Evolutionary Variation Applied to the Composition of CTG, for Woodwind Trio

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***Abstract**: This paper integrates a broad research on musical variation. It specifically addresses an original concept, namely "evolutionary variation" (EV), resulted from an association between Schoenbergian principles of Grundgestalt and developing variation and some ideas from Genetics and Evolutionary Biology. The application of this concept in a compositional system (Gr-S) aims at the production of a large number of variants from a basic musical idea, covering a wide spectrum of similarity relationships. An application of EV in the composition of CTG, for woodwind trio, is described in the second part of the paper.*

***Keywords**: Musical and Biological Evolution. Grundgestalt and Developing Variation. Computer-Aided Composition.*

I. Introduction

The present study aims to highlight special similarities between musical variation and genetic phenomena, which contributed to the elaboration of a new concept, *evolutionary variation*. The study integrates a broad research project intended basically to systematical approaches addressed to musical variation, under analytical and compositional perspectives. The research is theoretically based on two correlated principles elaborated by the Austrian composer Arnold Schoenberg, namely, developing variation and *Grundgestalt* (normally translated as "basic shape"), both resulted from an organicist conception of musical creation. Considered by Leonard Meyer as the most important extra-musical influence for the Romantic (especially Austro-German) composers [1], the trend of Organicism was decisively intensified in middle of the 19th century with the publication of works by Goethe (on the nature of plants) and, especially, Darwin, with his theory of evolution of the species [2]. Traces of this organic origins were deeply established in the Schoenbergian theory of *Grundgestalt*, as can be observed in his writings about this subject, being specially evidenced by the use of metaphors, like "seed", "organic growth", "internal development" and so on.[1]

In this research, the ties between music and biology are deliberately more tight and explicit. Concepts like *genomic/phenotypic* levels, *chromosomes*, *genealogy*, *ascendants/descendants*, *viruses*, among others, are not only part of the specific terminology, but also important components of adopted premises. Recently, a new branch was initiated taking as model Darwin's theories (and specially their modern unfolding, produced in the fields of Genetics and the so-called Neo-Darwinism [4], [5]). In this new approach, the concepts of "evolution" and "artificial selection"

[1] See, for example, [3].

were transposed from the realm of vegetal and animal life to the domain of music, which resulted in some prospective studies. One of them [6] describes an experiment for production of variants from a simple theme, through successive application of "micro-mutations" along 20 generations of descendants, with the help of a special computational software developed for the task. At each generation of 6 transformed "children", the most apt for continuing the lineage was selected becoming a"parent" for the next breeding (the adopted criteria for the selection were based on objective musical parameters: melodic contour, harmony and rhythmic configuration). This artificial selection strategy (similarly as that one used in farms for improving animal creation) can be associated to the developing variation techniques, but under an original and instigate perspective, since it promotes gradual divergences from the referential musical form according to some "evolutionary pressure", i.e., "directions" determined by the selective criteria ultimately adopted by the own composer. These findings constituted an important basis for the present study, associated to the systematical composition of organic musical pieces.

II. The Gr-System

The main motivation for the development of the Gr-System ("Gr" for *Grundgestalt*) was to investigate if it would be possible to produce music with a strict organic structure and in terms of maximal economy (i.e., with the use of the least possible external material). As one can easily see, this task would only be adequately accomplished with the aid of computational tools. Four programs were then idealized and grouped in a complex named *geneMus* (gM),[2] specifically destined to the production of variations in different operational levels. After a long phase of design and improvement, a more stable, versatile, and robust version of gM was recently consolidated. It is formed by four sequential and complementary modules, each one destined to a specific function, which are summarily described as it follows:[3]

- gM-01: produces abstracted variations (labeled in gM as "geno-theorems", or gTs) from a musical basic cell (the *Grundgestalt* or, in the research's terminology, the *axiom* [ax] of the system, the given external element). Two kinds of abstractions (identified as "chromosomes") are considered as referential in this process: the sequences of intervals (chromosome I) and temporal durations (chromosome R) that form the axiom. An indefinite number of generations of gTs (melodic and rhythmic) can be obtained through application of transformational operations to both chromosomes. Sequences of operations (inversion, augmentation, etc.) correspond in the system to "abstract" and progressive derivative procedures, or *developing variation of first order* (DV1);
- gM-02: is responsible for forming concrete musical building blocks (named as pheno-theorems, or pTs) through an exhaustively crossing-over of intervallic and rhythmic gTs produced in gM-01. Some filters (designed as fitness functions) were implemented in this module in order to select the "best" pTs (according the partiular intentions of the composer) and conversely eliminate the "ill-formed" ones, contributing for reducing the risk of overpopulation [8];
- gM-03: concatenates the selected pTs to form larger and more complex structures (similarly as motives are joined in the construction of themes), which are labeled as axiom-groups (axGrs). These constitute the referential forms for further derivation, performed in the next module;

[2] The four gM modules were implemented in the computational platform Matlab.
[3] For more detailed information, see [7].

