tempos of the piece *Intramolecular*.

In addition, the overall pitch movement of the flute and the violoncello is related to the double helix analogy. The pitch movement of the flute and the pitch movement of the violoncello have the same direction, but in an opposite way. (Fig. 6)

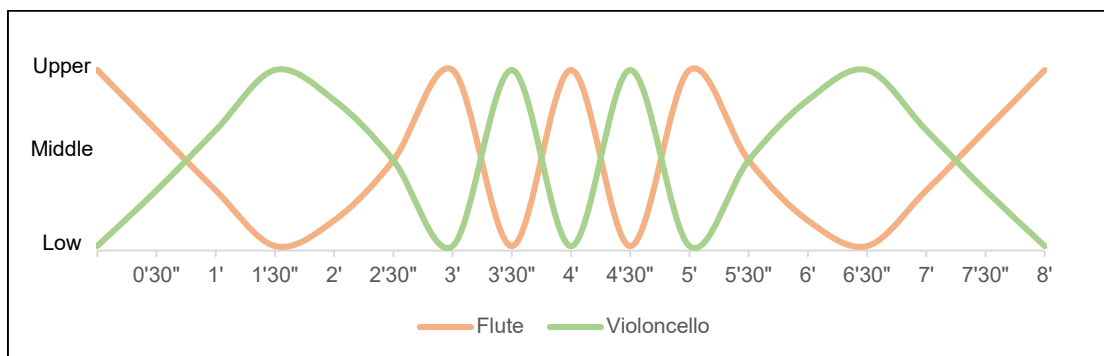


Fig. 6 Pitch structure of the piece *Intramolecular*.

b) The overall structure. Analogy of the Intramolecular formation

The first piece of this research, *Intramolecular*, is based on the concept of Triplex-DNA or triple stranded DNA. In a few words, the triplex-DNA is a DNA structure with three strands, which wind around each other. Furthermore, the piece is based on one of the two types of Triple-DNA: the intramolecular formation and its two types of formation (H-DNA and H*-DNA).

The structure of the piece has three sections, A – B – A. The first section (A) represents the two types of Intramolecular formation, H-DNA and H*-DNA, which have stabilized formations. The second section of the piece (B) represents the most destabilized triple-base pairs. So that, these concepts are represented in the piece as analogies of musical density, rhythms and tension:

Intramolecular Structure (Sections)			
Section	A		B
Structure	m. 1 – m. 40		m. 41 – m. 116
DNA Analogy	Stabilized triple-base pairs		Destabilized triple-base pairs

Table 2 Sections of the piece *Intramolecular*.

Moreover, each section has different parts that represent the triple-base pairs. The first section has two parts. The first part is an analogy of the triple-base pair TA*T, while the second part is analogy of the CG*C+. The second section has the same construction, but with three parts. In addition, the another appear of the first section has two parts too, but with different analogies of the triple-base pairs:

Intramolecular Structure (Sections and Parts)							
Section	A		B			A	
Part	A1	A2	B1	B2	B3	A1	A2
Structure	m. 1 – m. 24	m. 25 – m. 40	m. 41 – m. 64	m. 65 – m. 93	m. 94 – m. 116	m. 117 – m. 135	m. 136 – m. 142
Triple-base pair	TA*T	CG*C+	TA*G	CG*G	TA*G	TA*A	CG*G

Table 3 Sections and parts of the piece *Intramolecular*.

c) Pitch material. The DNA nucleobases and the triple-base pairs.

The pitch elements of each part of the piece are based on the concept of nucleobases. There are four types of nucleobases, and these nucleobases are represented in the piece as analogies of musical notes. That is, Adenine as a A, Guanine as a G, Thymine as a B, and Cytosine as a C. Each part of the piece is based on a combination of these nucleobases, in order to obtain analogies of the triple-base pairs.

For example, the first part of the piece starts with a B as a main musical note of the part. That is, the part is based on that note and little oscillations in terms of pitch, dynamics and density. (Fig. 7)

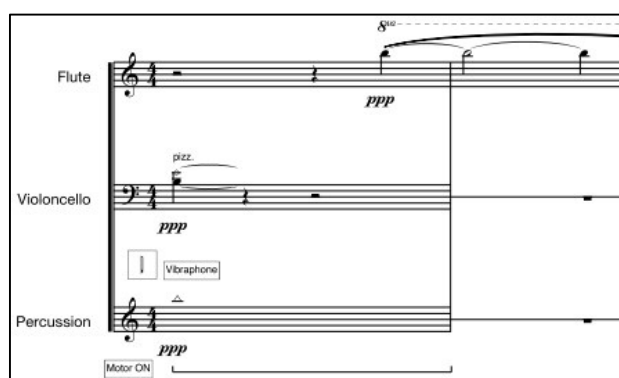


Fig. 7 Example of the bars 1-2 of the piece *Intramolecular*.

At the end of each part of the first section, the musical motifs of each instrument are based on the chemical formula of the nucleobase. Each

Nucleobase	Chemical formula
Adenine	C ₅ H ₅ N ₅
Guanine	C ₅ H ₅ N ₅ O
Cytosine	C ₄ H ₅ N ₃ O
Thymine	C ₅ H ₆ N ₂ O ₂

Table 4. Chemical formulas used in the piece *Intramolecular*.

In order to achieve the musical motifs, the atomic number of each chemical element gives the distance from the main note to the next note of the motif, and the number of atoms gives the number of repetitions of each note.

For example, the chemical formula of the Thymine is C₅ H₆ N₂ O₂. If the letter of each chemical elements is changed by its atomic number that formula is (B) 6₅ 1₆ 7₂ 8₂, Finally, each atomic

number is used as the number of semitones from the main note (in this case B) to the new note. The result is this musical note and its number of repetitions B F₅ C₆ F#₂ G₂. (Fig. 8)



Fig. 8 Example of the bars 11-12 of the piece *Intramolecular*.

d) Rhythmic material. Chemical elements of the nucleobases.

The main musical motifs of the piece have the analogy of the strands. That is, these motifs have the characteristic movement of the strands. Furthermore, this aspect is in one instrument and in the three parts, depending of the density of each section. (Fig. 9)

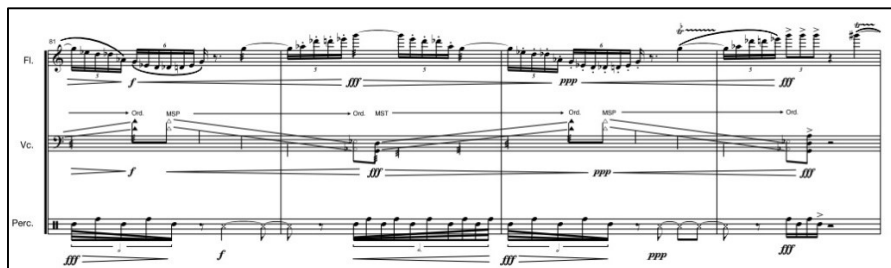


Fig. 9 Example of the bars 81-84 of the piece *Intramolecular*.

Furthermore, the rhythmic material of this piece is based on the number five. For example, the rhythmical crescendos and the rhythmical diminuendos are based on this number, in order to give a coherence to the rhythmical skeleton of the piece. (Fig. 10)

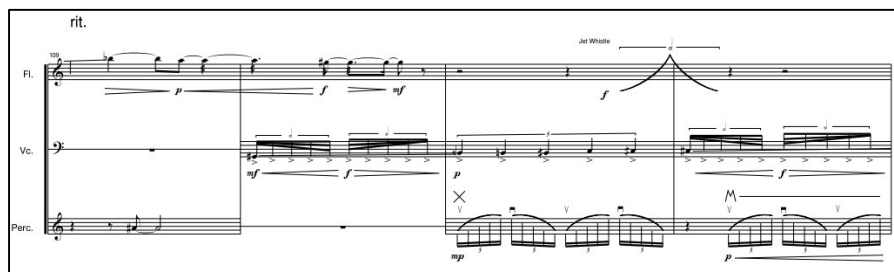


Fig. 10 Example of the bars 109-112 of the piece *Intramolecular*.

3.5 Composing with the concept: *Supercoiling* (2019), for string orchestra

The second piece composed with the DNA method is *Supercoiling*, a piece composed in 2019 for string orchestra. Its premiere was at Utvandrarnas Hus (Växjö, Sweden) on May 24, 2019, by Musica Vitae string orchestra and the conductor Michael Bartosch. *Supercoiling* is a composition for 14 individual instruments: four Violin I, four Violin II, three Violas, two Violoncellos and one Contrabass. The duration of the piece is 8 minutes.

a) Dynamics and Tempo Marks. Double helix analogy

The dynamics and the tempo marks of the piece are represented as analogies of the double helix strands. That is, the line of the dynamic's movement of the piece and the line of the tempo marks have the same movement, but in the opposite direction. (Fig. 11)

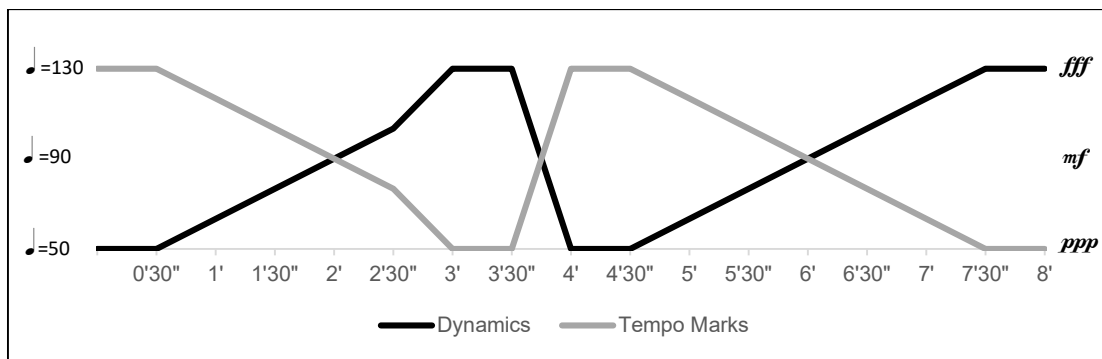


Fig. 11 Dynamics and Tempo Marks of the piece *Supercoiling*.

b) The overall structure. Analogy of the Supercoiling process

The overall structure of the piece is based on the biological process of supercoiling. In the supercoiling process, the DNA structure in which the double helix is further twisted about itself, creating a coiled structure.

This piece has two big sections, which represent the two types of phenomena that can occur in the supercoiling process: Type 1 topoisomerases and Type 2 topoisomerases:

Supercoiling Structure (Sections)		
Section	Section 1	Section 2
Structure	m. 1 - m. 78	m. 79 - m. 162
DNA Analogy	Type 1 Topoisomerases	Type 2 Topoisomerases

Table 5 Sections of the piece *Supercoiling*.

Furthermore, each section has two parts, which describes the transformation of the DNA through the process of supercoiling:

<i>Supercoiling Structure (Sections and Parts)</i>					
Section	Section 1			Section 2	
Part	A		B	A	C
Structure	m. 1 – m. 54		m. 55 – m. 78	m. 79 – m. 130	
DNA elements	The process from an unstressed DNA molecule to 5 supercoils		The process of cleaving one strand of the double helix, holds on the both ends and passes the other intact strand through the break after which it relights the strand	The process from an unstressed DNA molecule to 4 supercoils	
				The process of introducing negative supercoils in double-stranded DNA rather than to remove them, in order to achieve 5 supercoils	

Table 6 Sections and Parts of the piece *Supercoiling*.

In addition, each section of the piece has five parts, which are analogies of each process. That is, the first part or part A is divided in two sections, both in the Section 1 and Section 2. The other parts of the piece, that is, part B and part C have three different sections, which represent the states of the double helix:

<i>Supercoiling Structure (Sections, parts and subsections)</i>										
Section	Section 1					Section 2				
Part	A		B			A		C		
Section	A1	A2	B1	B2	B3	A1	A2	C1	C2	C3
Structure	m. 1 - m. 19	m. 20 - m. 54	m. 55 - m. 77	m. 78 (Senza Misura) p. 17	m. 78 (Senza Misura) p. 18	m. 79 - m. 97	m. 98 - m. 130	m. 131 - m. 148	m. 149 - m. 160	m. 161 (Senza Misura) - m. 162

Table 7 Sections, parts and subsections of the piece *Supercoiling*.

Section	DNA Elements
A1	An unstressed DNA double helix.
A2	The process of forming 5 negative supercoils.
B1	A circular double-stranded DNA, which has 5 negative supercoils.
B2	The cut of the strand.
B3	The stress and the underground DNA is eliminated by rewinding.
A1	An unstressed DNA double helix.
A2	The process of forming 4 negative supercoils.
C1	A circular double-stranded DNA, which has 4 negative supercoils.
C2	The process of using energy to add supercoils.
C3	The result of the process of adding energy: 5 negative supercoils.

Table 8 DNA elements included in each subsection of the piece *Supercoiling*.

c) Pitch material. The DNA nucleobases.

The four DNA nucleobases are used in order to achieve the four main pitches of the piece. That is, the analogy of the Adenine (A) generates the musical note A; Cytosine (C) generates the musical note C; Guanine (G) generates the musical note G; Thymine (T) generates the musical note B. (Fig. 12)

The image shows a musical score for five instruments: Viola (1), Viola (2), Viola (3), Violoncello (1), Violoncello (2), and Contrabass. The score is in 4/4 time and spans five bars. The Viola parts (1, 2, and 3) are mostly silent, with some activity in the final bar marked 'Punta d'arco' and 'MSP'. The Violoncello and Contrabass parts are more active, featuring dynamic markings such as *ppp*, *f*, and *mp*. The Contrabass part includes markings for 'MST (S.V.)' and 'Ond.'. The Violoncello parts also include 'MST (S.V.)' and 'Ond.' markings. The overall texture is sparse, with the lower strings providing the primary melodic and harmonic material.

Fig. 12 Example of the bars 1-5 of the piece *Supercoiling*.

In order to develop the material of the piece, in the course of the piece, the musical material narrows in the extreme notes through quartertones. That is, the lowest notes, G and A, up its tuning, whereas the highest notes, C and B, down its tuning. (Fig. 13)

This musical score shows five staves: two Violins (Vla. (1) and (2)), two Violas (Via. (3) and (1)), and a Cello (Cb.). The music is in 4/4 time. The Violin parts feature dynamic markings of *pp*, *mf*, and *pp*, with performance instructions like "[Punta d'arco] MSP" and "Whole Bow". The Viola parts also use *pp* and *mf* dynamics, with "arco" and "Whole Bow" markings. The Cello part includes *f* and *pp* dynamics, with "Ond." markings and a large crescendo line. The Violin (2) part has an "MST arco [S.V.]" marking.

Fig. 13 Example of the bars 21-25 of the piece *Supercouling*.

As a result of the compositional process of the piece, the musical notes that are defined as pedals or extremes (high pedal and low pedal) narrow in the course of the piece. In this example, the lowest G up its tuning, while the highest G down its tuning. (Fig. 14)

This musical score shows four staves: two Violins II (Vin. II (3) and (4)) and two Violas (Via. (1) and (2)). The Violin II parts have a *p* dynamic and a "[Punta d'arco] MSP" marking. The Viola parts feature *p* and *f* dynamics, with "MST arco [S.V.]" and "Ond." markings. The score illustrates the narrowing of pitch extremes over the five-measure span.

Fig. 14 Example of the bars 26-30 of the piece *Supercouling*.

Furthermore, each of the pitch material notes is used in order to establish pitch sections, that is, sections that are based on a specific pitch environment and its developing. For example, from the measure 36 there are four groups in terms of pitch. The first group (Violins I) has the A as pitch focus. (Fig. 15)

This musical score shows four staves for Violins I (Vin. I (1), (2), (3), and (4)). The music starts at measure 36. The Violin I parts feature dynamic markings of *mp*, *ff*, and *mp*. Performance instructions include "arco", "[Punta d'arco] MSP", "Col legno battuto", and "Col legno battuto". The score shows the development of a pitch section centered on the note A.

