George Perle's Twelve-Tone Tonality: Some Developments for CAC using PWGL

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ABSTRACT

This paper presents a description and some developments on Perle's theory and compositional system known as *Twelve-Tone Tonality*, a system that, because of its characteristics and fundamentals, is currently associated with Schoenberg dodecaphonic system. Some research has been made in the last few decades in order to develop his model in a Computer Assisted Composition (CAC) environment. After some efforts in order to analyse these prototypes, we realize that in general they were discontinued or outdated.

A three-scope proposal is so outlined: Firstly, to simplify the grasp of a system that presents an easily understandable starting premise but afterwards enters a world of unending lists and arrays of letters and numbers; Secondly, to present the implementation process already started using PWGL [1] (see Laurson, 1996; Laurson, 2003; Laurson, 2009). Finally, the model is applied in a short original compositional work, and it is presented and analysed emphasizing the standpoints properties of the system. Some further considerations were made regarding the continuity of this project where the construction of a dedicated PWGL library of Perle's model reveals a pre-compositional necessary tool. PWGL software was selected due to its specific fitting features: it is based on Common Lisp — perfectly powerful and suitable to process lists of integers — and it is specialized in CAC.

Keywords: *George Perle; Twelve-Tone Tonality (TTT); Twelve-Tone Music; Structural Symmetry; PWGL; Computer Aided Composition (CAC); Interval Cycles; Composition Techniques and Systems; Music Theory*

1 | INTRODUCTION

George Perle's Twelve-Tone Tonality (TTT) seems to be an almost forgotten issue in compositional and analytical common practice. It is difficult today to understand the reasons why his TTT system is not taught worldwide and consistently in music schools and conservatories. As Rosenhaus referred, "only a few musicians know the system and are in a position to teach others its use" (Rosenhaus, 1995, p. 1). For many, this situation happens 'simply because he has chosen to join the terms "twelve-tone" and 'tonality' (Carrabré 1993, p. 1). Still, his system has a supportive group of endeavours. The final results in his own compositional work confirm 'that the consistency of musical structure provided by twelve-tone tonality has allowed Perle to create music of great sophistication and emotional depth' (Carrabré, 1993, pp. 232-3). However, some musicians confessed that the system is not easy to put into practice [2]. Even George Perle, about his book, referred that 'some of my friendliest reviewers

admitted that they found Twelve-Tone Tonality "very tough reading." It is not, however, a book for "reading" in any ordinary sense, any more than a traditional harmony textbook would be' (Perle, 1996, p. xiii).

It is the aim of this research in a broad sense to start developing a computer library model for PWGL dedicated to Perle's Twelve-Tone Tonality (TTT) with direct application in Computer Aided Composition (CAC). Abridging some arithmetic manipulations this library should be helpful to make his system manageable and ready to be used as a practical pre-compositional tool.

2 | SYMMETRY IN MUSIC

The approach to George Perle's TTT inevitably requires an analysis/discussion of the concept of symmetry and its applications. His theory is grounded in symmetrical interval cycles in which a special type of tone row is employed.

From the Greek συμμετρειν, (meaning "measured together") symmetry is a universal concept used in a wide scope of diverse situations, from material objects (like flowers or stones) to abstract structures (like mathematics and music) [3]. Art, in its many expressions, has had a strong mimetic preference imitating the Nature where symmetry appears in several forms: Bilateral Symmetry (which is observed in relation to one plane or one line) and Radial Symmetry (which is observed over several planes which pass through a central axis or multiple lines that intersect at the same point) (Marques, 1998).

Symmetry could be found in the formal structure of a piece of music. It is a common practice for musicians (and useful) to use Letters to define the structural organization in sections of a musical work. Sometimes symmetric forms can be found (e.g. ABA, ABCBA). This kind of palindromic symmetry is extensive from Bach to Jazz.