- gM-04: yields generations of variants (theorem-groups, or thGrs) from the pre-produced axGrs, through application of transformational operations (analogously as happens in gM-01, but in this case involving concrete musical structures). This process is labeled as developing variation of second order (DV2);

The structure of gM and the correlations and specific functions of its four modules are summarized in Figure 1.

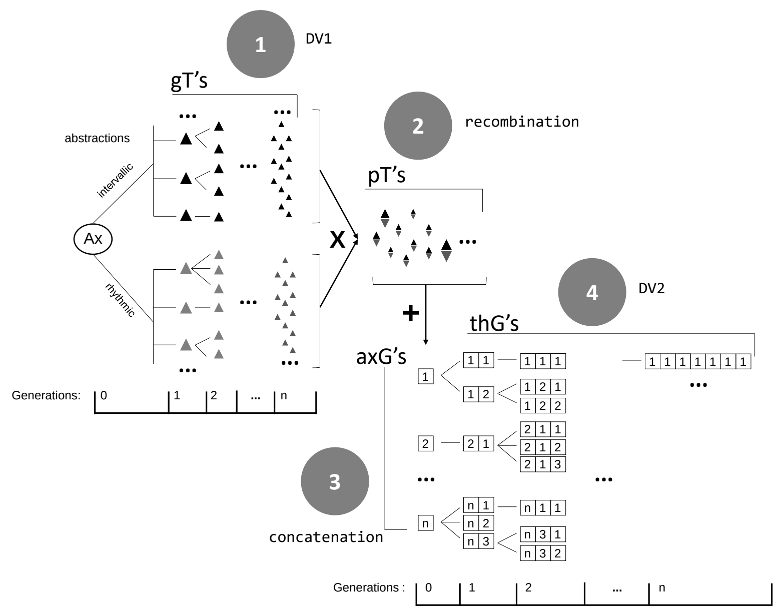

Figure 1: *Graphic representation of gM's structure and of its four modules (adapted from [7, p. 44]).*

The Gr-System depends on two important and correlated concepts: the coefficient of similarity and the derivative curve. The coefficient of similarity (Cs) of a given variant measures the "parenthood" degree between it and the referential form from which it ultimately derives,[4] being expressed as a real number between 0 (absolute contrast) and 1 (relation of identity).[5]

The derivative curve informs the fluctuations of Cs along the time. There are two types of curves: for planning and analysis. The former is used in the pre-compositional stage, with the finality to provide a broad idea of the intended derivative behavior of the musical material along the sections of a planned piece. For this reason, the planning derivative curve has an aspect rather of a sequence of rectangles than properly of a saw-like line. In turn, the analytical derivative curve aims at precisely describing the fluctuations of similarity relations in a finished piece, taking into account the involved voices at each beat.[6]

After concluding the production of the material (the abstract and concrete variants) and plotting the planning derivative curve, the compositional phase is properly ready to begin. A specific program, named *organiComposer*, was designed to aid the composer to structure a musical piece based on decisions and choices conditioned by his/her constructive intentions.

[4]The referential forms adopted for Cs measurement are of two kinds: the chromosomes I / R (in the case of the abstract derivation processes or, as above defined, DV1) and the axGrs (DV2). By definition, these forms are axiomatic in the system and have Cs = 1.

[5]The algorithms for calculating the coefficient of similarity are basically described in [9].

[6]For examples of the both types of derivative curves, see Figures 3 and 14.

Recently, a phase of practical tests for the system was initiated with the idealization of a compositional project entitled *Germinatas*, a cycle of 16 pieces, each one with four movements and specific instrumental formations (string quartet, piano, symphonic orchestra, etc.). *Germinata* I, for woodwind trio (oboe, clarinet and bassoon), is the first concluded piece of this project. The next part of the article is dedicated to examine the constructive processes employed in this work. Firstly, some general comments about the basic formal-derivative structure of the entire cycle, then a concise description of the production of the common material of *Germinata* I (i.e., the motivic substrate that is shared by the four movements of the piece), and finally a more specific and detailed exam of the last movement, entitled CTG.

III. The cycle *Germinatas*

The idealization of *Germinatas* was based on another link between the realms of music and genetics, considering specifically the four nucleotides that form the DNA, Adenine (A), Cytosine (C), Guanine (G) and Thymine (T). These elements were isomorphically associated to four profiles of similarity relations (Table 1). It is noteworthy to add that this association was purely arbitrary, with the only purpose of providing a useful means for structuring the pieces.

Table 1: *Correlations between nucleotides and similarity profiles in the Germinatas, considering four types of similarity relations measured in Cs values*

nucleotide	similarity relations	max./min. values for Cs
A	high similarity	1.00/.75
C	medium similarity	.74/.50
G	low similarity	.49/.25
T	high contrast	.24/.00

The internal organization of the movements in each of the 16 *Germinatas* also maps genetic processes, corresponding to a codon. Codons are structural elements that form the genetic code of a living form, consisting on nucleotide triplets (or three-letter "words") built by the combination of the bases A, C, G, and T. Since there are 64 possible triplets (4^3), the four movements of each one of the 16 *Germinatas* were structured as groups of four codons, in such a way that all the combinations without repetitions will be considered. Figure 2 presents a list of the 64 codons (and, isomorphically, the internal structures of the *Germinatas'* movements).