Fig. 15 Example of the bars 36-40 of the piece *Supercouling*.

The second group (Violins II) has the G as pitch focus. (Fig. 16)

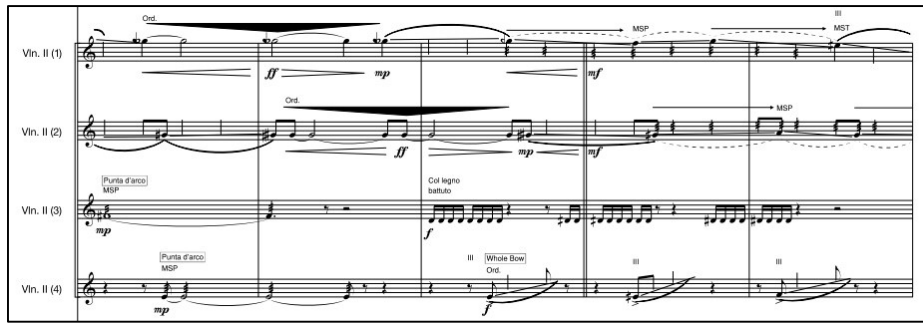


Fig. 16 Example of the bars 41-45 of the piece *Supercoiling*.

The third group (Violas) has the B as pitch focus. (Fig. 17)

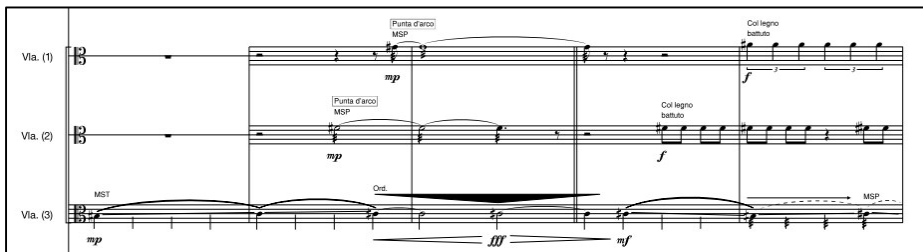


Fig. 17 Example of the bars 41-45 of the piece *Supercoiling*.

The fourth group (Violoncellos and Contrabass) has the C as pitch focus. (Fig. 18)

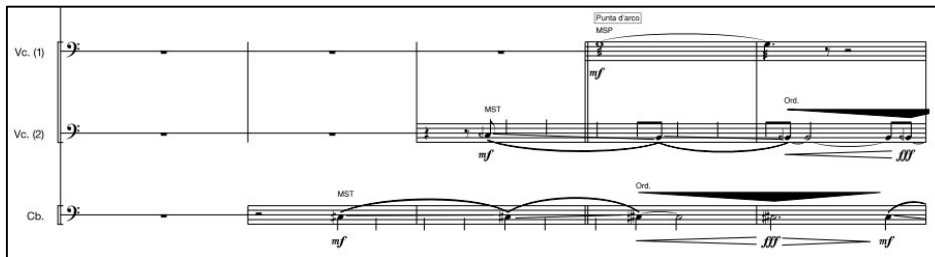


Fig. 18 Example of the bars 41-45 of the piece *Supercoiling*.

d) Rhythmic material. Chemical elements of the nucleobases.

The four nucleobases of the DNA have the same chemical elements, but in a different distribution. The chemical elements that give the structure of the nucleobase are Hydrogen (H), Carbon (C), Nitrogen (N) and Oxygen (O). This piece based its rhythmic material on the atomic number of each chemical element, that is, the number 6 for Carbon, the number 1 for Hydrogen, the number 7 for Nitrogen and the number 8 for Oxygen.

These numbers obtained from the atomic numbers of the chemical elements are used as number of beats. That is, the number 6 represents six beats, the number 1 represents one

beat, the number 7 represents seven beats and the number 8 represents eight beats. (Fig. 19)

Fig. 19 Example of the bars 16-17 of the piece *Supercoiding*.

The rhythmical elements can appear in the piece together, as the previous example, or separately. (Fig. 20)

Fig. 20 Example of the bars 43-45 of the piece *Supercoiding*.

In addition, the important fact is the number of beats, not its duration. For example, the number 6 can be represented by six quarter notes and six eighth notes. Furthermore, the presence of the number 5 is important in the rhythmic material. This number represents the number of supercoils of the DNA, which appears both in the pitch material and in the rhythmic material. (Fig. 21)

Fig. 21 Example of the bars 155-157 of the piece *Supercoiding*.

3.6 Definition and explanation of the compositional method of DNA

The second part of the Independent Project ends with this point, in which, once the theoretical concepts of DNA in music and DNA as a biological concept and process have been investigated, and the author of this research has explored the method through the compositions *Intramolecular* and *Supercoiling*, the basis of the compositional method of DNA is established.

The method of musical composition entitled DNA can be defined as a method based on the elements and processes of the DNA and its musical analogies. In order to obtain the musical elements or material, all the concepts of the DNA can be translated into music through analogies. That is, gestures, images and numbers are translated into music parameters. Furthermore, the processes inside the DNA can be used in order to obtain structures, plans or sections.

The following DNA concepts are converted in analogies in order to obtain musical material:

- The strands of the double helix: two strands, three strands or four strands
- The connections between the nucleobases and the strands
- The nucleobases: adenine, cytosine, guanine and thymine
- The chemical elements of the nucleobases: carbon, hydrogen, nitrogen and oxygen
- The processes related to DNA, such as the supercoiling process, or the concept of the triple-stranded DNA

The composer creates analogies and uses these concepts in order to obtain all the material for the piece. The composer has to decide how to use these analogies and processes, that is, there is no one way of creating the material from these analogies.

The compositional method of DNA investigated in this project is focused on creating analogies in order to produce material for the structure of the piece (the whole structure and the sections), pitch material, rhythm material, dynamics and tempo marks. Moreover, the analogies are achieved through DNA images, DNA processes, the numbers of the DNA elements, and the movement of the DNA parts.

The method of the researcher of this investigation is based on the method created by the composer Maria Mannone. Therefore, in both methods there are similarities and differences.

The idea of this investigation is to develop some of the ideas of Maria Mannone's method in order to create my own composition method.

Chapter 4: Brain Activity

4.1 Introduction to the concept of Brain Activity

The concept researched in this chapter has the same intention as the other concepts of this thesis, the intention of find connections and inspiration between music and science. The information that contains the field of the Brain Activity has been used mostly to generate musical material from scientific parameters and its translation to music.

There have been different attempts in the history of music and, concretely, since the 20th century, to generate musical material from brain activity parameters, such as the translation of an electroencephalogram to an audio signal in 1934 by Adrian and Matthews, or the piece *Music for Solo performer* composed by Alvin Lucier in 1965 using an EEG.

This chapter has been researched from different types of sources. The methods explained in this chapter have been explored by researchers from the field of science that have researched different ways of creating music from the brain activity.

These methods are focused on translating different parameters of brain activity into musical parameters. In order to obtain the parameters of the neuronal activity, these methods are based on the activity of different people and the different characteristics of processes related to the brain, like the sleep cycle.

For composing the piece with the concept of Brain Activity, the author of this research has focused on one process related to the brain and its different parameters and characteristics, the process of sleep cycle.

4.2 The concept of Brain Activity as a biological and chemical concept

Cognitive neuroscience is a field of study focus on the neural network of mental processes, between the intersection of psychology and neuroscience and physiological psychology. It mixes the theories of cognitive psychology and computational modelling with data about the brain.

Related to the topic of this investigation and the concept of cognitive neuroscience, there is a field of the concept of cognitive neuroscience: the study of sleep cycle.

The sleep cycle is formed by stages of long waves, stages of short waves (both are Non-REM sleep) and REM sleep or paradoxical sleep.

a) Sleep Cycle. Definitions

The different stages that characterize our sleep. A progression through the stages of Non-REM sleep to REM sleep with brain wave patterns that occur regularly every 90 minutes while we sleep. In a full 7 to 9-hour night of sleep there are around 4 to 6 sleep cycles. The process can be interrupted at any time.

b) Concepts and parameters

- **AMPLITUDE.** The vertical distance between a peak or a valley and the equilibrium point, that is, how big the wave is.
- **FREQUENCY.** How many cycles can happen in a certain amount of time (cycles per second). Measured in Hertz (Hz).
- **VOLTAGE (brain).** Electrical activity within the neurons of the brain. Measured in Volts (V), in this case Millivolts (mV).

c) Brainwaves

Rhythmic patterns of neural activity with a specific amplitude, frequency and voltage. There are 5 possible brain waves:

- **GAMMA waves.** The fastest brainwaves (40 Hz – 100 Hz) (38 Hz – 42 Hz).
- **BETA waves.** Associated with normal waking consciousness (12 Hz – 40 Hz) (12 Hz – 38 Hz).
- **ALPHA waves.** Deep relaxation and light meditation (8 Hz – 12 Hz) (8 Hz – 12 Hz).
- **THETA waves.** Deep meditation, dreams (4 Hz – 8 Hz) (3 Hz – 8 Hz).
- **DELTA waves.** Deep sleep and very deep meditation, a dreamless sleep (0 Hz – 4 Hz) (3 Hz – 5 Hz).

d) Stages of Sleep Cycle

STAGE 1 (1st NREM STAGE) | A drowsy state, a transition between the awakening state towards sleep.

- It represents a 10% of the process.
- **Amplitude:** low amplitude.
- **Frequency:** a transition between Alpha waves (8-12 Hz) to Theta waves (4-8 Hz).
- **Voltage:** low voltage.

STAGE 2 (2nd NREM STAGE) | A light sleep, muscle activity starts to decrease.

- It represents a 20% of the process.
- Amplitude: more than Stage 1
- Frequency: Alpha waves (8-12 Hz).
- Voltage: 50 mV.

STAGE 3 (3rd NREM STAGE) | Deep sleep, blood pressure falls, breathing slows, and temperatures drops even lower.

- It represents a 40% of the process.
- Amplitude: high amplitude.
- Frequency: Delta waves (0.5-4 Hz)
- Voltage: more than 75 mV

STAGE 4 (1st REM STAGE) | The brain is very active and the body paralyzed. The stage where we dream and the eyes are so active.

- It represents a 25% of the process.
- Amplitude: more than Stage 1
- Frequency: Alpha waves (8-12 Hz).
- Voltage: low voltage

In order to know in which stage of sleep the asleep subject is, there are several devices to know that, like electroencephalography (EEG), which recognize the timing of sleep cycles by distinction in brain waves manifested during non-REM sleep and REM sleep.

The whole sleep cycle could have a duration of 90 minutes, and in one night, there are between four and six sleep cycles.

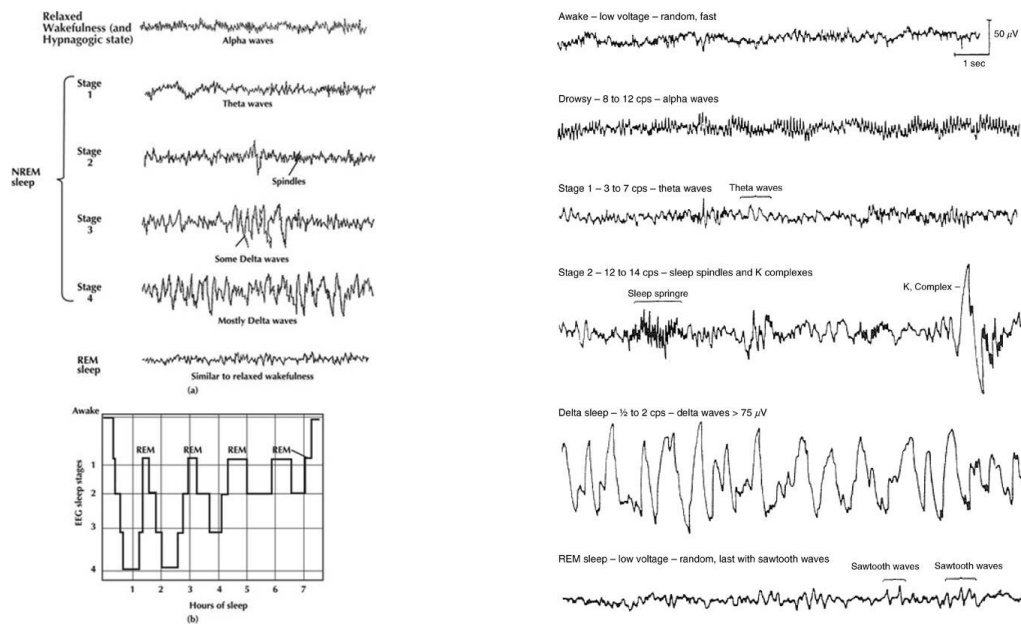


Fig. 22 Examples of the brainwaves included in a *Sleep Cycle*.

4.3 The concept of Brain Activity in music

4.3.1 Music Composition from the Brain Signal

The research article *Music Composition from the Brain Signal: representing the mental state by music* was written by Dan Wu, Chaoyi Li, Yu Yin, Changzheng Zhou and Dezhong Yao, and it is part of the research of the University of Electronic Science and Technology of China.

These researches propose representing the human the mental state through music, with a method to convert human electroencephalography (EEG) into musical material. The different concepts that form the level of the brain are obtained by EEG features and, then, these concepts are translated into musical parameters such as pitch, tempo, tonality and rhythm.

These researchers have obtained musical material with these five steps:

1. Extraction of the EEG signal features
2. Connection of the EEG features with the musical parameters of main note, tonality, rhythm to produce music segments
3. Generation of music bars from the connection of EEG features and the musical parameters of chord and note position
4. Fix the timbre, pitch, duration and volume of the notes
5. Construction of music melodies with the software Max/MSP and a MIDI file

After following these five steps, there are some consideration that have to be taken in order to produce musical material in a piece:

- Music Sequence. The length of a human EEG and the music sequence have the same duration.
- Main note. The main note of a melody (in this case the tonic) is based on the frequency of the human EEG. When the frequency of the EEG is high, the main note is high.
- Major and minor tonalities. The tonalities of this method are defined by the average of energy and its thresholds. When the average energy is lower than the threshold, there is a minor tonality and the average of energy is higher than the threshold there is a major tonality.
- Rhythm cadence. This musical parameter is related to the rate of alpha. That is, the rhythm cadence is dense when the rate of alpha is high.
- Note position. The researches have established four beats in a bar and four positions in a beat. The rhythm cadence determines the number of notes, while the amplitudes gives the position of the notes.
- Harmonic rhythm. For this research each bar has only one chord, and the notes of the bar can be part of the chord or not.

4.3.2 Neuronal Tones and Neuronal Melodies

Neuronal Tones is the title of a research done by Alain Destexhe, researcher from the French National Center for Scientific Research. This research is based on computer-generated music, and it uses recording of multiple neurons in order to obtain musical material.

In terms of music, the different pitches are converted from neurons and, the same music pitch is emitted when the given neuron appears. This way of getting musical material is used to apply concepts of brain signal like sleep cycle and its different parts of sleep with its characteristic elements.

Neuronal melodies is a research made by Alain Destexhe in 2012 with the same process like his *Neuronal Tones* explained above, but with a different generator material. In this research, A. Destexhe has used a dataset of 92 neurons.

These 92 neurons have been converted into musical material in order to create a piece for two instruments: woodblock and xylophone. The musical material for the woodblock

comes from the information of excitatory neurons, while the music for the xylophone has been obtained from the inhibitory cells.