Symmetry is something that should also be considered regarding scales and chord formation. Although functional tonality is build over non-symmetric combinations of notes — like the diatonic scale and the major triad – examples as the chromatic scale, the augmented chord, the diminished chord, or the diminished seven chord, those can all be found in functional tonal works.

The Portuguese composer Fernando Corrêa de Oliveira developed a musical system named 'Symmetric Harmony' and later a 'Symmetric Counterpoint'. In 'Symmetric Harmony' chords are formed starting from a central axis and adjusting pitches in opposite direction with the same interval relation with that axis. Applying the same technical principle to melody one gets 'Symmetric Counterpoint' (Oliveira, 1990).

The diatonic system is non-symmetric by nature. The diatonic scale is characterized by its specific semitones. The position of these semitones in a scale is crucial to determine the Mode. With the exception of the Dorian mode, we won't find symmetrically relevant scalar structures in the Tonal/Modal universe. The inversionally equivalence of the tonal Major scale and the Phrygian scale mode incurs in a semantic error regarding the relations of their grades in function: the Tonic/Final (finalis), and the Dominant/Tenor (repercussa) does not fit in the symmetric inversion (Perle, 1996, p. 5).

However, the concept of symmetry in music should not be limited to scales and letters. Emmanuel Amiot wrote an article about the notion of symmetry in music analysis where he presents a sort of examples of 'symétries de l'ensemble de notes considéré' (representing only a small partition within the 'théorie des groupes'), starting with Wagner's motive of desire, continuing with Mozart's Adagio from the D minor piano concerto, Bach's subject of Wohltemperiertes Klavier I — G minor fugue, Chopin's Ballade op.23, and Debussy's Puerta del Vino (Amiot, 1991).

The gradual dissolution of Functional Tonality at the end of the nineteenth century brought a new reality of symmetrical properties flourish. Extended Chromaticism gave rise to a semitone space of absolute symmetry with no relations in between the elements. It would be easily conceivable that symmetry became a necessity. Joseph Hauer's Tropes and Arnold Schoenberg's dodecaphonic system uses a structural pitch space based on the (absolutely symmetrical) twelve-tone scale. Symmetrical processes on inversion, retrogrades and retrograde-inversions (observable in the matrix), are systematically used in compositional processes. Those symmetrical functions were extended by Anton Webern´s invariance under transformation [4], and by Alban Berg's cyclic interval interpolation — as we will see in the next section. Additionally, Olivier Messiaen deserves a special place in this symmetric musical world: on the one hand, the division of the octave in symmetrical segments generating his modes of limited transposition; on the other hand, his interest in rhythms from Hindu and ancient Greek sources brought to his music an extensible use of non-retrogradable rhythms (palindromes).

3 | GEORGE PERLE TTT-TWELVE-TONE TONALITY

George Perle was an American composer, professor emeritus at the Aaron Copland School of Music and a recipient of the Pulitzer Prize for Music, thanks to his Twelve-tone system of composition based on cyclic intervals and symmetrical inversions. This structural method for composition started with the analytical work he has done with Alban Berg's compositions. This system was later crystallized in what he called 'Twelve-Tone Tonality' (Perle, 1996). Perle considers that the principle of "symmetry" present in his model is the key element that establishes a direct relationship with the Tonal System:

'I can sum up my present understanding of the meaning of symmetry for twelve-tone music in a few words. I believe that it can serve as the foundational premise of a coherent and natural twelve-tone harmonic language, just as the triad does for the harmonic language of diatonic tonality; and just as the universality of the triad presents diatonic tonal music with a normative principle that defines the meaning of dissonance — a controlled departure from the triad, which remains the referential norm even when it is momentarily absent — so can analogous departures from symmetrical relations provide a basis for prolongational procedures in twelve-tone tonal music' (Perle, 1996).