Four sequences was selected for *Germinata* I (see Table 2). Based on this selection, four planning derivative curves (one for each movement) were plotted (Figure 3). As previously stated, they represent only broadly the intended profiles of similarity for the movements,[7] but become an important and efficient basis for orienting the choice of the motivic-thematic material during the compositional phase.

IV. Production of common material for *Germinata* I

The composition in the Gr-System must begin with the choice of an axiom for becoming the very referential form for subsequent derivation. It can be an original musical fragment or be borrowed from an existent piece, as in the present case. For the axiom of *Germinata* I, intended to

[7] Since the primary aspect concerned in the graphs is the derivative behavior, the extensions of the three sections in each movement were roughly arbitrated as third parts (33%) of the total.

1	A	A	A	17	C	T	C	33	T	T	C	49	C	G	A
2	A	A	C	18	A	C	C	34	T	T	G	50	C	G	T
3	A	A	G	19	A	G	C	35	T	A	T	51	C	T	A
4	A	A	T	20	A	T	C	36	T	C	T	52	C	T	G
5	A	C	A	21	G	G	G	37	T	G	T	53	G	A	C
6	A	G	A	22	G	G	A	38	A	T	T	54	G	A	T
7	A	T	A	23	G	G	C	39	C	T	T	55	G	C	A
8	C	A	A	24	G	G	T	40	G	T	T	56	G	C	T
9	G	A	A	25	G	A	G	41	A	C	G	57	G	T	A
10	T	A	A	26	G	C	G	42	A	G	C	58	G	T	C
11	C	C	C	27	G	T	G	43	A	C	T	59	T	A	C
12	C	C	A	28	A	G	G	44	A	G	T	60	T	A	G
13	C	C	G	29	C	G	G	45	A	T	C	61	T	C	A
14	C	C	T	30	T	G	G	46	A	T	G	62	T	C	G
15	C	A	C	31	T	T	T	47	C	A	G	63	T	G	A
16	C	G	C	32	T	T	A	48	C	A	T	64	T	G	C

Figure 2: *List of the 64 possible codons/sectional sequences.*

Table 2: *Four-movement structure of Germinata I (hs: high similarity; ms: medium similarity; ls: low similarity; hc: high contrast)*

movement	corresponding codon	similarity relations
I	<ACG> [43]	hs-ms-ls
II	<TGA> [63]	hc-ls-hs
III	<CTA> [51]	ms-hc-hs
IV	<CTG> [52]	ms-hc-ls

be allusive to Brazilian musical popular genres, it was selected the anacrusis of the well-known choro *Carinhoso*, composed in 1917 by Pixinguinha and Braguinha (Figure 4).

The axiom (saved as a midi file) was then opened in gM-01, which abstracted its intervallic and rhythmic configurations, transcribing them as numeric strings, labeled as chromosomes I and R (Figure 5).

The derivative process was then ready to be initiated. Each chromosome was used as referential form for parallel production of 42 melodic and 21 rhythmic gTs. Some of these outcomes are shown in Figure 6.[8]

In gM-02 were then formed 882 pTs through mathematical combination of the 42 melodic and 21 rhythmic gTs. As previously stated, the pTs are basic concrete structures that approximately function as motives in the system (Figure 7 presents six of them).

The next step (in gM-03) was to form the referential axGrs. It was decided that each movement of *Germinata* I would be constructed based on a unique axGr (and, of course, their respective derivations). Thus, four axGrs were created through combination and concatenation of different pTs. This process involves three possible alternatives for each inserted pT: (1) transposition; (2) metrical displacement; (3) suppression of final notes. Needless to say that the composer, based on his own sense of form, must carefully consider the better combinations to do, selecting the

[8]For a detailed description of the functioning of gM-01, see [10].