The musical material of these instruments has been used to recreate some steps of the sleep cycle such as wakefulness, slow-wave sleep and REM sleep, generating MP3 files from this process of the brain signal. The first example is the excerpt *Awake Melody*, obtained from an awake subject. This example could be watched in an animated video, with representations of the LEP with colours, the excitatory neurons with the crosses and the inhibitors with circles. The second example is *Sleeping Melody*, based on the slow-wave sleep. The last example is obtained from the REM sleep stage, *Dreaming Melody*.

4.3.3 The Spikiss Project

Alain Destexhe and Luc Foubert are two researchers from the CNRS (French National Centre for Scientific Research). Both researchers, in their article *Composing music from Neuronal activity: The Spikiss Project*, describe how to translate brain signal into music. Concretely, they expose the way of converting selected groups of neurons to different scales, tones and rhythms:

We have made a more complex conversion by associating selected groups of neurons to different scales and tones, based on the similarity of their rhythmical activity. The goal is here not to study neuronal activity, but to use neuronal activity to drive music composition. (Destexhe and Foubert 2018, 239)

In order to obtain musical material or events, the researchers have translated neuron spikes into musical events, because these neuron spikes are impulses that they can use to obtain music through a MIDI protocol.

The material obtained from neuron spikes is converted to notes with fixed length and fixed velocity. All this material is mapped onto the keyboard, both in a diatonic scale and in a chromatic scale.

All this material has been used to create pieces based on different concepts of brain activity, such as sleep cycle, and concretely, the neuronal activity during the slow-wave sleep. During the slow-wave sleep, a mapping translated into the C major diatonic scale.

A mapping of the neurons can be defined as a set of neuroscience techniques based on the mapping of biological properties onto spatial representations of the human or non-human brain resulting in maps.

This way of obtaining material from the brain signal and, concretely, from the sleep cycle can be listen to in some examples produced by the researchers, such as *Sleeping Bells*, *Neuronal Bells* and *Sleeping Waves*.

4.4 Composing with the concept: *Sleep Cycle* (2019)

The method developed for this piece is based on analogies between the main features of the brain activity and music aspects and material. That is, the characteristics of the brain activity has been used in the result as generators of music material, such as structures, dynamics, tempo and rhythm.

Sleep Cycle is the result of the third part of this thesis. I composed the piece *Sleep Cycle* in 2019 and it was supervised by the teachers of the Academy of Music and Drama: Malin Bång and Ole Lützow-Holm.

Sleep Cycle is a piece for solo percussion, concretely for four toms, two bongos, two congas, suspended cymbal, tam-tam and spring drum. Its premiere was on 14th of January at the Höskolan för scen och music, and it was played by Simon Halvarsson.

This piece is based on the process of the Sleep Cycle. For this reason, this piece is divided in several sections that describe some aspects from the Sleep Cycle such as frequency, amplitude or brainwaves.

In order to use the concepts of the sleep cycle, the frequency, the amplitude and the brainwaves that characterised each stage of the process are used as music analogies. For this reason, the frequency of each stage is used as tempo, the amplitude of each stage is used as dynamic and the brainwaves are used as inspiration of rhythms and oscillations of dynamics and tempos.

Furthermore, the piece and the process of a sleep cycle have the similar duration of each stage. For this reason, each stage of the process is adapted to the general duration of the musical piece, eight minutes.

a) Structure. The structure of the piece is based on the concept of sleep cycle and its different sections. Each part of the piece has the similar duration that each part of the sleep cycle process in terms of percentage:

SECTION	STAGE	PERCENTAGE	TEMPO MARK	DURATION
Introduction	Awakening	5%	0' - 0'24"	24"
S1	Drowsy	5%	0'24 - 0'48"	24"
S2	Light sleep	10%	0'48" - 1'36"	48"
Transition	T	2'5%	1'36" - 1'48"	12"
S3	Deep Sleep	40%	1'48" - 5'	3'12"
Transition	T	2'5%	5' - 5'12"	12"
S2	Light Sleep	10%	5'12 - 6'	48"
S4	REM Sleep	25%	6' - 8'	2'

Table 9 Structure of the piece *Sleep Cycle*.

b) Dynamics. The dynamic level of the piece is obtained from an analogy between the voltage of each part of a sleep cycle and dynamics. (Fig. 23)

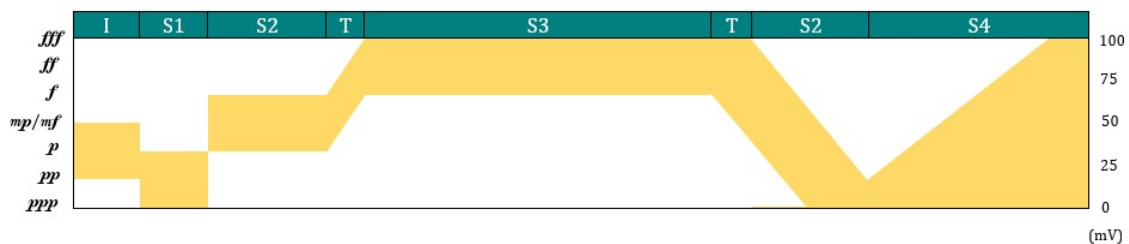


Fig. 23 Dynamic structure of the piece *Sleep Cycle*.

c) Tempo. The frequency that characterizes the parts of a sleep cycle is used to create the tempos of the piece. (Fig. 24)

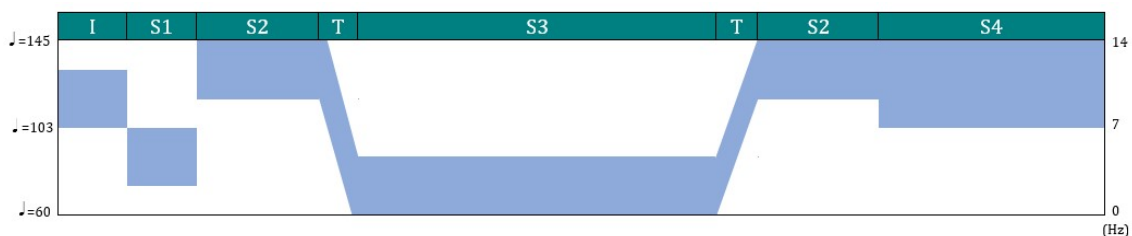


Fig. 24 Tempo structure of the piece *Sleep Cycle*.

d) Musical gestures. The different brainwaves that appear in a normal sleep cycle are used to imitate and transform its form into music:

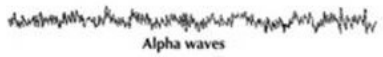
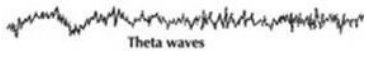
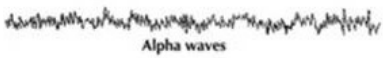
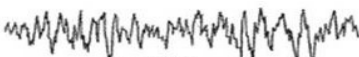
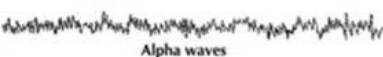
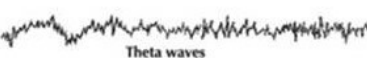
SECTION	STAGE	BRAINWAVE	BRAINWAVE
Introduction	Awakening	 Alpha waves	Alpha
S1	Drowsy	 Theta waves	Theta
S2	Light sleep	 Alpha waves	Alpha
S3	Deep Sleep	 Mostly Delta waves	Delta
S2	Light Sleep	 Alpha waves	Alpha
S4	REM Sleep	 Theta waves	Theta

Table 10 Brainwaves included in the piece *Sleep Cycle*.

e) Density. The density of each section is created from the type of brainwaves and the biochemical parameters that each part has.

4.5 Definition and explanation of the compositional method of Brain Activity

The compositional method of Brain Activity is based on the biochemical parameters that characterizes this concept, the images and processes that contain this type of information and the translations of this features into music.

In order to obtain musical material, the biochemical parameters are translated into music through different methods. However, there are some similar concepts in the methods presented in this thesis.

The parameters presented in an EEG are translated into music in order to create musical parameters, such as dynamics, rhythms, tempos, musical gestures and density.

These musical parameters can be obtained with different methods, but the method developed for the composer and author of this research is based on these concepts:

- The structure as an analogy of the structure of a biochemical process related to the Brain activity.

- Dynamics as analogies of the voltage of a biochemical process related to the Brain Activity.
- Tempos as analogies of the frequency of a biochemical process related to the Brain Activity.
- Musical gestures as representations of the size, movement and type of the brainwaves.
- Density as representation of the size, movement and type of the brainwaves.

Even though the piece *Sleep Cycle* has been composed with the process, the parameters described above can be adapted and used in every biochemical process translated into music. That is, these musical parameters can be used in other biochemical processes in order to compose pieces based on other Brain activities.

Chapter 5: Results

This thesis presents three composition methods related to chemistry and biology: crystallization, DNA Music and Brain Activity. Each of these composition methods have been explained from different points of view: from the biochemical point of view and from the music composition point of view. Furthermore, I have developed each composition method in order to create my own understanding of the composition method. For these reasons, the results obtained in this thesis are the following:

- To define the composition method of crystallization for Edgard Varèse, Jean Sibelius, Chou Wen-Hung and Ayal Adler, in order to know their similarities and differences about the concept of crystallization in their pieces.
- To define the composition method of DNA Music for Maria Mannone, Clara Maïda, Peter Gena and Laurie Spiegel, in order to know their similarities and differences about the concept of DNA in their pieces.
- To define the composition method of Brain Activity in the researches presented in this thesis, in order to know their similarities and differences about the concept of Brain activity.
- The piece *Crystallized*, for ensemble, composed by Óscar Calatayud-Gómez in 2018 with the composition method of crystallization.
- The piece *Intramolecular*, for flute, violoncello and percussion, composed by Óscar Calatayud-Gómez in 2019 with the composition method of DNA Music.
- The piece *Supercoiling*, for string orchestra, composed by Óscar Calatayud-Gómez in 2019 with the composition method of DNA Music.
- The piece *Sleep Cycle*, for solo percussion, composed by Óscar Calatayud-Gómez in 2020 with the composition method of Brain Activity.

Chapter 6: Conclusions

After researching the three composition methods explained in this thesis, and after exploring and composing with each composition method, it is possible to affirm some conclusions about the topic researched in this thesis.

Each of the composers explored in the chapters about crystallization, DNA Music and Brain Activity has a personal understanding of the concept. For this reason, one conclusion is that there are no strict rules about how to use these composition methods.

The process of crystallization has been used for most of the composers presented in this thesis to clarify and to explain composition methods. That is, the process and concepts about crystallization have not used as an inspiration, an influence or a base for the composition, but as a metaphor of the structure and the different developing of musical materials.

The concept of DNA as a music composition method is used in a lot of different ways, such as creating analogies, using features of DNA, translating parameters of DNA. The reason is that DNA is a field of multiple choices, and each composer interested in the topic has chosen similar or different parameters.

However, the basis of each composition method of DNA is the same for every composer. This basis has the parameters about nucleobases, connections and the double helix of DNA.

The concept of Brain Activity in music has been investigated for a lot of researches from non-music fields. These researches have focused on translating different parameters of Brain Activity into music. In addition, there are existing examples about composers using Brain Activity concepts in pieces.

Finally, most of these composition methods are based on translating biochemical parameters into music, or creating analogies between biochemical gestures or images and music. For this reason, it is possible to affirm that there are no rules about using these composition methods. Each composer needs to find a different way of creating material from the concepts, processes and parameters presented in this thesis.

This thesis has been a way of improving the knowledge about composition for the composer and author of this research.

Researching and composing pieces with the methods presented in this Independent Project, the author and composer of this thesis have learnt many concepts about composition. Furthermore, the scores and recordings of the pieces written by the composer give different type of approach and artistic results:

a) Crystallization – *Crystallized* (2018)

On the one hand, with the first method related to a biochemical concept or process, crystallization, the researcher of this text has learnt and explored that is possible to compose a piece without a preliminary structure. That is, at the beginning of my piece *Crystallized*, I have created a lot of musical cells that have been mixed together in order to create the main musical phrases of the piece at the last section. Therefore, this is another way of creating musical material in my pieces, the way of creating big musical material at the end from small cells from the beginning.

On the other hand, about the artistic result of the piece, I was able to listen to the process of developing and creating the musical material of my piece. The first section has a clear way of presenting the cells, and the second and third section of the piece presents a clear result of the new musical material created from the first cells. Furthermore, the musical density, pitch and dynamics, as well as the material, help the listener to differentiate different sections and motifs.

Finally, it is possible for the composer to apply this method in future compositions and, specifically, for the structure and material of his pieces.

b) DNA Music – *Intramolecular* (2019) and *Supercoiling* (2019)

With the second method researched in this thesis, the composer has been focused on musical gestures and pitch development. With this method, he has learnt and has explored a different way of creating musical gestures, from DNA images and concepts. Another important concept that he has researched has been the development of pitch and structures in both pieces. For this reason, he has applied these concepts to future compositions.

About the artistic result, I was able to listen to the concepts in my piece *Intramolecular*. Nonetheless, I am more satisfied with my piece *Supercoiling* for the following reasons: on the one hand, I was able to create a network with the concepts that worked better in *Supercoiling* than in *Intramolecular*, probably due to the fact that the amount of instruments that participating in the string orchestra piece. On the other hand, the different variety of textures and possibilities of the string orchestra produced a clearer result for me.

For these reasons, even though I am very satisfied with the piece *Intramolecular*, from my point of view, *Supercoiling* is the piece of this thesis in which I have been able to develop and listen to my ideas.

c) Brain Activity – Sleep Cycle (2019)

With the last composition method researched in this Independent Project, I have learnt and explored some concepts about translating biochemical ideas to the structure of a piece. Every method explained in this thesis has been related to concepts like structure, pitch, dynamics, musical cells and tempos. With this method, I have obtained the necessary information for these concepts from biochemical parameters. Therefore, with this method and piece I have explored different ways of creating musical material.

About the artistic result of the method and piece composed, I looked for another type of piece, based on rhythms and non-pitch motifs. I was able to use the musical concepts in a non-pitch-based music. For this reason, I am satisfied with the piece and with the idea that the concepts can be applied both for pitch music and non-pitch music.

In conclusion, with these three methods, I have learnt and explored many musical concepts and parameters in my pieces. Consequently, I have applied these concepts and parameters in a conscious and unconscious way in my new pieces. An example of this has been my piece *Se le vio caminar...* (2020), a piece for symphony orchestra that includes some of these musical results researched and explored in this thesis.

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Submitted audio files:

Audio 1 Crystallized

Audio 2 Intramolecular

Audio 3 Supercoiling

Audio 4 Sleep Cycle

Appendix 1. Interview with Maria Mannone

1. Why did you decide to use your research on musical gestures as analogy of DNA?

DNA is fundamental for living nature as its structural, hidden source. In addition, it has an aesthetically elegant and easily recognizable geometry. You can draw a few lines and everybody may recognize a stylized form of DNA. Because my research on gestures also involves drawing movements and schematization of complex images into a few lines, I thought of DNA as a possible application of abstract ideas. A core idea of my approach is the notion of 'gestural similarity': we can think of specific sounds and images as having been generated by the same gestures. For example, detached gestures can generate a collection of points on a piece of paper as well as a sequence of detached (staccato) notes, while an undulated gesture can produce a rising-descending melody as well as an S-shaped curve. Thus, we can give sound to the images by using these analogies.

2. How could you describe the method of music composition of DNA?

I tried to render musically essential elements that characterize a generic DNA structure. We have the double helix, which I approximately rendered with two sinusoids. I mapped a few sampled points of these sinusoids within musical pitch and I got the notes of the two intertwined melodies. Then, I considered the basis as chords, and I used their initials (A for adenine, C for cytosine, T for thymine, G for guanine), as abbreviations of musical chords (I interpreted T as 'ti,' the syllable used in American solfeggio to indicate B, names 'Si' in Italian). In particular, as explained in the paper "Knots, Music and DNA," I associated A with the minor triad A-C, C as a major third C-E, T as a minor third B-D. I represented the connection between bases of the double helix as glissandi. In this way, I obtained the basic material I used in my musical composition titled "DNA."