Schoenberg's system is widely used in Universities and Music academies, both in the teaching process and in the compositional process. Although the TTT was developed almost at the same time, it is a fact that only a few are familiar with it — or even use it. This problem could be caused by the prime characteristic of this system: set lists capable of an almost endless possibility of combinations.

Authors like Carrabré (1993), Foley (1999), and Rosenhaus (1995), proposed new approaches and extensions to Perle's theory in order to make it more accessible and comprehensible. In fact the subject is far from being exhausted. A short list of researchers developed software related with Perle's theory some years ago: James Carr (1995) developed an application that he called '12-tt 2.0'. This application was capable of generating an 'encyclopedia' with lists of vectors and matrices; Gretchen Foley developed an application named 'T3RevEng' directed to Aided Analysis; Dave Headlam created a set of applications to matrix identification (Lansky, 2001); and Christopher Winders design an application that can slide a cyclic set over another in order to produce every possible vertical alignments (Foley, 2006). Those

applications either, they do not exist or they were simply discontinued.

George Perle's theory had its origin due to a misinterpretation on Schoenberg's system: In the late thirties, he accessed to a reduction of the score of Alban Berg's Wozzek where he distilled everything he could. He realized that starting with a set one could prepare a matrix. Then he assumed that any note in this matrix could be selected (note axis) and four neighbour notes (two horizontal and two vertical) established as members of the harmony. Soon he realized that the result was ambiguous, too inconstant and without any basis for systematization, because the amount of existing intervals in a set is multiplied by the number of harmonic possibilities in its realization. But Perle realized that certain series disclose a consistent pattern: Those series based on constant cycles of symmetrical intervals.

'My first attempt at what I took to be twelve-tone composition was based on the following P and I row forms:

```
b   c   d   f   a   ab  g   f#  d#  e   bb  c#  (b

b   bb  cb  f   c#  d   d#  e   g   f#  c   a   (b
```

From these I derived a collection of adjacency relations by pairing three-note segments that shared the same pivotal pitch class, as in the following array, in which the horizontally stated segments are taken from P and the intersecting vertically stated segments from I:

```
  f#        f         c#        d         d#        ab
b c d    bb c# b    c d f    f# d# e   d# e bb   d f a
  a         d         d#        e         g         c#


  g         e         bb        c         b         a
g f# d#  ab g f#    a ab g    f a ab    e bb c#   c# b c
  c         f#        f         b         ab        bb
```

In effect, the distinction between retrograde-related row forms was eliminated and any note was free to move to either of its neighbours in either of two inversionally complementary forms' (Perle, 1996, p. xi).