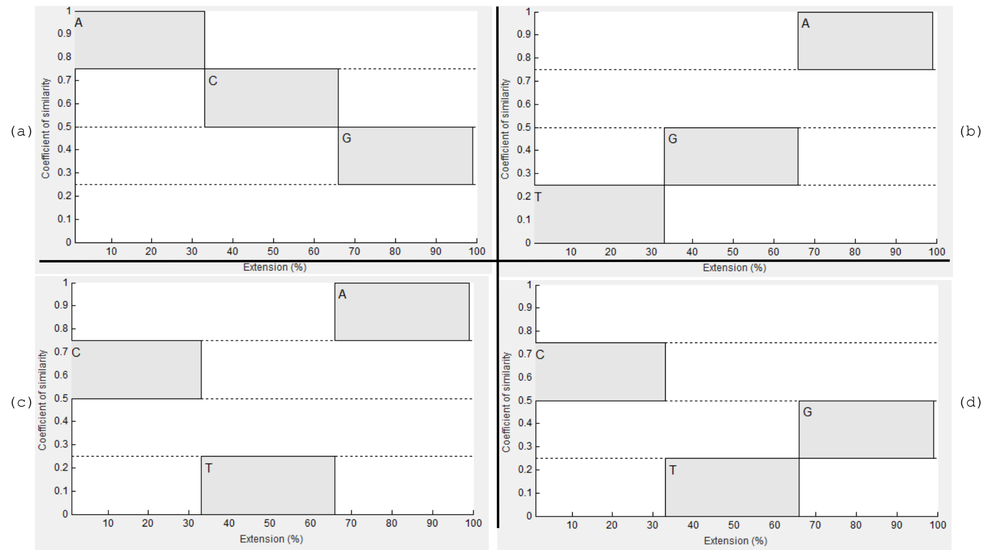

Figure 3: *Germinata I: Planning derivative curves of the four movements: ACG (a); TGA (b); CTA (c); CTG (d).*

Figure 4: *Pixinguinha and Braguinha: Carinhoso (anacrusis), taked as axiom of Germinata I.*

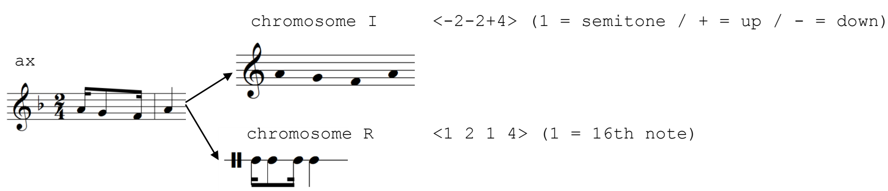

Figure 5: *Germinata I: axiom and chromosomes I and R.*

components according to their melodic contour and rhythmic configurations and contextual relations (as, for example, parallelism and contrast between segments). Figure 8 shows the formation of axGr-5 (used as referential form for the fourth movement, CTG),[9] identifying the pTs used as its components and the corresponding transformations which were applied, based on the three above mentioned options.

In gM-04 each axGr becomes a kind of patriarch of a lineage of variants, which are obtained through developing variation of second order (DV2). More precisely, in this phase it is properly initiated the process of evolutionary variation, as it will be detailed in the next sections, dedicated

[9]This apparent incongruence – i.e. the fourth movement's axGr is numbered with "5" and not "4" (as one could logically expect) – is due to the fact that, actually, there were produced for the piece in gM-03 six axGrs. Of these, only four were selected for the movements, respectively: axGr-1, axGr-3, axGr-4 and axGr-5.

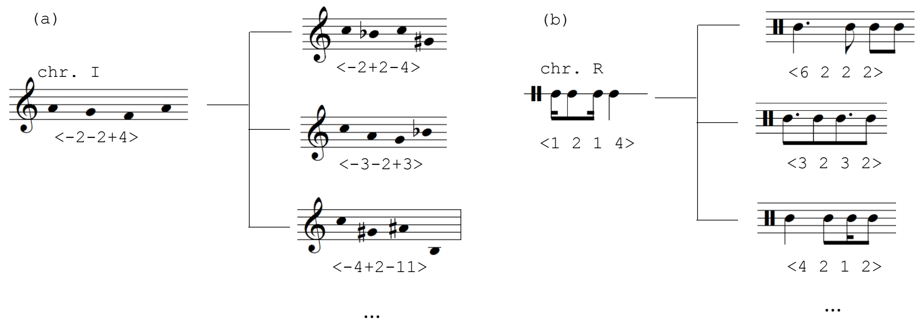

Figure 6: *Germinata I: some melodic and rhythmic gTs obtained from chromosomes I (a) and R (b) through developing variation of first order.*

Figure 7: *Germinata I: pTs numbers 1, 38, 77, 208, 314, and 536.*

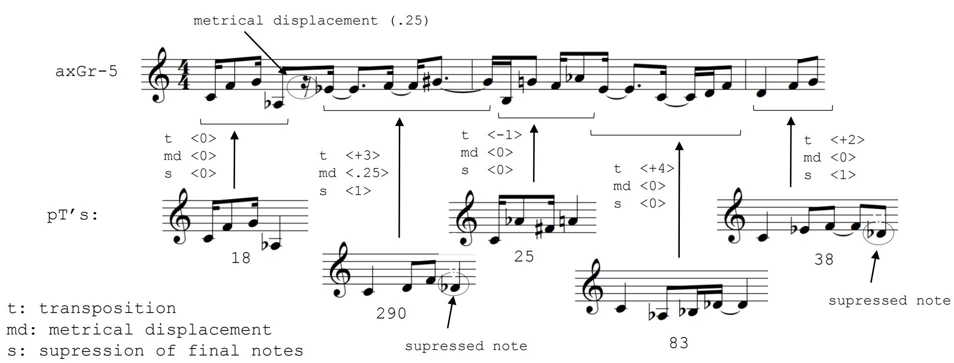

Figure 8: *Germinata I: formation of axGr-5, through combination of pT's numbers 18, 290, 25, 83, and 3.*

to describe the construction of CTG.