3. How was the process of composing your piece DNA?

I am used in thinking a lot before composing 'experimental' music, trying to find the most effective strategy to obtain the best result for my purposes, and also aesthetically appealing. For example, we can choose the upper and lower note and the discretization level before starting the mapping of points from a function into sounds. These degrees of freedom do not intake the original overall shape, but they allow for a more personal sound result. After having obtained the described musical materials, I used them as basic elements to compose the piece. I enjoy introducing in my music some extra-musical elements, but I prefer to keep control over the overall musical piece.

4. Do you think that the analogies that you develop in your work (for example strands and nucleobases) can be applied to more musical elements (for example not only at intervals or at melodic lines)?

Yes, this can be possible. The first musical parameters I usually take into account are pitch and time, as a personal taste, as well as for our sensibility to 'melodic profiles' and their intuitiveness. There is some research in cross modal correspondences attesting the strong (though not completely universal) between melodic movements and up-down movement in

the space. However, the more are the information we want to transform into sound, the more parameters we need. For example, in the paper “Knots, Music and DNA” I describe also possible musical renditions of supercoiling as ‘curves of curves,’ playing around not only with pitch but also with other musical parameters such as loudness. I could have been doing the opposite: starting from loudness and adding pitch and melodic lines as further parameters.

However, if we want that the final sound/musical result may somehow remind the listener of the initial visual shape, we have to choose carefully parameters and their variations according to gestural similarity. For example, loudness variations, and not only pitch variations, are connected with the perception of movement: a periodic change of loudness can remind us of an approaching-stepping away movement, and this can be connected with the drawing of a helix via movements towards and away from the listener. In this case, we are ‘drawing’ an imaginary object via sound variations; this is related with Doppler Effect — when the (real) movement of a (real) sound source provokes a variation of its (perceived) loudness and pitch.

5. Do you think that this method of composition can be applied to any compositional style, or can it only be applied in a tonal environment?

This can be applied to different compositional styles. Tonality is not a requirement here. We can either derive the initial material in the way I did and then using them, for example, in a completely atonal framework. We could also get an atonal initial musical material via specific modifications in the mapping described above. The core idea of the proposed method does not lie within specific notes or harmonies but in the overall structures. We may associate a different cluster to each base instead of *bichords*, or two series to the double helix. If the ‘final perceived result’ is close, it means, if the listener can retrieve the essential initial structure, the goal is reached.

6. How would you define your compositional style?

I define my style as a classic-jazz-experimental combination of my heritage with extra-musical influences via mathematics. My hope is trying to find some ‘universals’ in artistic expression and techniques, some structures, abstract ideas that can be embodied in this or that specific artwork, in this or that specific artistic language. When I do not make experiments, I like to improvise in a mixture of classical and jazzy style. I composed an opera about animal experiments for soli, choir, and chamber orchestra.

7. Who are the composers (and conductors) that have most influenced you in your career?

I love Mahler’s music for its complex and yet organic structures, for its tension as a continuous development. I also love Nino Rota mainly for the connection of his music with cinema. Italian opera and in general vocal music influenced a lot my writing style. My Composition professor in Italy (Marco Betta), the first one who suggested me to join music and mathematics, played a striking role in my career. While I was studying at IRCAM, I had the privilege of meeting Pierre Boulez, who appreciated the work I was developing at that

time — a vision of Paris metro system as a cardiovascular system keeping Paris alive, that I named ‘Paris, La Ville Pulsante’ — and encouraged me in pursuing my personal and original ideas.

8. What are your future projects related to your research on gestural music and DNA?

I am currently developing my theoretical and practical (compositional) research by strengthening its connections with other theories and research areas. Diagrams, categories, and nested structures are powerful tools to investigate musical structures and structures from nature. DNA is a part of it. We can focus on ‘visible’ nature such as the external form of trees and flowers. From grammars to Lindenmayer systems, from growth comparisons to variations on musical forms, there is a continuous interplay between mathematical, natural and naturalistic, and artistic tension and beauty that deserves to be deeply investigated. I composed new music and I have been writing papers. For the future, I think I will come back to DNA from this extended perspective.

9. Do you think that your studies in the field of physics have allowed you to have new ideas for your pieces?

Yes, definitively. Physics is also a way of thinking on nature, a continuous search for hidden connections and of invariant laws. In itself, Physics probably includes the main reasons why we are doing science. Its skeleton, Mathematics, connects the concrete reality of nature with the *Hyperuranion* of perfect and unreachable entities. Math is like a way of thinking. Physicist Paul Dirac would have agreed that research in Physics (and in Math) could not be detached from search for beauty, with, at the same time, variety and unity. Moreover, the same sense for beauty can inspire while composing music.

There cannot be two identical fugues, yet you can think of ‘the fugue’ and attaching a sense of drama to its form itself. Vortex motions, spirals, ammonites’ shapes and tentacles, fast repetitions of branches, fugue’s *strettos* (Italian ‘*stretti*’); do probably have something in common. That ‘common thing’ attracts me and urges me to write new music. New developments of my research on gestures are involving dance. This is another way to connect movements in space and time — and that is already physics! — with music and composition.

10. How would you define your research on gestural music?

Never ending. I got some ideas that helped me to break a wall. Behind the wall, there was a new universe to discover. I don’t think I’ll find a definitive ‘truth’ or something, but the way to explore such a new space, connecting different objects and creating new bridges, is probably the meaning of what I’m doing. Research is somehow like a journey: it is not only matter on which points A and B we are connecting, but also of which path(s) we are choosing and which things we are experiencing along the way.

Óscar Calatayud-Gómez

CRYSTALLIZED

(2018)

for Ensemble



Óscar Calatayud-Gómez

CRYSTALLIZED

(2018)

for Ensemble

Óscar Calatayud-Gómez: CRYSTALLIZED
© 2018 Óscar Calatayud-Gómez. Göteborg (Sweden)

Duration: 6'40" minutes

Instrumentation

Voice 1

Voice 2

Alto Saxophone 1 (Eb)

Alto Saxophone 2 (Eb)

Percussion: Toms, Snare Drum, Hi-hat, Ride Cymbal, Bass Drum, Suspended Cymbal

Hammond

Electric Guitar 1

Electric Guitar 2

Double Bass 1

Double Bass 2

Performance Notes

Crystallized is based on the chemical process of Crystallization. Through the musical analogy that is established, this piece develops its musical elements as well as the chemical process of Crystallization, based on the principle that there is no predetermined structure, the structure is the result of the development of cells and primary motifs that exist at the beginning of the piece.

Crystallized is a piece composed in 2018 for ensemble of improvisation, with the following instrumentation: 2 voices, 2 Alto Saxophones (Eb), percussion, Hammond, 2 Electric Guitars and 2 Double basses. Its premiere was in Katakomberna (Göteborg, Sweden) on January 19, 2019, by the ensemble of improvisation of the Academy of Music and Drama of Göteborg (Sweden).

Contact



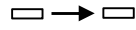
To request the materials of the piece and details or questions about Crystallized, contact the composer: ocalatayudgomez@hotmail.com

Notation Notes







VOICE

- Sung on a consonant
- ◆ Diaphragm vibrato
- △ Inhale
- ▲ Exhale
- × Plosive (soft)

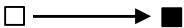

HAMMOND

-  Black notes cluster (around the given area)
-  White notes cluster (around the given area)
-  Presets transition



DOUBLE BASS

-  Cracking sound
-  Pizzicato Bartok
-  Cluster (around the given area)
-  Damp the strings (with the entire palm)
- Over pressure
- Very light pressure
-  Vibrato
-  Bowing the tailpiece

ALTO SAXOPHONE

- Noise
- Pitch
-  Transition from noise to sound
- ▼ Slap
- × Key click
-  Vibrato intensity

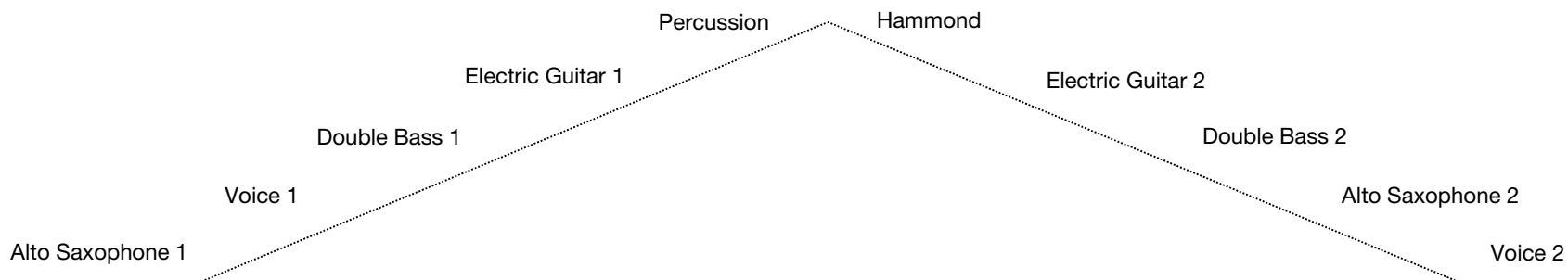
ELECTRIC GUITAR

-  Vibrato (increase and decrease)
-  Vibrato (increase)
- ▼ Bow direction
- M _____ Mute pitch completely
- E Bow _____ E Bow
- Noise sound (touch cable head to produce sound)

GENERAL NOTES

- ▽ Lowest note possible
- △ Highest note possible

Ensemble Disposition



General Indications

Time indications

Each of the musicians uses a stopwatch (like a mobile phone stopwatch) to follow the temporary indications indicated in the score.



In order to start the chronometers at the same time, the part at the lower left end (Alto Saxophone 1) counts down 3 seconds with the right hand fully raised.



3 – 2 – 1 – Start Timers: 0'00"

The first motifs of the piece start at 8". All the last cells of the work end at 6'40".

Repetition indications



Repetition Arrow/Line. It indicates how long a motif should be repeated. The performer is free to decide (within the repetitions of the same cell) the duration, speed, and individual dynamics (in cases that are not specified). The musician should not perform very long pauses between repetitions of the same cell.

In the blanks between the end of the arrow and the next repetition box the musician should not interpret.

General dynamic indications

The general dynamic of the piece is achieved through the superposition of motifs and their repetition through improvisation. The result that the entire ensemble must produce, in terms of dynamic, is specified in the second table of the work. In addition, each cell has (or does not) oscillations of dynamics that are performed only by one cell, and that must be performed within the general dynamic result.

mf

Score
Duration: 6'40"

CRYSTALLIZED

for Ensemble


Óscar Calatayud-Gómez
(2018)

Start Timers: 0'00"



Voice 1
Musical notation with dynamics: *p*, *mf*, *pp*, *p*.
Lyrics: tʃ tʃ m

Voice 2
Musical notation with dynamics: *pp*, *mf*, *pp*, *mf*, *p*.
Lyrics: Tal Tal

Alto Saxophone 1 (E)
Musical notation with dynamics: *p*, *mf*, *mf*, *p*.

Alto Saxophone 2 (E)
Musical notation with dynamics: *mf*, *p*, *mf*.

Percussion
Toms
Musical notation with dynamics: *pp*, *mf*, *pp*, *mf*, *p*.

Hammond
Musical notation with dynamics: *pp*, *mf*, *pp*, *mf*.

Electric Guitar 1
Musical notation with dynamics: *p*, *mf*, *p*.

Electric Guitar 2
E bow
Musical notation with dynamics: *mf*, *pp*.

Double Bass 1
Musical notation with dynamics: *pp*, *mf*.

Double Bass 2
Musical notation with dynamics: *mf*, *pp*.

1'04"

1'12"

1'20"

1'28"

1'36"

1'44"

1'52"

(pp) cresc.

mf cresc.

Vc. 1

Vc. 2

A. Sx. 1

A. Sx. 2

Perc.

Hamm.

E. Gtr. 1

E. Gtr. 2

D.B. 1

D.B. 2

Snare Drum (with brushes)

Bass Drum

Hi-hat

Ride cymbal

Percussion Key
Percussion Volume: Normal
B Preset

pont. → ord.

2'00"

2'08"

2'16"

2'24"

2'32"

2'40"

2'48"

(cresc.) **ff** *pp* sub.

cresc.

Vc. 1

Vc. 2

A. Sx. 1

A. Sx. 2

Perc.

Hamm.

E. Gtr. 1

E. Gtr. 2

D.B. 1

D.B. 2

pp *mf* *pp* *mf* *pp*

pp *mf* *pp*

mf *p* *mf* *p*

pp *mf* *pp* *mf* *pp*

(Hi-hat (With brushes))

pp *mf* *pp*

B preset. Percussion key
Percussion Volume: normal
Percussion decay: fast

p *mf*

mf

Touch Cable head to produce noise

Disconnect Cable from E. Guitar

pp *mf* *p* *mp*

mf *p* *mf*

mf *p* *mf* *p*

pp *mf* *p* *mp*

2'56"

3'04"

3'12"

3'20"

3'28"

3'36"

3'44"

mf

dim. . .

Vc. 1

Vc. 2

A. Sax. 1

A. Sax. 2

Perc.

Hamm.

E. Gtr. 1

E. Gtr. 2

D.B. 1

D.B. 2

The score includes the following elements:

- Vc. 1:** A melodic line starting at 3'28" with dynamics *p*, *mf*, and *pp*. Includes a notation box with notes and accents.
- Vc. 2:** A rhythmic accompaniment starting at 3'04" with dynamics *p*, *pp*, *mf*, and *pp*. Includes a notation box with rhythmic patterns.
- A. Sax. 1:** A melodic line starting at 3'28" with dynamics *pp* and *mf*.
- A. Sax. 2:** A melodic line starting at 3'28" with dynamics *pp*, *mf*, and *pp*.
- Perc.:** Includes Hi-hat and Bass Drum parts starting at 3'12" with dynamics *mf*, *p*, *pp*, *mf*, and *pp*.
- Hamm.:** Piano accompaniment starting at 3'04" with dynamics *pp*.
- E. Gtr. 1:** Electric guitar part starting at 3'04" with dynamics *pp*, *mf*, and *pp*. Includes a notation box with a *8va* marking.
- E. Gtr. 2:** Electric guitar part starting at 3'04" with dynamics *pp*, *mf*, *pp*, *mf*, and *pp*. Includes a notation box with a *Disconnet cable from E. Guitar* instruction.
- D.B. 1:** Double bass part starting at 3'28" with dynamics *pp*, *mf*, *p*, and *mp*.
- D.B. 2:** Double bass part starting at 3'04" with dynamics *mf*, *p*, *pp*, and *mf*. Includes a notation box with accents.

3'52" 4'00" 4'08" *pp* 4'16" *ppp* 4'24" *fff* 4'32" *ppp* 4'40" *fff*

Vc. 1

Vc. 2

A. Sx. 1

A. Sx. 2

Perc. (Toms) (Snare Drum)

Hamm.

E. Gtr. 1

E. Gtr. 2

D.B. 1

D.B. 2

Vc. 1

Vc. 2

A. Sx. 1

A. Sx. 2

Perc.

Hamm.

E. Gtr. 1

E. Gtr. 2

D.B. 1

D.B. 2

Hi-hat (with brushes)
pp *mf* *p* *mp*

Touch Cable head to produce noise
pp *mf* *p* *mp*

Disconnect cable from E. Guitar

5'44" 5'52" 6'00" 6'08" 6'16" 6'24" 6'32" 6'40"

p cresc. *mf cresc.* *f cresc.* *fff*

Vc. 1

Vc. 2

A. Sx. 1

A. Sx. 2

Perc.