4 | PWGL IMPLEMENTATION

The PWGL application (Patch Work Open GL) is an object-oriented platform that uses Common
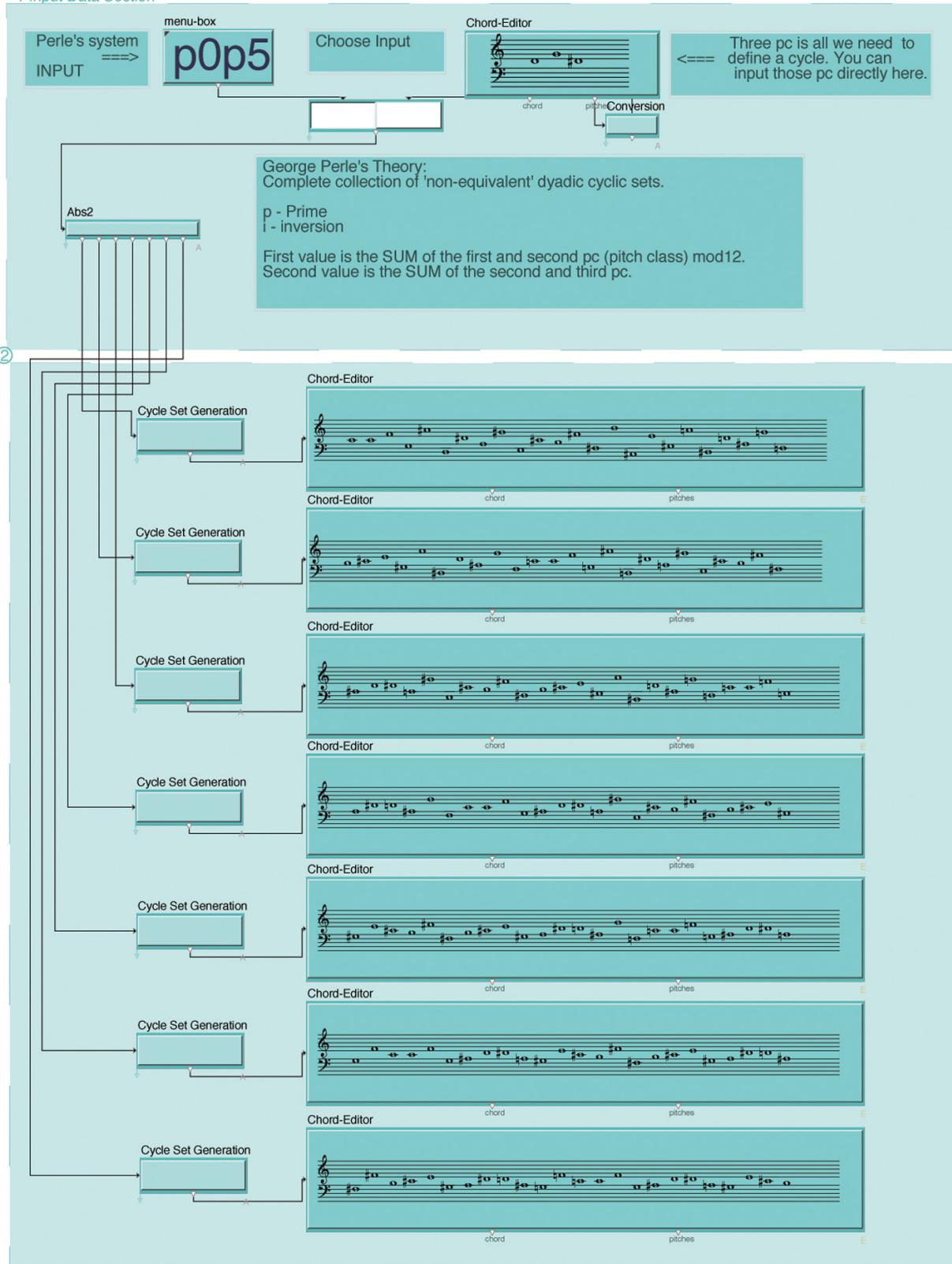
FIGURE 1 | Front Panel of the Patch.

Lisp operating as kernel on its background. Mikael Laurson's research group in the Sibelius academy, Helsinki, is constantly developing PWGL. The specific features of this software include a powerful and suitable list processing, adequate to manage series of cycles, symmetries, and sets.

4.1 THE INPUT SECTION

The front window of the PWGL patch presents a pannel where the fundamentals of Perle's theory are visible. It helps the understanding the basics for generating the cycles. The starting point is to select Perle's terminology in the popup 'menu-box' or a three-note set that defines the cyclic intervallic constant relation in the 'Chord Editor'. The 'menu-box' contents the complete collection of non-equivalent dyadic cyclic sets as determine by Perle (Perle, 1996, p. 253) [5].
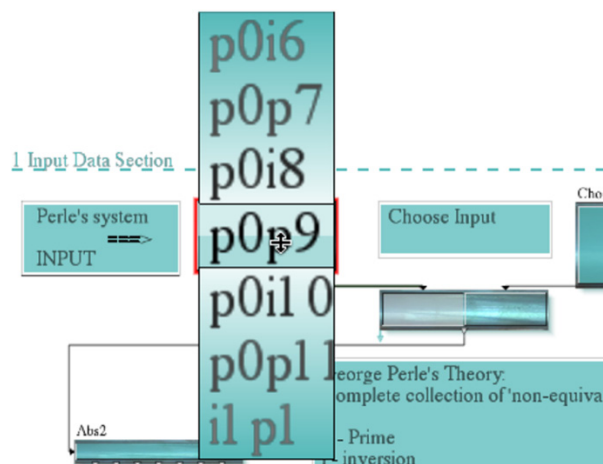

FIGURE 2 | Menu-box selection.