V. The evolutionary space of CTG

A specific motivic-thematic material of a piece built in the Gr-System consists essentially on the set formed by a given referential form (axGr-5, in the present case) and all the thGrs that derive from it. This set corresponds to the evolutionary space (ES) of the piece.[10] An ES is formed through a special type of developing variation process, namely, evolutionary variation (EV), which results

[10]The idea of evolutionary space was inspired by Richard Dawkins' concept of "genetic space" (see [4, pp. 81-91]).

from gradual and cumulative mutations (frequently quite subtle, almost imperceptible) along generations of variants. In a sense, EV can be compared (in a radically more compacted time-scale, of course) to the process of formation of the animal and vegetal species. Although the amount of modification between a given referential form and its immediate offspring is normally low, under a broader perspective, considering the whole derivative process and its multiple branching, divergence can reach extreme rates. In musical terms, this can provide a wide range of forms with distinct degrees of similarity in relation to the basic theme.

It is important to add that not necessarily all the elements of an ES must be present in the piece. Some of them may simply be created as intermediate stages in the formation of more meaningful structures (according to some constructive intentions). In sum, the "area" covered by the ES of a given piece depends directly on compositional needs and particular requirements, as it will be later evident. An ES is formally expressed as:

$ES_{\text{p}} = \{axGr_{\text{n}}, {}^{*}thGr_{\text{n}}\}$, where ES_{p} is the evolutionary space of the piece p,$axGr_{\text{n}}$ is the axiom-group of number n, and ${}^{*}thGr_{\text{n}}$ is the total of theorem-groups derived from $axGr_{\text{n}}$.

An ES_{p} is therefore formed in the module gM-04, dedicated to the production of thGrs from a given axGr. In the specific case of CTG, its ES comprised 53 elements ($axGr - 5plus52thGrs$), distributed into 7 main branches and 8 generations. A special function of gM-04 is used to produce a graphic representation of the EV in the format of a genealogical tree. Figure 9 shows the ES of CTG (ES_{CTG}): the nodes correspond to the thGrs and the lines represent their respective derivations. As can be observed, due to the fact that some thGrs are more "prolific" than others, it is considerably difficult to obtain a complete and clear visualization of the precise branching in some parts of the tree (as the cluster in the framed area in Figure 9a). In these cases, the program allows to magnify the view of the section in question, as it is shown in Figure 9b.

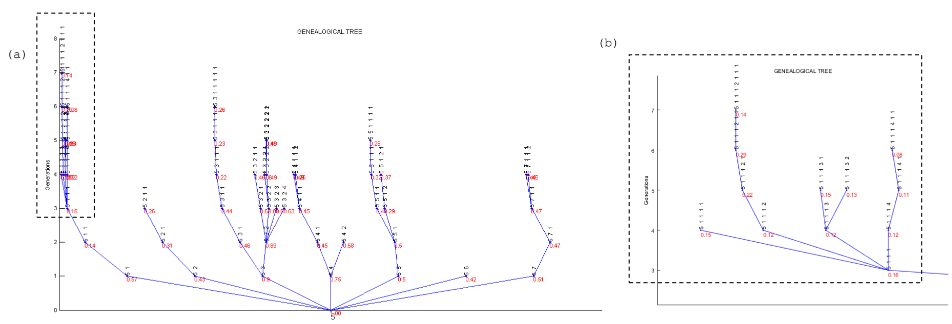

Figure 9: *GerminataI/CTG: ES as a genealogical tree (a); detailed view of the selected area (b). Nodes indicate variants (thGr's), their Gödel-vectors (see bellow) and coefficients of similaity are notated, respectively, in black and red.*

Each thGr receives a label corresponding to its lineage description, expressed as a vector, named *Gödel-vector* (Gv),[11] whose first element is the number of the considered axGr (5, in the present case). The remain components describe the genealogical trajectory of the form. Be, for example, the thGr, with Gv <5 1 1 2 3>. It corresponds to the following genealogical description (the vector content must be read backwards): "third descendant of the second descendant of the

[11]To more information about the elaboration of the *Gödel-vector*, the origins of its formulation and the algorithms involved in the genealogical description of variants in the system, see [11].

first descendant of the first descendant of the fifth 'patriarch'". Besides the Gv, the genealogical tree also informs the Cs indexes of the involved thGr (the numbers in red in Figure 9a).

A thGr (generically named as a "child") results from application of at least one transformational operation to a referential form (its "parent"). The operations can be intervallic (i.e. acting on the parentâĂŹs chromosome I), rhythmic (chromosome R) or intervallic-rhythmic (indistinctly applicable to the both structures). Table 3 presents a basic list of the available operations in gM-04.