Hamm.

E. Gtr. 1

E. Gtr. 2

D.B. 1

D.B. 2

The Percussion part includes a box with labels: (Suspended Cymbal), (Snare Drum), (Bass Drum), (Toms). The Hamm. part includes a box with text: B preset, Percussion key, Percussion Volume: normal, Percussion decay: fast, and a MIDI code: 88 8110 000.

Óscar Calatayud-Gómez

INTRAMOLECULAR

(2019)

trio for flute, violoncello and percussion



Óscar Calatayud-Gómez

INTRAMOLECULAR

(2019)

trio for flute, violoncello and percussion

Óscar Calatayud-Gómez: INTRAMOLECULAR
© 2019 Óscar Calatayud-Gómez. Göteborg (Sweden)

Duration: 8' minutes

Instrumentation

Flute

Violoncello

Percussion

Vibraphone (soft mallets, hard mallets)

Waterphone (bow, superball mallet)

Frame Drum (superball mallet)

Contact

To request the materials of the piece and details or questions about Intramolecular, contact the composer: ocalatayudgomez@hotmail.com

Performance Notes

Intramolecular is a piece based on the concept of DNA and its elements: strands, nucleobases and connections. In this piece the parts of which the DNA image is formed are developed by gestural and structural analogies, that is, each of the concepts of which the DNA is characterized (strands, nucleobases and connections) and the chemical elements that are found in it (nitrogen, oxygen, hydrogen and carbon) give the compositional basis of the piece.

Intramolecular is a trio composed in 2019 for flute, violoncello and percussion (vibraphone, Waterphone and frame drum). Its premiere was at Högskolan för scen och musik (Göteborg, Sweden) on May 10, 2019, by the ensemble Mimitabu.

This piece is part of a research on music composition methods related to chemistry and biology made by the composer of this piece. Specifically, it is inspired by the method developed by composer Maria Mannone about gestural music and its application in DNA.

General Notation Notes



Short Fermata (2")



Long Fermata (5")

Quarter Tones

¼ lower than a	regular ♭	¼ higher than a	regular ♭	¼ lower than a	regular #	¼ higher than a
regular ♭		regular ♭		regular #		regular #

Notation Notes

FLUTE



Whistle Tones



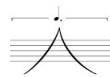
Exhale through the flute



Lip Pizzicato



Keyclicks



Jet Whistle

Non Vib. → Molto Vib.

Vibrato (transition from Non Vibrato to Molto Vibrato)

Molto Vib. → Non Vib.

Vibrato (transition from Molto Vibrato to Non Vibrato)



Bamboo Tones



Singing while playing



Slap

VIOLONCELLO

MSP

Molto Sul Ponticello

Ord.

Ordinario

MST

Molto Sul Tasto

ST

Sul Tasto

SP

Sul Ponticello

× ⊗

Scratch Tone (Unpitched sound)

Muting the strings by lightly touching it with several fingers or the palm of the hand.



White Noise (Unpitched sound)

Muting the strings by lightly touching it with several fingers or the palm of the hand.



Overpressure (Pitched sound)

An increase in bow pressure while maintaining bow speed and point of contact.



Pizzicato Bartok



Highest note possible











Highest note possible (with harmonics)











String indications

It indicates which string should be used.

VIBRAPHONE

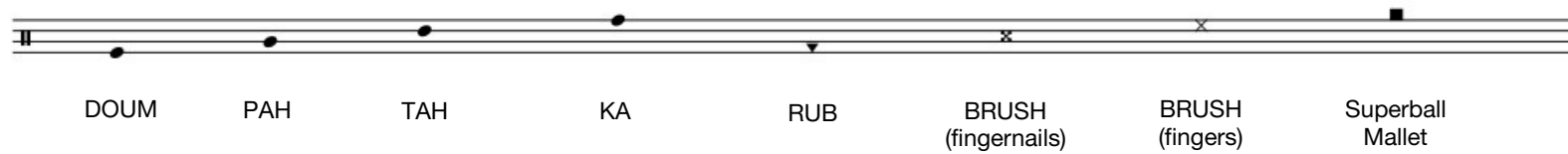
-  Bowed
Notehead: It indicates the duration of the friction of the bow
Tie: It indicates that the sound continues without the friction of the bow
- NP  M Transitions from Nodal Point to Middle Point
-  Pitch bend
-  Playing with the fingers
-  Mallet Shafts (Strike directly on the bars)
-  One line glissando
-  Soft Mallets
-  Hard Mallets

WATERPHONE

-  "Extremity". Play at the end of the rod
-  "Middle". Play in the middle of the rod
-  "Welding". Play near the seam point of the rod
-  Col legno batuto
-  Playing on the lower diaphragm with the Superball mallet
-  Continuous motion in "8"
-  Straight line motion
-  Circular motion

* In the whole piece the vibraphone must be played with the motor

FRAME DRUM



Score

🕒 8 minutes

INTRAMOLECULAR

Trio for flute, violoncello and percussion



Óscar Calatayud-Gómez
(2019)

Andante lontano (♩ = 85)

rit.

Flute: *ppp*, 8va, *ppp*, *pp*, *p*

Violoncello: *ppp*, pizz., *ppp*, arco (White Noise. Muting the strings)

Percussion: *ppp*, Motor ON, NP, M, *pp*, *p*

Fl. (5): Whistle Tones, *ppp*

Vc.: Molto Sul Pont., *ppp*, *pp*

Perc.: NP, *ppp*, *pp*, *ppp*

INTRAMOLECULAR - 2

8^{vz} - - - - -

Non Vib. → Molto Vib. → Non Vib.

Exhale through the flute

Fl. *ppp* *p* *f* *mf* *ppp*

Vc. → ST → Ord. *pp* *p* *ppp* *p* *f* *mf* *ppp*

Perc. *ppp*



13 *Meno mosso, lontano* (♩ = 70)

rit.

Exhale through the flute

Non Vib. → Molto Vib. → Non Vib.

Whistle Tones

Fl. *f* *ppp* *ppp* *p* *pp* *pp* *p*

Vc. *pizz.* *f* *arco* *MSP* *ppp* *Ord.* *MST* *pp*

Perc. *ppp* *p*

NP → M

19 Larghetto misterioso (♩ = 55)

17

Fl. *f* *p* *mf* Lip pizz. *mf*

Vc. Ord. → MST *f* *p* *mf* pizz. *mf* arco Ord. → MSP *mp* *pp*

Perc. NP *pp* *p* *ppp* *pp* *mf* *ppp*

(Mallet shafts. Strike directly on the bars)

rit.

Non Vib. → Molto Vib. → Non Vib.

21

Fl. *pp* *p* *pp* *p* *f* *mf*

Vc. *pp* *p* *pp* *p* *f* *mf* Ord. → ST → MSP

Perc. *p* *mf*

25 Lento ma più agitato (♩ = 40)

accel.

Musical score for measures 25-28. The score is in 3/4 time and features three staves: Flute (Fl.), Violin (Vc.), and Percussion (Perc.).

- Fl.:** Starts with a piano (*p*) triplet, followed by a mezzo-piano (*mp*) phrase, then a pianissimo (*pp*) quintuplet, and a piano (*p*) phrase. The final section features a forte (*f*) quintuplet and a mezzo-forte (*mf*) phrase.
- Vc.:** Features a mezzo-soprano piano (*MSP*) section starting at measure 26 with a piano (*p*) quintuplet, followed by a section marked *ST* (Soprano Tenore) with a piano (*p*) phrase and a forte (*f*) phrase, and finally a mezzo-forte (*mf*) phrase.
- Perc.:** Starts with a piano (*p*) triplet, followed by a mezzo-piano (*mp*) phrase and a piano (*p*) phrase. The final section features a forte (*f*) phrase and a piano (*p*) phrase.

Dynamic markings include *p*, *mp*, *pp*, *f*, and *mf*. Performance instructions include *MSP*, *ST*, and accents (Δ).



29 Più mosso (♩ = 55)

accel.

Musical score for measures 29-32. The score is in 3/4 time and features three staves: Flute (Fl.), Violin (Vc.), and Percussion (Perc.).

- Fl.:** Starts with a piano (*p*) phrase, followed by a mezzo-piano (*mp*) phrase, a pianissimo (*pp*) phrase, a mezzo-piano (*mp*) phrase, a pianissimo (*pp*) phrase, a piano (*p*) phrase, and a mezzo-piano (*mp*) phrase.
- Vc.:** Features a mezzo-soprano piano (*MSP*) section starting at measure 30 with a piano (*p*) phrase and a mezzo-piano (*mp*) phrase, followed by a section marked *Ord.* (Ordinary) with a piano (*p*) phrase and a mezzo-piano (*mp*) phrase.
- Perc.:** Starts with a piano (*p*) phrase and ends with a mezzo-piano (*mp*) phrase.

Dynamic markings include *p*, *mp*, and *pp*. Performance instructions include *MSP*, *Ord.*, and a Waterphone symbol.

35 Più mosso, più agitato (♩ = 70)

Musical score for measures 33-36. The score is for Flute (Fl.), Violoncello (Vc.), and Percussion (Perc.).

- Fl.:** Measures 33-36. Dynamics: *mp*, *p*, *mf*, *p*, *f*, *mf*, *mp*. Includes triplets (3), sextuplets (6), and a fermata.
- Vc.:** Measures 33-36. Dynamics: *pp*, *mp*, *p*, *f*, *mf*. Includes quintuplets (5) and a triplet (3).
- Perc.:** Measures 33-36. Dynamics: *p*, *f*, *mp*. Includes quintuplets (5) and dynamic markings *M*, *V*, *W*.



accel.

Musical score for measures 37-40. The score is for Flute (Fl.), Violoncello (Vc.), and Percussion (Perc.).

- Fl.:** Measures 37-40. Dynamics: *p*, *mp*, *pp*, *mp*, *p*, *pp*. Includes a triplet (3).
- Vc.:** Measures 37-40. Dynamics: *mp*. Includes a triplet (3) and dynamic markings *Ord.*, *MSP*.
- Perc.:** Measures 37-40. Dynamics: *pp*, *mp*, *p*, *mp*. Includes quintuplets (5) and dynamic markings *Col legno battuto*, *Ord.*, *M*, *V*.

41 Andante agitato (♩ = 85)

40

Fl. *mp* *p* *f* *mf* *f* *mf*

Vc. *p* *mf* *mf* *mf* *ff* *mf*

Perc. *mf* *mf*

(Keyclicks)

(Slap)

IV (Scratch Tone. Muting the strings)

W V

Frame Drum



accel.

45

Fl. *f* *mf* *p* *f* *mf*

Vc. *p* *mf* *mp* *p* *mf* *ff* *mf*

Perc. *mf* *f* *mf* *f* *mf*

52 Più mosso, più agitato (♩ = 100)

Musical score for measures 49-52, featuring Flute (Fl.), Violoncello (Vc.), and Percussion (Perc.).

- Fl.:** Measures 49-50: *mf*, *p*, *mp*. Measures 51-52: *sfz*, *f*.
- Vc.:** Measures 49-50: *sfz/p*. Measure 51: *Ord.*. Measure 52: *f*. Includes a box labeled "1 (Scratch Tone. Muting the strings)".
- Perc.:** Measures 49-50: *mf*, *p*, *mp*. Measures 51-52: *f*, *mf*, *f*, *mp*. Includes triplets and sextuplets.

Dynamic markings: *mf*, *p*, *mp*, *sfz*, *f*, *sfz/p*, *Ord.*



accel.

Musical score for measures 53-56, featuring Flute (Fl.), Violoncello (Vc.), and Percussion (Perc.).

- Fl.:** Measures 53-54: *mf*, *p*, *f*. Measures 55-56: *mf*, *f*, *mp*.
- Vc.:** Measures 53-54: *f*. Measures 55-56: *f*, *mf*. Includes a quintuplet in measure 55 and triplets in measures 55 and 56.
- Perc.:** Measures 53-54: *f*. Measures 55-56: *f*. Includes a quintuplet in measure 55.

Dynamic markings: *mf*, *p*, *f*, *mp*, *Ord.*

INTRAMOLECULAR - 8

57

Fl.

Jet Whistle

mp *f* *mf* *f*

Vc.

ff *mf*

Perc.



61

Fl.

Jet Whistle

mp *f* *mf* *f*

Vc.

f *mp*

Perc.

f *mf* *ff*

65 Più mosso, più agitato (♩ = 115)

Fl. *ff* *mf* *ff* *f* *mf* *ff*

Vc. *ff* *pizz.*

Perc.



accel.

Fl. *mf* *ff* *f* *ff* *mf* *p*

Vc. *ff* *arco* *MSP* *MST* *mf* *ff*

Perc. *ff* *f* *ff* *mf* *ff* *f*

INTRAMOLECULAR - 10

73

Fl.

Vc.

Perc.

Jet Whistle

(Scratch Tone. Muting the strings)

MSP

Ord.

ff

pp

mf

ff

ff

f

ff

f

ff

pp

mf



80 Allegro animato, energico (♩ = 130)

77

Fl.

Vc.

Perc.

MST

ppp

ppp

fff

f

mf

ppp

fff

ff

f

mf

mf

f

INTRAMOLECULAR - 11

81

Fl.

Vc.

Perc.

Ord. MSP

Ord. MST

Ord. MSP

Ord.

f *fff* *ppp* *fff*

f *fff* *ppp* *fff*

fff *f* *fff* *ppp* *fff*



rit.

85

Fl.

Vc.

Perc.

IV (Scratch Tone. Muting the strings)

I

IV

I

f *fff* *ppp* *fff*

f *fff* *ppp* *fff* *ppp*

fff *f* *fff* *ppp* *mf*

INTRAMOLECULAR - 12

89

Fl.

Vc.

Perc.

fff *f* *ppp* *fff* *ppp*

fff *f* *fff* *ppp*

f *fff* *mp* *ff*

Ord. → Ord. → Ord.

MST

MSP

94 **Meno mosso** (♩ = 115)

93

Fl.

Vc.

Perc.

pp *ff* *mf* *ff* *f* *mf* *ff*

ff *mf* *ff* *mf* *pp*

pp *mf* *ff* *ff* *mf* *f*

Jet Whistle

MSP

MSP

rit.

Whistle Tones

Exhale through the flute

97

Fl. *f* *mf* *ff* *ff* *f* *f* *mf* *f*

Vc. *ff* *pp* *mf* *ff* *f*

Perc. *ff* *pp* *mf* *ff* *mf*

IV (Scratch Tone. Muting the strings)

I



101

Fl. *mf* *pp* *mf* *ff* *ff*

Vc. *pp* *ff* *pp* *ff*

Perc. *ff* *pp* *ff*

IV

I

MST

3

106 *Meno mosso, meno animato* (♩ = 100)

105

Fl.

Vc.

Perc.

MSP

Ord.

Waterphone

p *f* *mf*

mf *ff* *mf*

f



rit.

109

Fl.

Vc.

Perc.

Jet Whistle

p *f* *mf*

mf *f* *p* *f*

mp *p*

5 5 5 5

5 5 5

Jet Whistle

113

Fl.

Vc.

Perc.

mf *f* *p* *f* *mf* *f* *p* *f*

mf *p* *f*

f *mp* *mf*



117 Andante lontano (♩ = 85)

rit.

Non Vib. → Molto Vib. → Non Vib.

Exhale through the flute

Fl.

Vc.

Perc.

mf *mf* *mf*

mf *mf*

mf *f*

INTRAMOLECULAR - 16

121

Fl. *mf* *p* *f* *mf*

Vc. *mf* *p* *f* *mf*

Perc. *mp* *mf*

(White Noise. Muting the strings)



125 *Meno mosso, lontano* (♩ = 70)

rit.