Evaluating all the boxes on the right of the 'Cycle Set Generation' will produce all the relative Inversionally Complementary Cycles.

As we can verify in Figure 1, the sum of the first two-notes of the series returns Sum 0 (based on the common-practice use of pitch-class values in Mod12 where C=0, C#=1, ... B=11). The sum of all the second and third notes returns Sum 5. As explained by Perle 'the pitch class relations between any pair of such ordered set is reducible to the pitch-class relations between two representations of the semitonal scale' (Perle, 1996, p. 7). Those sums are fixed in the synoptic p0p5.

Starting with a C-C dyad on the first serie, the cycles resultant continue chromatically with a B-C# dyad, and end with a F#-F#. Reaching the middle of the octave, the next resulting set would not be of non-equivalence since the equivalence exists between G-F and F-G starting series.

4.2 VERTICALIZATION

The next step is the verticalization of the cycle constructed with each note of the serie as the axis-note and its neighbours as the constant interval cycle. This constant intervallic structure is the core of his theory. As Perle explains:

'Every tone appears always in the neighbourhood of two other tones in an unchanging combination which produces an intimate relationship most similar to the relationship of a third and a fifth to its root. [...] only a very special type of set will generate consistent and coherent adjacency relations and thus function as a "logical and controllable" referential structure for twelve-tone harmony. The principle of verticalization provides no basis for a total and systematic control of the harmonic dimension when it is applied to the general Schoenbergian set, but it will do exactly this when applied to any type of cyclic set' (Perle, 1996, p. 27).
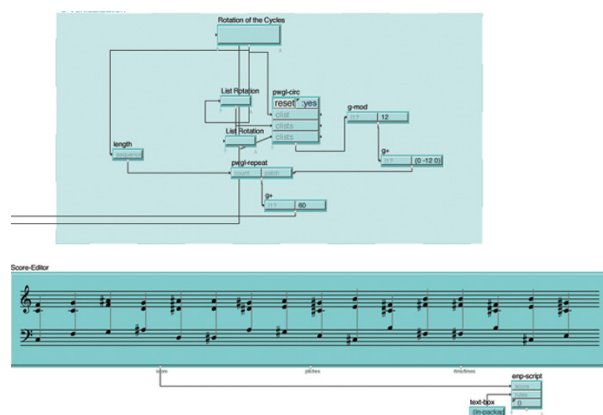

FIGURE 3 | Axis Verticalization.

4.3 INVERSIONALLY RELATED SET FORMS

The next step is the alignment of two cognate sets. Cognate sets are 'inversionally related set forms that share a single series of dyads. Each of these may also be interpreted in terms of another alignment of the interval-7 cycles' (Perle, 1996, p. 22). Perle referred to interval-7 only because it was the example used. Any interval cycle could be divided in the middle were it always starts inverting the cycle. For example, our interval-5 cycle is an inversion of interval-7 as could be observed in the Figure 4. Any inversion of an interval cycle results in a cognate relation set. Perle exemplifies:
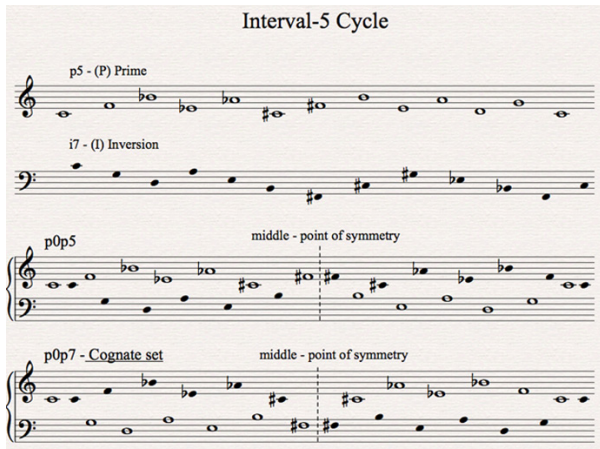
FIGURE 4 | Cognate Set.