Table 3: *Formal description of the operations, considering chromosome of application and corresponding algorithm, where <a> and <b> are, respectively, the numeric transcriptions of a "parent" and its "child", p is prime number between 2 and 11 and q = 1.5, 2 or 3.)*

operation	chromosome	algorithm
inversion (INV)	I	<b> =-1*<a>
multiplication (MUL)	I	<b> =p*<a>
augmentation (AUG)	R	<b> =q*<a>
diminution (DIM)	R	<b> =0.5*<a>
expansion (EXP)	IR	<b> =<a>+ p
contraction (CNT)	IR	<b> =<a>- p
retrogradation (RET)	IR	$<a_n,...a_1,a_0> = <a_0,...a_{n-1},a_n>$
rotation (ROT)	IR	<b> =$< a_1, a_2...a_n,a_0 > = < a_0,a_1,...a_{n-1},a_n >$

There are two types of operational application: general and mutational. The former affects the entire content of the "parent", while in the second type just one element — randomly selected by the program — is modified.[12] This case emulates genetic, intracellular mutation, promoting a very gradual developmental process. The resulting child is always quite similar to its parent, but their own children (and the children of these, and so long) will certainly contribute to increase more and more the divergence, which, after some generations, causes a wide and varied spectrum of correlate musical ideas. With the purpose of expanding the range of possibilities it is also possible to combine two or more operations (general and/or mutational) in a single application. Figure 10 presents four of the innumerable alternatives for variant production from a hypothetical "parent".

The production of the thGrs that form ES$_{CTG}$ was conditioned not only by needs of variety and contrast of the musical material, but also by the pre-established limits of similarity relationships, determined in the planning derivative curve (see Figure 3). Since these limits constrain the average Cs values (Cs$_{av}$) to be lower than 0.75 in all of the movement's three sections, the production of variants was directed to the selection of more divergent outcomes (which, in turn, would also breed descendants with low similarity in relation to axGr-5). It is relevant to add that in the Gr-System the selective process is always mediated by the composer's sense of form, which represents the ultimate and most decisive factor for the choice of the best (artistically speaking) results among a multitude of alternatives at each phase of the process. Figure 11 presents a subset of ES$_{CGT}$, informing their respective genealogical labels and Cs indexes.

[12]Frequently a mutational operation produces an ill-formed variant (with extremely large melodic range, for example). In this cases, the variant is simply discarded and, of course, leaves no descendants. It is noteworthy that such a situation is quite similar to what happens in organic life, since most of mutations that occur in the genome of a being imply in none advantage for it (if do not cause its death).

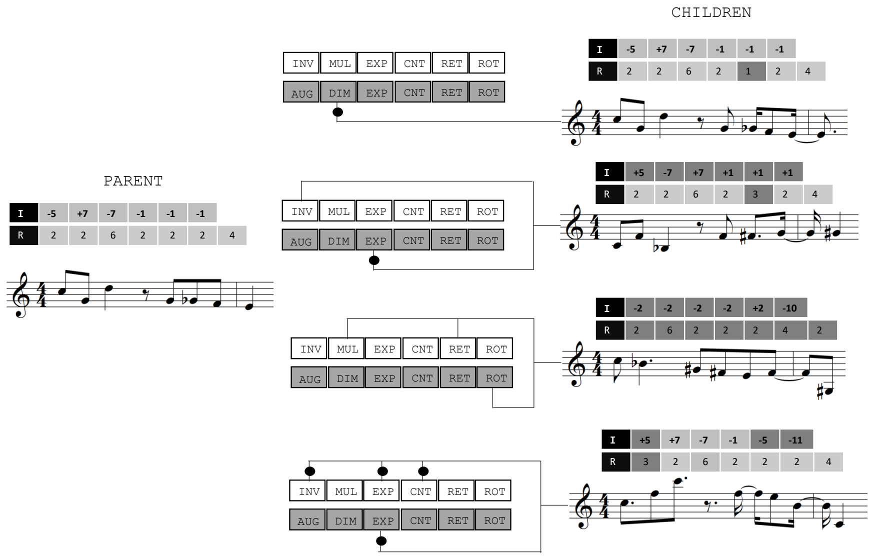

Figure 10: *Four thGr's ("children") derived from a hypothetical "parent" through application of single or combined transformational operations. Above each form is its "genetic code" (chromosomes I/R). The darker rectangles correspond to the modified characteristics. The black circles indicate mutational operation.*

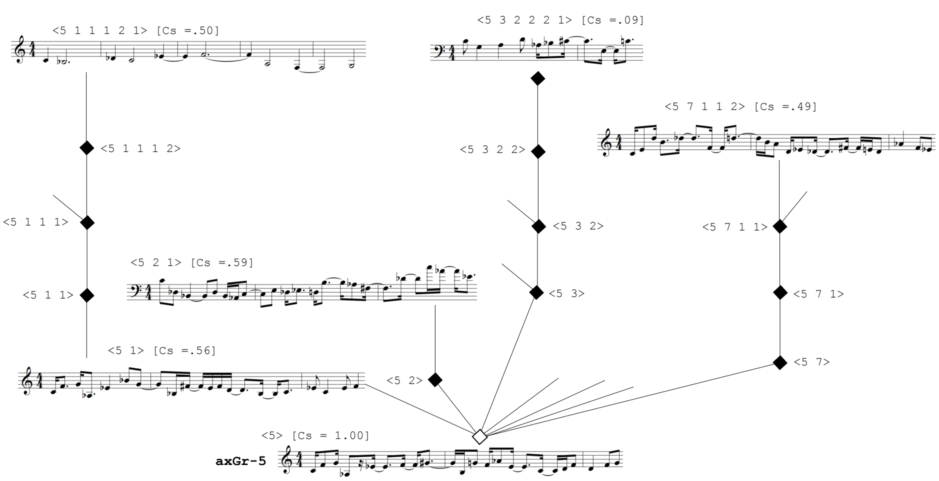

Figure 11: *Germinata I/CTG: topological diagram presenting five thG's derived from axGr-5 (genealogical label <5>) with their respective Cs values: <5 1> (first generation), <5 2 1> (second generation), <5 7 1 1 2> (fourth generation), <5 1 1 1 2 1> and <5 3 2 2 2 1> (fifth generation).*