Fl. *pp* *mf* *mp*

Vc. *mf* *p* *mf > mp* *mp* *mf*

Perc. *mf*

Col legno battuto

Ord.

(White Noise. Muting the strings)

129

Fl. *f* *p* *mf* *mp* (Keyclicks)

Vc. *f* *p* *mf* *mp* pizz.

Perc. *f* *mp*



rit.

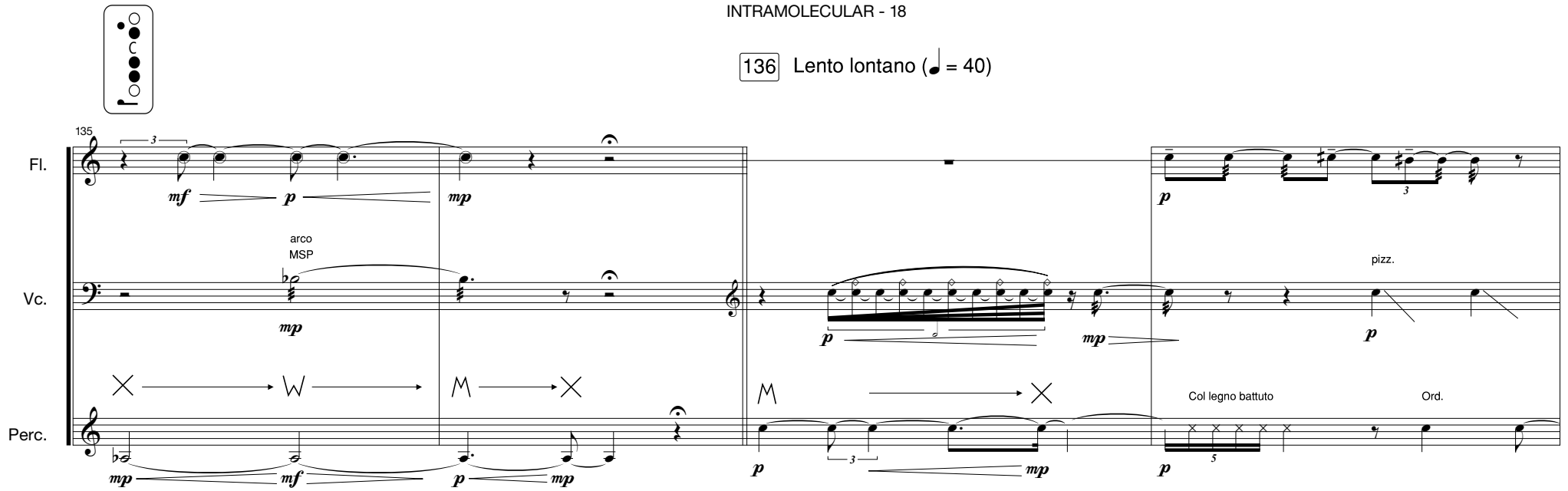
132

Fl. *mp* *mf* *mp*

Vc. *mp*

Perc. *mp* *p* *mp* *p*

136 Lento lontano (♩ = 40)



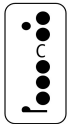
Musical score for measures 135-140. The score is for Flute (Fl.), Violoncello (Vc.), and Percussion (Perc.).

- Fl.:** Measures 135-137: *mf* (triple), *p*, *mp*. Measure 138: Rest. Measure 139: *p* (triple), *mp*. Measure 140: *p* (triple).
- Vc.:** Measures 135-137: *mp* (arco MSP). Measure 138: *p* (triple), *mp*. Measure 139: *p* (pizz.). Measure 140: *p* (pizz.).
- Perc.:** Measures 135-137: *mp*, *mf*, *p*, *mp*. Measure 138: *p* (triple), *mp*. Measure 139: *p* (triple), *mp*. Measure 140: *p* (triple).

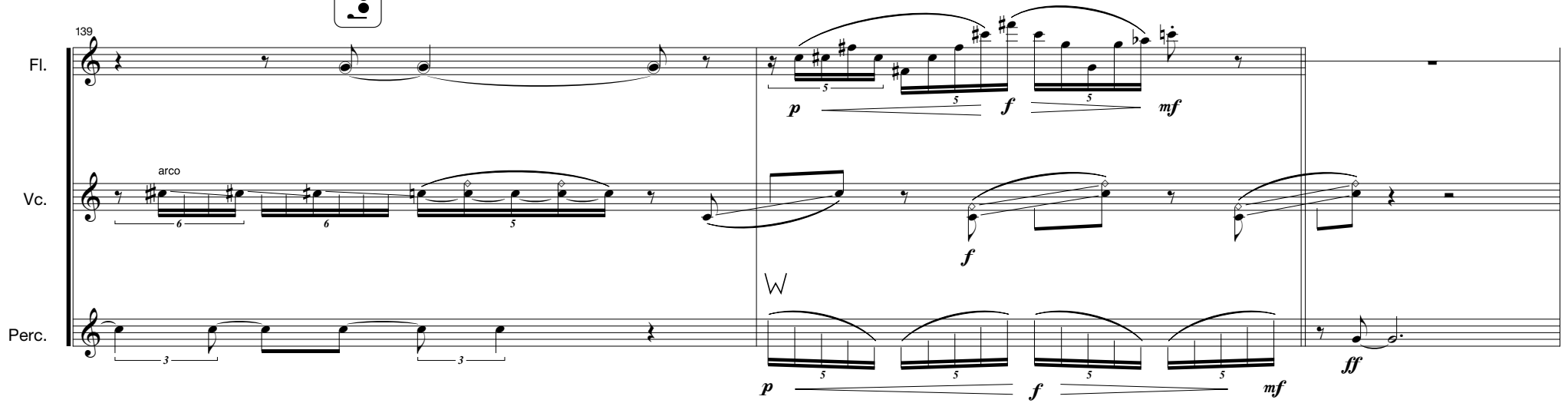
Performance markings: Percussion includes 'Col legno battuto' and 'Ord.' in measure 140. Flute includes a dynamic hairpin in measure 136. Violoncello includes 'arco MSP' and 'pizz.' markings.



accel.



141 Più mosso (♩ = 55)

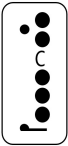


Musical score for measures 139-141. The score is for Flute (Fl.), Violoncello (Vc.), and Percussion (Perc.).

- Fl.:** Measure 139: Rest. Measure 140: *p* (triple), *f* (triple), *mf* (triple). Measure 141: Rest.
- Vc.:** Measure 139: *arco* (triple), *f* (triple). Measure 140: *f* (triple). Measure 141: Rest.
- Perc.:** Measure 139: *p* (triple), *f* (triple), *mf* (triple). Measure 140: *p* (triple), *f* (triple), *mf* (triple). Measure 141: *ff* (triple).

Performance markings: Percussion includes 'W' in measure 140. Flute includes dynamic hairpins in measure 140. Violoncello includes 'arco' and 'f' markings.

142 Senza Mesura



0'00" 0'05" 0'10" 0'21"

Fl. *p* < *ff* > *mf* *mf* < *ff* > *p*

Vc. MSP, MST *p* < *ff* > *mf* *mf* < *ff* > *p*

Perc. *p* < *ff* > *mf* *mf* < *ff* > *p*

Vibraphone

0'21" 0'26" 0'31" 0'46"

Fl. *pp* < *p* > *ppp*

Vc. MSP *pp* < *p* > *ppp*

Perc. *ppp*

Óscar Calatayud-Gómez

SUPERCOILING

(2019)

for string orchestra



Óscar Calatayud-Gómez

SUPERCOWLING

(2019)

for string orchestra

Óscar Calatayud-Gómez: SUPERCOILING
© 2019 Óscar Calatayud-Gómez. Göteborg (Sweden)

Duration: 8' minutes

Instrumentation

String orchestra: 4-4-3-2-1

Violin I (1)
Violin I (2)
Violin I (3)
Violin I (4)

Violin II (1)
Violin II (2)
Violin II (3)
Violin II (4)

Viola (1)
Viola (2)
Viola (3)

Violoncello (1)
Violoncello (2)

Contrabass

Performance Notes

Supercoiling is a piece based on the concept of DNA and the process of supercoiling. This piece is divided into two sections that represent the supercoiling processes that occur in the DNA, produced by type 1 and type 2 of topoisomerases. That is, these two sections describe the process of formation, development and transformation of the movement of DNA strands.

Supercoiling is a piece composed in 2019 for string orchestra. Its premiere was at Utvandrarnas Hus (Växjö, Sweden) on May 24, 2019, by Musica Vitae string orchestra and the conductor Michael Bartosch.





This piece is part of a research on music composition methods related to chemistry and biology studied by the composer of this piece. Specifically, it is inspired by the method developed by composer Maria Mannone about gestural music and its application in DNA.










Contact

To request the materials of the piece and details or questions about Supercoiling, contact the composer: ocalatayudgomez@hotmail.com

General Notation Notes

Quarter Tones

						
¼ lower than a	regular ♭	¼ higher than a	regular ♭	¼ lower than a	regular #	¼ higher than a
regular ♭		regular ♭		regular #		regular #

MST	Molto Sul Tasto	MSP	Molto Sul Ponticello
Ord.	Ordinario		Overpressure (Pitched sound) An increase in bow pressure while maintaining bow speed and point of contact.
	Highest note possible		Pizzicato Bartok
	Scratch Tone (Unpitched sound) Muting the strings by lightly touching it with several fingers or the palm of the hand.		White Noise (Unpitched sound) Muting the strings by lightly touching it with several fingers or the palm of the hand.
	Tapping the body of the instrument with fingers		Semitone oscillations Ascending a semitone and descending a semitone from the indicated sound.
	“Chicharra effect” (Cicada effect) Bowing on the D string at a point roughly equidistant between the bridge and the tailpiece, using flat hair at or near the frog.		String indications It indicates which string should be used.
1/2 Legno	Half-Col legno It indicates playing half with the hair and half with the wood of the bow for more pitch component than typical Col legno.	s. v. m. v. f. v.	Slow speed vibrato Medium speed vibrato Fast speed vibrato

SUPERCOILING

for string orchestra



Óscar Calatayud

Óscar Calatayud-Gómez

(2019)

Allegro lontano e misterioso (♩ = 130)

The score is for a string orchestra in 4/4 time, marked 'Allegro lontano e misterioso' with a tempo of 130 beats per minute. It features eight staves: Violin I (1-4), Violin II (1-4), Viola (1-3), Violoncello (1-2), and Contrabass. The score is mostly blank, with musical notation appearing in the lower half. The Viola parts (1-3) feature 'Punta d'arco' markings and dynamics of *ppp* and *mf*. The Violoncello (1) and Contrabass parts include 'MST [S.V.]' and 'Ord.' markings, with dynamics ranging from *ppp* to *f*. The Violoncello (2) part also includes 'Ord.' markings and dynamics of *ppp*, *mp*, and *ppp*. The Contrabass part includes 'MST [S.V.]', 'Ord.', and 'MSP' markings, with dynamics of *ppp*, *f*, and *ppp*.

SUPERCOILING - 2

6

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

Col legno battuto

p

Col legno battuto

p

Col legno battuto

p

pizz.

p

Whole Bow

mp *ppp* *mp* *ppp*

mp *ppp* *mp* *ppp*

mp *ppp*

MSP

MST [m.v.]

MST [m.v.]

MST [m.v.]

MST [f.v.]

ppp

8^{va} [S.V.]

ppp

SUPERCOILING - 3

(8^{me})

Violin I (1) *ppp* *f* *ppp* Ord. *MSP*

Violin I (2) *ppp* *mp* *ppp*

Violin I (3) Ord. *Punta d'arco* *MSP* *ppp* *mp* *ppp* *Whole Bow*

Violin I (4) Ord. *Punta d'arco* *MSP* *ppp*

Violin II (1) *ppp* *ppp* *f* *ppp* Ord.

Violin II (2) *Punta d'arco* *MSP* *ppp* *mp*

Viola (1) *ppp*

Viola (2) *ppp*

Viola (3) *ppp*

Violoncello (1)

Violoncello (2)

Contrabasso

SUPERCOILING - 4

poco a poco rit.

16

Vln. I (1) Ord. m.v. MSP Ord. f.v.

Vln. I (2) MSP MST m.v.

Vln. I (3) mp ppp Whole Bow

Vln. I (4) mp ppp mp ppp

Vln. II (1) MSP MST m.v.

Vln. II (2) Whole Bow ppp mp ppp

Vln. II (3)

Vln. II (4)

Vla. (1) Col legno battuto p

Vla. (2) Col legno battuto p

Vla. (3) Col legno battuto p

Vc. (1) pizz. p

Vc. (2)

Cb. MST S.V. pp

SUPERCOILING - 5

(... poco a poco rit. ...)

(8^{va})

21

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

I (White Noise. Muting the strings)

mp

IV (White Noise. Muting the strings)

mp

Col legno battuto

mp

Col legno battuto

mp

III

mp

Punta d'arco MSP

Whole Bow

pp

mf

pp

mf

pp

mf

arco

Punta d'arco MSP

pp

mf

pp

mf

MST S.V.

pp

Ord.

f

pp

Ord.

f

pp

III

SUPERCOILING - 6

(... poco a poco rit. ...)

26

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

pp

p

p

f

MST

arco [S.V.]

Punta d'arco

MSP

Ord.

MST

MST

MST

SUPERCOILING - 7

31 ♩ = 105

Col legno battuto

mf

I Ord.

mf

Col legno battuto

mf

Col legno battuto

mf

Punta d'arco MSP

p

f

Whole Bow

p

f

p

Punta d'arco MSP

p

f

Whole Bow

p

f

p

Whole Bow

f

p

f

p

Ord.

f

p

MSP

Vla. (1)

Vla. (2)

p

III

MSP

Vla. (3)

Vc. (1)

mf

I (Scratch tone. Muting the strings)

Vc. (2)

mf

IV (Scratch tone. Muting the strings)

Cb.

SUPERCOILING - 8
poco a poco rit.

36

8^{va} Ord.

Vln. I (1)

mp

ff

mp

Vln. I (2)

arco

mp

ff

mp

Vln. I (3)

Punta d'arco

MSP

Col legno battuto

mp

f

Vln. I (4)

Punta d'arco

MSP

Col legno battuto

mp

f

MST

Vln. II (1)

mp

MST [m.v.]

Vln. II (2)

mp

MST [m.v.]

Vln. II (3)

MST

Vln. II (4)

Vla. (1)

MST

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

Detailed description of the musical score: The score is for a section titled 'SUPERCOILING - 8' with the instruction 'poco a poco rit.'. It features a multi-staff arrangement. The Violin I section (Vln. I (1) to (4)) is the most active, with Vln. I (1) playing a melodic line starting at measure 36, marked *mp*. Vln. I (2) plays a similar line, also *mp*. Vln. I (3) and (4) play a rhythmic pattern of eighth notes, marked *mp*, with the instruction 'Punta d'arco' and 'MSP'. Vln. I (3) also has 'Col legno battuto' markings. Vln. I (4) has 'Col legno battuto' markings and triplet figures. The Violin II section (Vln. II (1) to (4)) is mostly silent, with Vln. II (1) and (2) playing a melodic line starting later, marked *mp*, with 'MST [m.v.]' markings. Vln. II (4) has 'MST' markings. The Viola section (Vla. (1) to (3)) is mostly silent, with Vla. (2) playing a melodic line starting later, marked *mp*, with 'MST' markings. The Violoncello section (Vc. (1) to (2)) and Contrabass (Cb.) are mostly silent. Performance instructions include 'arco', 'Punta d'arco', 'MSP', 'Col legno battuto', and dynamic markings *mp*, *ff*, and *f*. A hairpin crescendo is shown over the first two measures of the Violin I parts. A 'MST' (Mute) instruction is present in the Violin II and Viola parts.