FIGURE 5 | Axis-Dyad Chord Alignment.

'In the following series of set forms each member of the complex is preceded and followed by a cognate set form:

p0p7 i7i2 p2p9 i9i4 p4p11 i11i6 p6p1 i1i8
p8p3 i3i10 p10p5 i5i0 (p0p7)' (Perle 1996, 24).

In sum, any set form could be paired with any inversionally related set form in order to produce the twelve transpositions of a symmetrical tetrachord as could be observed in Figure 5.

4.4 AXIS-DYAD ALIGNMENT

Figure 5 presents two inversionally related sets, p0p5 and i9i2, and the resulting axis alignment with the dyads forming tetrachords over a bass (axis). This would be the next step on this research-in-progress in way to allow the realization of any possibilities available regarding the interest of the music creator. It would simplify the time-consuming pre-compositional stage circumventing the tribulation of concatenation under lists of numbers (or notes), liberating the composer to decide and choose which material serves his/her interest better. And that is the real significance of Computer Aided Composition meaning.

5 | APPLICATION IN PRACTICE

Figure 6 presents the opening of a song where some properties of Perle's system are applied. This example remains focusing exclusively the harmonic context and will not concern with note-duplication and/or the ordering of the set represented in each axis-dyad chord of the system. The construction derives from the p0p5/i1i8 array during the eight first bars before a changing of array in bar nine [6]:
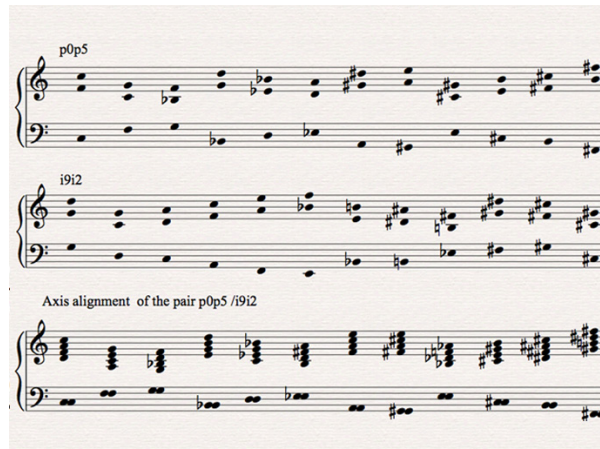
p0p5: 0 *0 5 7* t *2 3 9 8 4 1* e *6 6* e *1 4 8 9 3 2 t 7 5* 0 0
i1i8: 0 *1 7 6* 2 e *9 4 4 9* e *2 6 7* 1 0 8 5 3 t t *3 5 8 0 1*

The first bar, letter a, combines the three-note segments, *t 7 5 / 1 7 6*. The same axis-dyad chord gives us bars four and five. The second and third bars, letter b, represents a different alignment of the same array combining the three-note segments, *8 9 3 / e 9 4*. The same happens in bars seven and eight. In bar nine a new alignment occurs with segments e *6 6 / 2 6 7*. As can be disclosed, the sliding alignment is a priority need in the pre-compositional TTT system. That kind of procedure is a constant need in order to explore the array's qualities. The PWGL library must include such a feature while revealing more easily the 3+3 segments in visual music notation.