VI. Composing CTG

In spite of its name, the program *organiComposer* (oC) was not designed with the purpose to substitute for the intellectual and creative work of a human composer.[13] Rather, it must simply be used as a tool for aiding him/her to structure a piece constructed according to Gr-System's parameters. The elements and functions of the program are present in its user interface (Figure 12).

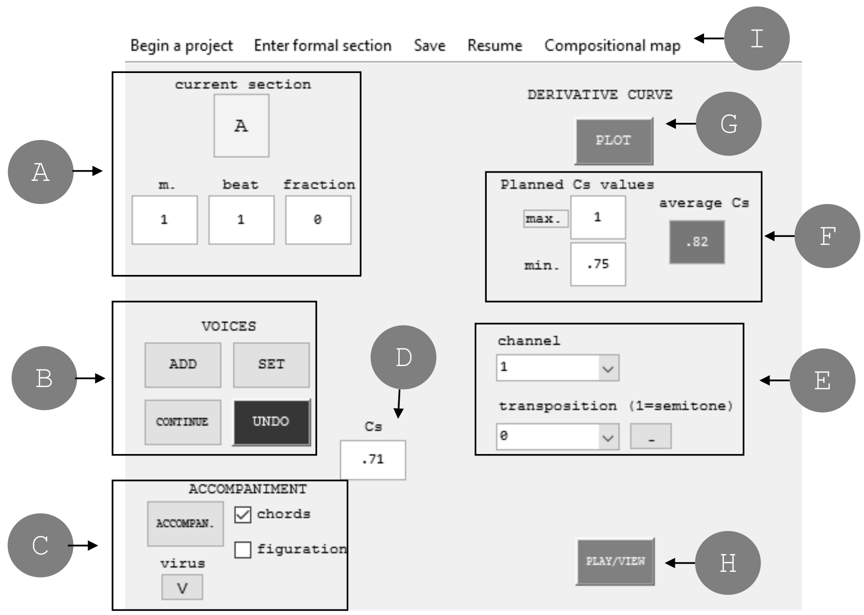

Figure 12: *oC's user interface: Information about localization: (A) section label ("A" in the present case) and positional data (measure number, beat and beat fraction) for entering a MI; (B) Buttons for opening a midi file corresponding to a MI and for inserting it in the coordinates established in A; (C) Buttons for selecting and inserting accompaniment (gTs / viruses); (D) Field corresponding to the Cs index of an inserted MI; (E) Information about the working voice (i.e., the voice selected for performing a selected MI): midi-channel and interval of transposition; (F) Fields that show the minimum and maximum values predetermined by the planning derivative curve and the Cs_{av} of the section; (G) Button for plotting the analytical derivative curve (see Figure 14a); (H) Button for hearing and viewing (in a piano-roll diagram) what was composed until that moment; (I)I. Menu tag for the compositional map (Figure 14b).*

In essence, the work with oC does not differ much from a conventional compositional process. At any instant the composer is faced with various decisions to make, concerning aspects like coherence, balance, changes of mood, tempo, texture, and so long. The program merely aids the user – literally – to *compose* (according to the Latin etymology of the verb: *com+ponere*, or put together) selected melodic/harmonic elements in selected metrical points transposed to selected pitch regions in the formation of selected textures.

[13] This program introduces a new and specific sense for the concept of "musical idea" (from now on referenced as MI). In this context, MI is a generic label used for naming one of the four possible melodic-harmonic materials employed in oC. Two of them are the forms components of the ES (axGr and thGrs), which constitute the most important elements for the composition. The remaining forms are used as subsidiary material constituting the accompaniment in homophonic textures, which can be formatted as consistent rhythmic figuration or chords: the melodic gTs (or MgTs produced in gM-01) as well the *viruses*. A virus is an external element (i.e., not produced in the system) that the composer (with whatever constructive reason) inserts in the piece (for example, a segment of the chromatic scale).

The insertions of elements are preserved in a temporary midi file, which allows the composer, at any moment, to verify the provisional results, edit the definitive score (including tempo indications and dynamic, articulation and expression marks) and, of course, to make eventual adjusts and corrections or even add ornamentation. In simpler terms, it provides a kind of *in natura* sketch to be elaborated and refined. An illustration of this adaptive process is shown in Figure 13, with a short passage of CGT in both versions.