SUPERCOILING - 9

44 ♩ = 90

Violin I (1) *mf* Ord. *mf*

Violin I (2) *mf* Ord. *mf*

Violin I (3) *mf*

Violin I (4) *mf*

Violin II (1) *ff* *mp* *mf* Ord. MST

Violin II (2) *ff* *mp* *mf* Ord. MST

Violin II (3) *mp* *f* Punta d'arco MSP Col legno battuto

Violin II (4) *mp* *f* III Whole Bow Ord. III

Viola (1) *mp* *f* Punta d'arco MSP Col legno battuto

Viola (2) *mp* *f* Punta d'arco MSP Col legno battuto

Viola (3) *mp* *fff* *mf* Ord. MST

Violoncello (1) *mf* Punta d'arco MSP

Violoncello (2) *mf* *fff* Ord.

Contrabasso *mf* *fff* *mf* Ord. MST

SUPERCOILING - 10

Musical score for SUPERCOILING - 10, measures 46-50. The score is arranged in a system of 13 staves, divided into two systems of six staves each, with a seventh staff at the bottom. The instruments are:

- Vln. I (1)
- Vln. I (2)
- Vln. I (3)
- Vln. I (4)
- Vln. II (1)
- Vln. II (2)
- Vln. II (3)
- Vln. II (4)
- Vla. (1)
- Vla. (2)
- Vla. (3)
- Vc. (1)
- Vc. (2)
- Cb.

Key features and performance instructions:

- Measures 46-50:** The score begins with measure 46, marked with a (S^{ost}) dynamic marking.
- Vln. I (1) & (2):** Feature long, sweeping melodic lines with slurs and vibrato. Vln. I (1) has a first finger (I) marking.
- Vln. I (3) & (4):** Play rhythmic patterns, including triplets. Vln. I (3) has a first finger (I) marking and "Ord." (Ordinary) instruction. Vln. I (4) has a first finger (I) marking and "Col legno battuto" instruction.
- Vln. II (1) & (2):** Feature long, sweeping melodic lines with slurs and vibrato. Vln. II (2) has a third finger (III) marking and "MST" (Mordent) instruction.
- Vln. II (3) & (4):** Play rhythmic patterns, including triplets. Vln. II (4) has a third finger (III) marking and "Ord." instruction.
- Vla. (1) & (2):** Play rhythmic patterns, including triplets. Vla. (1) has a second finger (II) marking and "Ord." instruction. Vla. (2) has a third finger (III) marking.
- Vla. (3):** Features long, sweeping melodic lines with slurs and vibrato. Has a third finger (III) marking and "MST" instruction.
- Vc. (1) & (2):** Play rhythmic patterns, including triplets. Vc. (1) has a "Whole Bow" instruction and a forte (*f*) dynamic marking. Vc. (2) has a mezzo-forte (*mf*) dynamic marking and a fourth finger (IV) marking with "MST" instruction.
- Cb.:** Features long, sweeping melodic lines with slurs and vibrato. Has a third finger (III) marking and "MST" instruction.

SUPERCOILING - 12

(8^{va})

56

MSP

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

pp

f

fff

f

(Cicada effect. Bowing on the D string at a point roughly equidistant between the bridge and the tailpiece, using flat hair at or near the frog.)

f

II (Scratch tone. Muting the strings)

f

III (Scratch tone. Muting the strings)

f

IV (Scratch tone. Muting the strings)

f

SUPERCOILING - 14

poco a poco rit.

65

MSP

Vln. I (1)

ff *mf* *ff*

Vln. I (2)

(8^{va})
MSP

ff *mf* *ff*

Vln. I (3)

(Cicada effect)

ff

Vln. I (4)

(Cicada effect)

ff

Vln. II (1)

MSP

ff *mf* *ff*

Vln. II (2)

(Cicada effect)

ff

Vln. II (3)

(Cicada effect)

ff

Vln. II (4)

(Cicada effect)

ff

Vla. (1)

I (Scratch tone. Muting the strings)

ff

Vla. (2)

II (Scratch tone. Muting the strings)

ff

Vla. (3)

MSP

ff *mf* *ff*

Vc. (1)

III (Scratch tone. Muting the strings)

ff

Vc. (2)

MSP

ff *mf* *ff*

Cb.

MSP

ff *mf* *ff*

I

II

III

IV

Ord.

II Ord.

Ord.

III Ord.

IV

SUPERCOILING - 15

(... poco a poco rit. ...)

8^{va} ----->

69

Vln. I (1) *ppp* *fff* *mf* *fff*

Vln. I (2) *ppp* *fff* *mf* *fff*

Vln. I (3) *fff*

Vln. I (4) *fff*

Vln. II (1) (Cicada effect) *fff*

Vln. II (2) *ppp* *fff* *mf* *fff*

Vln. II (3) (Cicada effect) *fff*

Vln. II (4) *fff*

Vla. (1) (Scratch tone. Muting the strings) *fff*

Vla. (2) (Scratch tone. Muting the strings) *fff*

Vla. (3) *ppp* *fff* *mf* *fff*

Vc. (1) (Scratch tone. Muting the strings) *fff*

Vc. (2) *ppp* *fff* *mf*

Cb. *ppp* *fff* *mf*

MST

MSP

ppp *fff* *mf* *fff*

(Cicada effect) 3

(Scratch tone. Muting the strings)

(Scratch tone. Muting the strings)

(Scratch tone. Muting the strings)

(Scratch tone. Muting the strings)

SUPERCOILING - 16

(... poco a poco rit. ...)

♩ = 60

74

Vln. I (1)

Vln. I (2)

Vln. I (3) Ord.

Vln. I (4)

Vln. II (1) II Ord.

Vln. II (2) II

Vln. II (3)

Vln. II (4)

Vla. (1) Ord.

Vla. (2) III Ord.

Vla. (3) III

Vc. (1) Ord.

Vc. (2) IV

Cb. IV

fff

fff

fff

fff



Violin I (1-4): Treble clef, G major. Part 1 (10s): *ppp* tremolo, *fff* sustained. Part 2 (3s): *fff* tremolo. Part 3 (5s): *fff* tremolo. Part 4 (5s): *fff* tremolo. Part 5 (3s): *ppp* notes with fingerings I-IV.

Violin II (1-4): Treble clef, G major. Part 1 (10s): *ppp* tremolo, *fff* sustained. Part 2 (3s): *fff* tremolo. Part 3 (5s): *fff* tremolo. Part 4 (5s): *fff* tremolo. Part 5 (3s): *ppp* notes with fingerings I-IV.

Viola (1-3): Alto clef, G major. Part 1 (10s): *ppp* tremolo, *fff* sustained. Part 2 (3s): *fff* tremolo. Part 3 (5s): *fff* tremolo. Part 4 (5s): *fff* tremolo. Part 5 (3s): *ppp* notes with fingerings I-IV.

Violoncello/Double Bass (1-3): Bass clef, G major. Part 1 (10s): *ppp* tremolo, *fff* sustained. Part 2 (3s): *fff* tremolo. Part 3 (5s): *fff* tremolo. Part 4 (5s): *fff* tremolo. Part 5 (3s): *ppp* notes with fingerings I-IV.

Violoncello/Double Bass (4): Bass clef, G major. Part 1 (10s): *ppp* tremolo, *fff* sustained. Part 2 (3s): *fff* tremolo. Part 3 (5s): *fff* tremolo. Part 4 (5s): *fff* tremolo. Part 5 (3s): *ppp* notes with fingerings I-IV.

Viola (4): Alto clef, G major. Part 1 (10s): *ppp* tremolo, *fff* sustained. Part 2 (3s): *fff* tremolo. Part 3 (5s): *fff* tremolo. Part 4 (5s): *fff* tremolo. Part 5 (3s): *ppp* notes with fingerings I-IV.

Violoncello/Double Bass (5): Bass clef, G major. Part 1 (10s): *ppp* tremolo, *fff* sustained. Part 2 (3s): *fff* tremolo. Part 3 (5s): *fff* tremolo. Part 4 (5s): *fff* tremolo. Part 5 (3s): *ppp* notes with fingerings I-IV.

SUPERCOILING - 18

20"

5"

5"

Musical score for SUPERCOILING - 18, featuring Violins I and II, Violas, Violas, Cellos, and Double Basses. The score includes dynamic markings (*ppp*), performance instructions (MST, Tapping the body of the instrument with fingers), and section markers (I, II, III, IV).

Violins I (Vln. I): Four staves (1-4). Each staff has a melodic line with dynamic markings *ppp* and performance instructions MST. Section markers I, II, III, IV are indicated. A 20" section is marked at the top.

Violins II (Vln. II): Four staves (1-4). Each staff has a melodic line with dynamic markings *ppp* and performance instructions MST. Section markers I, II, III, IV are indicated. A 5" section is marked at the top.

Violas (Vla.): Three staves (1-3). Each staff has a melodic line with dynamic markings *ppp* and performance instructions MST. Section markers I, II, III, IV are indicated. A 5" section is marked at the top.

Violas (Vla. (2)): Three staves (1-3). Each staff has a melodic line with dynamic markings *ppp* and performance instructions MST. Section markers I, II, III, IV are indicated. A 5" section is marked at the top.

Cellos (Vc.): Two staves (1-2). Each staff has a melodic line with dynamic markings *ppp* and performance instructions MST. Section markers I, II, III, IV are indicated. A 5" section is marked at the top.

Double Basses (Cb.): One staff. Melodic line with dynamic markings *ppp* and performance instructions MST. Section markers I, II, III, IV are indicated. A 5" section is marked at the top.

Performance Instructions: "Tapping the body of the instrument with fingers" is written below the staves for Vln. I (4), Vln. II (4), Vc. (1), Vc. (2), and Cb. A box with an 'X' is placed over the staff lines for these instruments during the 5" sections.

Section Markers: Roman numerals I, II, III, IV are placed above the staves to indicate specific sections of the music.

Dynamic Markings: *ppp* (pianissimo) is used throughout the score to indicate a very soft dynamic level.

SUPERCOILING - 19

79 Allegro lontano e misterioso (♩ = 130)

8^{va}
[S.V.]
Ord.

MST [S.V.]

MSP

Ord.

Vln. I (1)

ppp

Vln. I (2)

ppp

Vln. I (3)

MST [S.V.]

ppp

Vln. I (4)

Vln. II (1)

Whole Bow
MSP

ppp

mp

Vln. II (2)

Whole Bow
MSP

ppp

Vln. II (3)

Whole Bow
MSP

ppp

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

SUPERCOILING - 20

84

Vln. I (1) *f* *ppp* *m.v.* *MSP* *Ord. f.v.*

Vln. I (2) *MST* *Ord.* *f* *ppp* *m.v.*

Vln. I (3) *MST* *Ord.* *f* *ppp* *m.v.*

Vln. I (4)

Vln. II (1) *Punta d'arco* *ppp* *Whole Bow* *mp* *ppp*

Vln. II (2) *Punta d'arco* *mp* *ppp* *Whole Bow* *ppp* *mp* *ppp*

Vln. II (3) *mp* *ppp* *Punta d'arco* *Whole Bow* *ppp* *mp* *ppp*

Vln. II (4) *pizz.* *p*

Vla. (1) *1/2 legno* *p*

Vla. (2) *1/2 legno* *p*

Vla. (3) *1/2 legno* *p*

Vc. (1)

Vc. (2)

Cb. *MST S.V.* *ppp*

SUPERCOILING - 21

89

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

MST [S.V.]

Whole Bow MSP

ppp

mp

Punta d'arco

MST

ppp

MST

MST

Ord.

f

Detailed description: This is a page of a musical score for a string ensemble. The score is divided into systems for Violins I (4 parts), Violins II (4 parts), Violas (3 parts), Violoncellos (2 parts), and Contrabass (1 part). The first system shows the beginning of the piece at measure 89. The Violin I parts have a melodic line starting with a half note, followed by a series of eighth notes. The Violin II parts are mostly silent. The Viola parts enter in the third system with a rhythmic pattern of eighth notes. The Violoncello and Contrabass parts provide a harmonic foundation with sustained notes and rhythmic patterns. The score includes various performance instructions such as 'Whole Bow', 'MST', 'ppp', 'mp', 'Punta d'arco', and 'Ord.'. The Contrabass part ends with a dynamic marking of 'f' (forte).

SUPERCOILING - 22

poco a poco rit.

94

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

pizz.

p

1/2 legno

p

1/2 legno

p

1/2 legno

p

Punta d'arco

Whole Bow

ppp

mp > *ppp*

ppp

ppp

mp

ppp

mp

ppp

MST

Ord.

f

ppp

Ord.

f

ppp

m.v.

MSP

MST (f.v.)

8^{va}

S.V.

pp

SUPERCOILING - 23

(... poco a poco rit. ...)

99

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

MST S.V.

pp

f

pp

Ord.

Whole Bow MSP

Punta d'arco

arco Whole Bow MSP

mp

mf

pp

mp

mp

mp

I (White Noise. Muting the strings)

IV (White Noise. Muting the strings)

SUPERCOILING - 24

(... poco a poco rit. ...)

104

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

MSP

Ord.

MST

Whole Bow

mf

pp

p

f

MST [S.V.]

Whole Bow

MSP

SUPERCOILING - 25

109 ♩ = 105

I (Scratch tone. Muting the strings)
mf

II (Scratch tone. Muting the strings)
mf

1/2 legno
mf

1/2 legno
mf

1/2 legno
mf

1/2 legno
mf

IV
mf

Whole Bow MSP
p *f* *p*

Punta d'arco
p *f* *p*

Whole Bow
p *f* *p*

Whole Bow MSP
p *f* *p*

Whole Bow
p *f* *p*

Whole Bow
p *f* *p*

III
p MSP

Ord.
f *p* MSP

Punta d'arco
f *p*

Whole Bow
f *p*

Vcl. (1)

Vcl. (2)

Cb.

SUPERCOILING - 26

(... poco a poco rit. ...)

114

Violin I (1-4) and Violin II (1-4) parts are mostly silent, indicated by a horizontal line with a dot. Violin II (4) begins with a tremolo at *mp* and then plays a triplet of eighth notes at *f* with the instruction "Col legno tratto".

Viola (1) and Viola (2) parts are mostly silent. Viola (3) begins with a tremolo at *mp* and then plays a triplet of eighth notes at *f* with the instruction "Col legno tratto".

Violoncello (1) and Violoncello (2) parts play a melodic line with a *mp* dynamic. The Violoncello (1) part includes a *ff* dynamic marking and the instruction "Col legno tratto".

Contrabasso part plays a melodic line with dynamics *mp*, *ff*, and *mp*. It includes the instruction "Col legno tratto".

Performance instructions include "Punta d'arco MSP" and "MST Ord.".

119

Vln. I (1) *mf* *ff*

Vln. I (2) *mf*

Vln. I (3) *mf*

Vln. I (4) *mf* *fff* *mf*

Vln. II (1) *ff* *mp* *mf*

Vln. II (2) arco *mp* *f*

Vln. II (3) *mp* *f* IV Whole Bow Ord. IV IV

Vln. II (4) *mp* *f* 3 3

Vla. (1) *ff* *mp* *mf*

Vla. (2) *mp* *f* Col legno tratto

Vla. (3) 3 3 3 3 3 3 3 3 3 3 3 3

Vc. (1) *mf* III MST

Vc. (2) 3 3

Cb. IV MST *mf*

8va Ord.

Punta d'arco MSP

Ord. MST

Ord.

Ord. MST

arco Punta d'arco MSP

Punta d'arco MSP

Whole Bow Ord.

Col legno tratto

Col legno tratto

MST

MST

MST

MST

SUPERCOILING - 28

poco a poco rit.