Bar nine presents a different interval set combination, in this case the interval-6 and interval-1, but this matter is not in the scope of this research (see Perle 1996, 67-70). The modulatory properties of the tonal TTT system will be discussed on the next occasion.

6 | CONCLUSIONS

Perle's theory still presents a sparkling freshness nowadays due to his harmonic solutions concerning Twelve-tone music. The implementation of his system in PWGL reveals fruitful assisting the pre-composition stage. The time-consuming difference between handwriting approach and PWGL process will surely increase with subsequent improvements on this research subject. A few musical works were being aided with these patches, and analytical conclusions should be present in future articles. Still, an expansion on Perle's theoretical system towards a new pre-compositional model, suggests a comparative analysis with other relevant 12-tone

FIGURE 6 | Practical Application.

structural organization theories. The articulation between Perle's model and the PWGL implementation is a clear objective, and the next step is to make it public. A PWGL specific library dedicated to this matter will be a subsequent stage of development and future research.

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ENDNOTES

[1] PWGL is the successor of PatchWork, a computer program conceived by Mikael Laurson during the late 1980s. PWGL is a Lisp-based visual computer-assisted composition program and is currently being developed at Sibelius Academy. For a better knowledge about PWGL please visit: http://www2.siba.fi/PWGL

[2] These reflections simply represents a particular situation lived within a small universe in a music college. It is not the intention of this research to study and measure the weight of Perle's theory within the music practioners worldwide or localy.

[3] The precise notion of symmetry has several operational definitions and measurable. The symmetrical objects can be material (people, molecules, bricks) or abstract structures (mathematical equations, series). Symmetry may be observed in geometric transformations like rotation, reflection and scaling; in space relations; in time measuring, in functional movements, in complex equations, in language, in abstract knowledge and in music. One can find applications of the concept in all those scientific fields, starting with geometry and biology, and finishing in the arts in general (Andreatta, 2003).

[4] Invariant formations are also the side effect of derived rows where a segment of a set remains similar or the same under transformation. These may

be used as "pivots" between set forms, sometimes used by Anton Webern and Arnold Schoenberg (Perle, 1991, pp. 91-93).

[5] The complete collection of dyadic cyclic sets could be accessed in Perle's Appendix where he explains the meaning of equivalent sets. 'Sets that share the same pair of tonic sums are equivalent to each other. [...] Thus, the interval-1 set p0p1 is equivalent to i1i0, the set of the same tonic sums and the complementary interval, 11; the interval-2 set p0p2 is equivalent to the interval-10 set p2p0; the interval-3 set p0p3 is equivalent to the interval-9 set i3i0; etc (Perle, 1996, p. 253).

[6] Analytical tools are based on Perle and referential authors. Letters t and e designate respectably integer 10 and 11 (Foley, 1999; Foley, 2006).

BIOGRAPHIC INFORMATION

Telmo Marques is a Portuguese arranger, composer and pianist from Porto. He teaches piano, music analysis and composition at ESMAE — Superior Music School. He attended the Porto Conservatory of Music where he studied piano and composition with Hélia Soveral, Fernanda Wandschneider, Cândido Lima and Fernando Lapa. He did further studies with Jean Martin, Carlos Cebro, Fernando Puchol, and Paul Trein. He graduated in piano from ESMAE (Prize Eugénio de Almeida — best classification), completed a Master of Arts in the UK. He is currently a Computer Music PhD candidate at the School of Arts of the Portuguese Catholic University (UCP) being supervised by Paulo Ferreira-Lopes. As a composer he receives commissions for Orchestras, Soloists, and Chamber Music. *Porto 2001 European Cultural Capital and Guimarães 2011 European Cultural Capital* are two examples. He has also contributed to a wide range of music-theatre pieces, documentaries, and hundreds of commercials. He has taken part in many recordings of Portuguese artists as pianist, arranger and/or producer.

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