Figure 13: *Germinata I/CTG (mm.46-50): sketch-like version (a); final version (b).*

Besides this evident practical aspect, the main and exclusive advantage of using oC for composing in the system is the possibility of registering two graphic schemes: the analytical derivative curve and the compositional map. These mutually complementary graphs provide a precise structural overview of a composed piece in the Gr-System.

The analytical derivative curve of CGT is shown in Figure 14a. As it can be observed, in each one of three sections, the Cs_{av} (represented by the red lines) was plotted within the pre-established C'âĂŹs limits (the dotted horizontal lines) of the respective planning derivative curve (Figure 3d), which therefore matches the similarity profile intended for the movement. The rectangles in the compositional map (Figure 14b) represent the various MIs used in each instrument/channel (1 for the oboe, 2 for the clarinet and 3 for the bassoon). The shades of gray are associated to the class of MI employed, from the darkest to white: axGr, thGr, MgT, and virus (observe that the genealogical label and Cs are added in the two first cases).[14] The combined visualization of both graphs provides an interesting perspective of the correlations between form, texture and similarity behavior.

[14]As it can be noted, in this movement there are only two brief uses of non-essential material (MgT and virus), both as punctuation at the end of section T. Their Cs indexes are not considered in the calculus of the Cs_{av}.

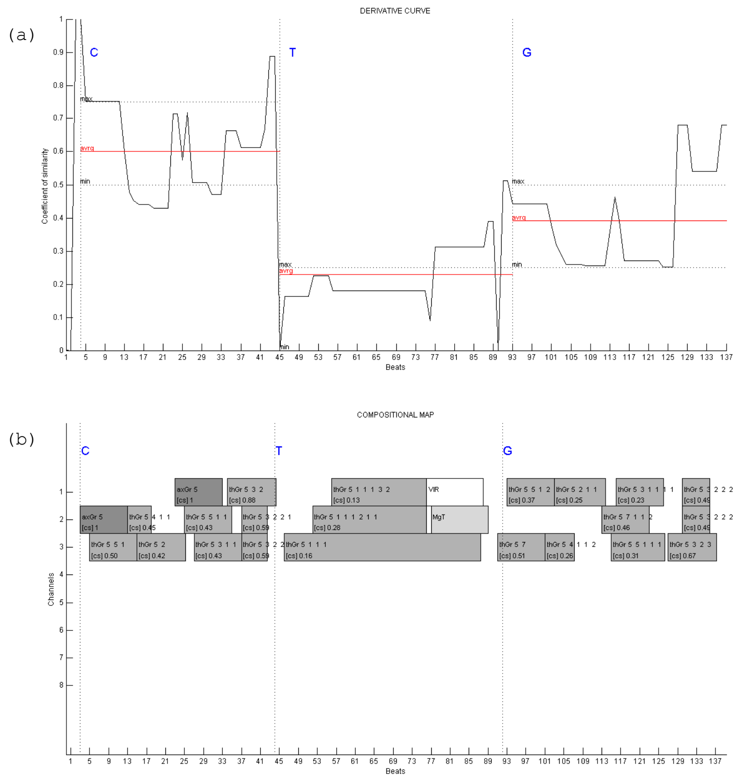

Figure 14: *Germinata I/CTG: analytical derivative curve (a) and compositional map (b).*

VII. Conclusions

This paper introduced the concept of evolutionary variation, associated to organic musical composition and to genetic processes, resulting from a new branch of a broad research project intended to systematically study variation in music. This branch is dedicated to the elaboration of a system (Gr-S) for organic and maximally economic composition aided by computational tools (gM and oC). The application of this concept in the composition of the fourth movement of *Germinata* I (CTG) yielded a large number of musical ideas within a wide spectrum of similarity in relation to the basic material, forming what the CTG's evolutionary space (ES_{CTG}). From this repository there were selected the musical ideas used to compose the piece, according to predetermined similarity profiles, an original sort of structuring strategy.

In spite of the fact that some parts of the programs that integrate the system still require adjustments and improvements, the results obtained in this study reveal its efficiency and flexibility.[15]

[15] Gr-S' flexibility can be clearly evidenced if we consider the following points: (a) a given axiom inserted in gM-01 can potentially yield an astronomic number of gTs; (b) The pTs produced through combination of gTs can be concatenated in a virtually infinite number of manners (considering the available options of permutation, transposition, metrical displacements and suppression of notes); (c) each one of the (infinite) possible axGrs thus formed can, in turn, produce infinitely wide evolutionary spaces. It is very instigating to speculate that even if we stipulated a closed structural planning and basic material (for example, the derivative curve of Figure 3d and ES_{CTG}) for, say, 100 different composers, we would certainly obtain 100 radically different pieces (although – and almost paradoxically – they would be closely related by their common origins), since these would depend largely on the individual skills and the myriad of decisions taken during their compositional processes.

Due to the several artificial selection strategies implemented in the gMs modules, the composer can control the entire derivative process, by selecting the variants according to his/her particular constructive intentions. Moreover, the compositional process, performed with the algorithmic aid of oC, is non-determinist and plainly dependent on the composer's imagination, sense of form and creativity.

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