124

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

mf

Col legno tratto

f

8^{va}

MSP

I Ord.

MST

II

III Ord.

Col legno tratto

IV Ord.

III

III Ord.

Col legno tratto

IV

IV

Detailed description: This is a page of a musical score for a string and woodwind ensemble. The score is divided into systems for Violins I (Vln. I), Violins II (Vln. II), Violas (Vla.), Violas/Celli (Vc.), and Contrabass (Cb.). The top system (Vln. I) includes a rehearsal mark '124' and a dynamic marking 'mf'. The Vln. I (1) part features a long, sweeping melodic line with a 'Col legno tratto' instruction. The Vln. I (2) part has a rhythmic pattern of eighth notes with 'Col legno tratto' and a dynamic 'f'. The Vln. I (3) part has a melodic line with 'Col legno tratto' and a dynamic 'f'. The Vln. I (4) part has a melodic line with 'Col legno tratto' and a dynamic 'f'. The Vln. II parts (1-4) have various rhythmic and melodic patterns, with 'Col legno tratto' and 'Ord.' (Ordine) markings. The Vla. parts (1-3) have rhythmic patterns with 'Col legno tratto' and 'Ord.' markings. The Vc. parts (1-2) have rhythmic patterns with 'Col legno tratto' and 'Ord.' markings. The Cb. part has a melodic line with 'Col legno tratto' and 'Ord.' markings. The score includes various performance instructions such as 'Col legno tratto', 'Ord.', 'MSP', 'MST', and '8^{va}'. The tempo is marked 'poco a poco rit.'.

SUPERCOILING - 29

131 Andante moderato, agitato e con vigore (♩ = 75)

Musical score for SUPERCOILING - 29, measures 129-134. The score is for a full orchestra and includes parts for Violins I and II, Violas, Violas, Cellos, and Double Basses. The tempo is Andante moderato, agitato e con vigore (♩ = 75). The score is divided into four measures, each with a different time signature: 3/4, 2/4, 4/4, and 3/4. The dynamics range from *pp* to *ff*. The score includes various musical notations such as slurs, accents, and dynamic markings. The first measure (129) starts with a *pp* dynamic and a *ff* dynamic. The second measure (130) starts with a *f* dynamic and a *pp* dynamic. The third measure (131) starts with a *ff* dynamic and a *pp* dynamic. The fourth measure (132) starts with a *pp* dynamic and a *ff* dynamic. The score includes various musical notations such as slurs, accents, and dynamic markings. The first measure (129) starts with a *pp* dynamic and a *ff* dynamic. The second measure (130) starts with a *f* dynamic and a *pp* dynamic. The third measure (131) starts with a *ff* dynamic and a *pp* dynamic. The fourth measure (132) starts with a *pp* dynamic and a *ff* dynamic. The score includes various musical notations such as slurs, accents, and dynamic markings.

SUPERCOILING - 30

134

Vln. I (1)

Vln. I (2) (Cicada effect) *f*

Vln. I (3) (Cicada effect) *f*

Vln. I (4) (Cicada effect) *f*

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1) IV (Scratch tone. Muting the strings) *f*

Vc. (2) IV (Scratch tone. Muting the strings) *f*

Cb. IV (Scratch tone. Muting the strings) *f*

III

IV

III Ord.

IV Ord.

III Ord.

III

II Ord.

III Ord.

SUPERCOILING - 31

(♩ = ♩.)

139

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

SUPERCOILING - 33

149 ♩ = 60

Violin I (1) *ff* **IV** **III**

Violin I (2) *ff* **Col legno battuto** **Ord.**

Violin I (3) *ff* **Col legno battuto** **Ord.**

Violin I (4) *ff* **Col legno battuto** **Ord.**

Violin II (1) *ff* **IV** **III**

Violin II (2) *ff* **IV** **III**

Violin II (3) *ff* **IV** **III**

Violin II (4) *ff* **IV** **III**

Viola (1) *ff* **III** **II**

Viola (2) *ff* **III** **II**

Viola (3) *ff* **III** **II**

Violoncello (1) *ff* **Ord.** **III** **III**

Violoncello (2) *ff* **Ord.** **III** **III**

Contrabass *ff* **Ord.** **I** **I**

SUPERCOILING - 34

154

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

IV (White Noise. Muting the strings)

pp

p

mp

SUPERCOILING - 35

158

Vln. I (1) *mf* *f* *8va*

Vln. I (2) (Scratch tone. Muting the strings) *mf* *f*

Vln. I (3) (Scratch tone. Muting the strings) *mf* *f*

Vln. I (4) (Scratch tone. Muting the strings) *mf* *f*

Vln. II (1) *mf* *f* *8va*

Vln. II (2) *mf* *f* *8va*

Vln. II (3) *mf* *f* *8va*

Vln. II (4) *mf* *f*

Vla. (1) *mf* *f*

Vla. (2) *mf* *f*

Vla. (3) *mf* *f*

Vc. (1) *mf* *f* *ff* IV (Scratch tone. Muting the strings)

Vc. (2) *mf* *f* *ff* IV (Scratch tone. Muting the strings)

Cb. *mf* *f* *ff* IV (Scratch tone. Muting the strings)

10'' 5'' 5'' 10'' 3'' 5'' 2'' 5''

Vln. I (1) *mf* (Cicada effect) *mf*

Vln. I (2) *mf* (Cicada effect) *mf*

Vln. I (3) *mf* (Cicada effect) *mf*

Vln. I (4) *mf* (Cicada effect) *mf*

Vln. II (1) *mf* I

Vln. II (2) *mf* II

Vln. II (3) *mf* III

Vln. II (4) *mf* IV

Vla. (1) (Scratch tone. Muting the strings) *mf* 6

Vla. (2) (Scratch tone. Muting the strings) *mf* 7

Vla. (3) (Scratch tone. Muting the strings) *mf* 8

Vc. (1) *mf* IV III IV II III

Vc. (2) *mf* IV III IV II III

Cb. *mf* IV III IV II III

SUPERCOILING - 37

162 ♩ = 50

3" 10" 5" 5"

(Cicada effect)₅

Vln. I (1)

Vln. I (2)

Vln. I (3)

Vln. I (4)

Vln. II (1)

Vln. II (2)

Vln. II (3)

Vln. II (4)

Vla. (1)

Vla. (2)

Vla. (3)

Vc. (1)

Vc. (2)

Cb.

8^{va} MSP → MST → Ord.

fff *ppp* *fff*

I

II

III

IV

6

7

8

I II III IV

I II III IV

I II III IV

Óscar Calatayud-Gómez

SLEEP CYCLE

(2019)

for solo percussion



Óscar Calatayud-Gómez

SLEEP CYCLE

(2019)

for solo percussion

Óscar Calatayud-Gómez: SLEEP CYCLE
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Duration: 8 minutes

Instrumentation

Four Toms

High Tom
High-Mid Tom
Low-Mid Tom
Low tom

Two Bongos

High Bongo
Low Bongo

Two Congas

High Conga
Low Conga

Spring Drum

Tam-tam

Suspended Cymbal

Contact

To request the materials of the piece and details or questions about Sleep Cycle, contact the composer: ocalatayudgomez@hotmail.com

Mallets/Sticks

Triangle Stick

Superball mallet

Soft Mallets

Hard mallets

Wood mallets

Plastic mallets

Yarn head mallet

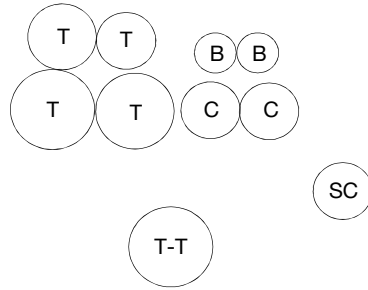
Performance Notes

Sleep Cycle is a piece based on the different parts of the sleep process, from the part where the human being is awake to the last part of the REM sleep. In order to create the musical material of this piece, there are some analogies between the brain waves as musical gestures, the voltage as dynamics and the frequency as tempo marks. This piece has five different sections that simulate and represent different parts or stages of the human process of the sleep cycle.

Sleep Cycle is a piece composed in 2019 for solo percussion. Its premiere was at Högskolan för scen och musik (Göteborg, Sweden) on January 14, 2020, by Simon Halvarsson.

This piece is part of a research on music composition methods related to chemistry and biology made by the composer of this piece. Specifically, it is inspired by a method based on the stages of the sleep cycle developed by some composers and scientists.

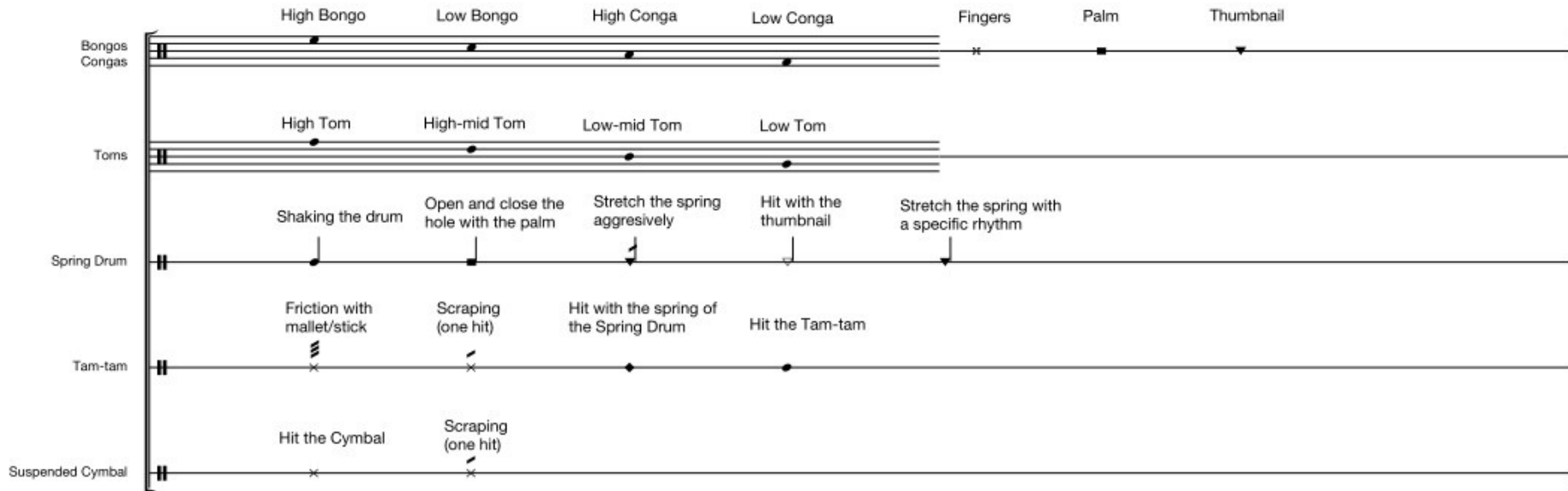
Set-up



Notation Notes

- s.m. Soft Motion (Spring Drum)
- m.m. Medium Motion (Spring Drum)
- f.m. Fast Motion (Spring Drum)

Notation Notes



Score
Duration: 8 minutes approx.

SLEEP CYCLE

for solo percussion



Óscar Calatayud

Óscar Calatayud-Gómez

Allegro agitato (♩ = 125)
A relaxed wakefulness or hypnagogic state...

Bongos
Congas

Plastic mallets

Toms

mp *mf* *p* *mf*

Bg.
Cg.

T.

p *mf* *p* *mf* *p* *mf*

Bg.
Cg.

T.

rit. with fingers

A Andante loutano (♩ = 95)
Drowsy, sleepy, somnolent...

p *mf* *p* *mf* *pp*

Bg.
Cg.

T.

(tremolo with fingers 1 and 5)

(With the palm)

(Thumbnail)

SLEEP CYCLE - 2

B Allegro marcato (♩ = 125)
A light sleep, a shallow sleep...

poco a poco accel.

25

Bg. Cg. T.

cresc. poco a poco

I.h. 2 plastic mallets

f

p

poco a poco accel.

(♩ = 145) rit. (♩ = 125)

31

Bg. Cg. T.

f *p* *mf*

f *p*

poco a poco accel.

37

Bg. Cg. T.

f

f

rit. (♩ = 125) accel. (♩ = 145) rit. (♩ = 125) poco a poco accel.

43

Bg. Cg. T.

f *p* *mf* *p*

SLEEP CYCLE - 3

C Lento tranquillo ma sonoro (♩ = 60)
A slow sleep, external stimuli do not matter...

49 (♩ = 145) poco a poco rit.

Bg. Cg. *p* *cresc.*

T. *f*

Sus. C. *mf* *cresc.* *ff*

Soft mallets

Suspended Cymbal

Spring Drum

Tam-tam

55

Sp. D. Superball Mallet *f* *ff* *fff*

T-T *f*

Sus. C.

s.m. m.m. f.m.

Hand icon

61

Sp. D. *ff* *f* *fff* *ff*

T-T Scraping (one hit) *ff*

Sus. C. *f* *fff*

Spring Drum

Tam-tam

SLEEP CYCLE - 4

67

Sp. D.

T-T

Sus. C.

ff

ff

ff

Scrapping with a triangle stick (continously)

Hard mallets

f

fff

73

Sp. D.

T-T

Sus. C.

m.m. → s.m. simile

s.m. → m.m.

Triangle Stick

Triangle Stick

ff

f ff

f ff

f ff

f ff

f

f

fff

79

Sp. D.

T-T

Sus. C.

f.m.

Yarn head mallet secco

Aluminum head mallet (Crotale mallets)

Aluminum head mallet (Crotale mallets)

fff

f

f

f

f

SLEEP CYCLE - 5

85

Sp. D. *ff* *fff* *f* *ff*

T-T *ff* *fff*

Sus. C. *ff* *fff*

f.m. s.m. m.m.

D poco a poco accel.

r.h. 2 wood mallets

E Allegro marcato (♩ = 125)
A light sleep, a shallow sleep...

poco a poco accel.

91

Bg. Cg. *fff* *f* *p*

T. *fff* *f* *p*

Sp. D. *fff* *ff* *f*

f.m. m.m. s.m.

l.h. 2 wood mallets

(♩ = 145)

rit.

(♩ = 125)

97

Bg. Cg. *f* *p* *mf*

T. *f* *p* *mf*

poco a poco accel.

102

Bg. Cg. *f* *p*

T. *f* *p*

SLEEP CYCLE - 6

(♩ = 145)

107

Bg. Cg. T.

f

5

rit.

(♩ = 125) poco a poco accel.

f *p*

(♩ = 145) rit.

112

Bg. Cg. T.

mf *p*

(♩ = 125) poco a poco accel.

F

G Andante moderato, risoluto (♩ = 100)
The REM sleep, where dreams appear...

117

Bg. Cg. T. Sp. D. Sus. C.

I.h. Soft mallets

mf *p* *mf*

r.h. s.m. m.m.

p *mf*

122

Bg. Cg. T. Sp. D. Sus. C.

p *mf*

s.m. m.m.

p *mf*

r.h. 2 soft mallets

SLEEP CYCLE - 7

127

Bg. Cg.

T.

Sp. D.

Sus. C.

p

mf

p

132

Bg. Cg.

T.

mf

ppp

137

Bg. Cg.

T.

mf

l.h. 1 wood mallet
r.h. 1 wood mallet

142

Bg. Cg.

T.

mp

SLEEP CYCLE - 8

H Allegro agitato, risoluto (♩ = 125)
The REM sleep, the brain activity increases...

147 accel.

Bg. Cg.
T.
Sus. C.

I Allegro quasi vivace, risoluto (♩ = 145)
The sleep is about to conclude...

152

Bg. Cg.
T.
Sus. C.

157

Bg. Cg.
T.

162

Bg. Cg.
T.