Conceptual Blending in Biomusic Composition Space: The "Brainswarm" Paradigm

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ABSTRACT

Conceptual blending and biomusic composition spaces are approached in this work, in an effort to identify in them any creative potentialities as new compositional trajectories. The basic ideas and objectives of these two spaces are approached through a paradigm, consisting of a relevant, compositional work of the author, namely "Brainswarm", which employs real-time acquisition of the body/hands gestural information along with the brain activity of the so-called bio-conductor. The latter acts as a mediator between the real (instrumental ensemble) and the virtual (consisting of swarm ontologies) worlds. The nature of the work allows for exploration and discussion upon specific realization, organization and aesthetic issues, surfacing the main conceptual blending axons involved. The proposed compositional trajectory calls for further understanding of the functional mechanisms of the human body and brain, so to be creatively used in a shared, yet blended, aesthetic expression.

1. INTRODUCTION

Music composition evokes a series of processes that, in a blended fashion, co-exist (in parallel and/or in an antagonistic way), structuring a creative form that, sometimes, could be approximately modeled or other times reveals just a glimpse of its essence, even in the composer him/herself. This always surfaces the question "how does this work?" and connects the actual work with the process of analysis and the construction of a related music theory. The latter has various view stands, like those from, e.g., Allen Forte, who described music theory as the "explanation of and speculation about musical structures" [1], or from Arnold Whittall, who writes that theory's purpose is "to identify the various materials of a composition and to define the way they function" [2], or from Rosemary Killiam, who states the "music is patterned sound, and theory the method which seeks to determine the pattern" [3], or even from Patrick McCreless, who connotes that "music theory has produced a way of knowing" [4].

Each of the aforementioned definitions, however, imply that theory happens *after* the fact. Theory is born of the intention to explain something which *already exists*. Consequently, the focused should be placed upon distinguishing between theory, i.e., the explanation of how a piece works, and method, that is, how the composer actually works. Nevertheless, analysis of the blending between theory and composition act is essential, since it could reveal the way theory comes into play before the fact.

From a pragmatic point of view, a vast plurality of theories exists. Moreover, in most cases, during the dynamic phenomenon of the compositional act of contemporary music, rarely a 'theory' is perceived as something that it could be directly applied in a conscious way to the compositional work. This leads to the description of theory as a *shadowy presence*, as a background to creativity; something that is there behind the composer when s/he is working.

There are theories that have to do with systems, e.g., set theory, canons, processes, anything to do with a systematic ordering of material. The understanding of these systems is resident in the background, perhaps as an intuitive sense of pattern. Another example is the theory of evolution, i.e., the understanding of evolution not as progress towards a goal, but as an adaptation to a changing environment, provoking an overall sense of transformation during the evolution of the work. The latter implies possible differences in time perception, leading to disconnection of the linear order of time, allowing a sense of ambiguous unfolding (e.g., as in Toru Takemitsu's work). Moreover, the theories or practices of John Cage, especially the profound concept of non-intention, the idea that the work is not about expressing oneself, combined with Morton Feldmans' thinking of "letting the sounds be themselves", allow for an overall sense of detachment from material.

The abovementioned ideas (theories) hover somewhere in the background, forming an atmosphere surrounding of the composers' thoughts. In an effort to shed light upon this fuzzy nature of the compositional process in the dark reaches, the notion of *conceptual blending* embedded within the *biomusic composition* approach are adopted here. The way these two pathways can be interwoven in the creative process is exemplified through the analysis of a recent music work by the author, namely "Brainswarm".

The rest of the paper is organized as follows. Sections 2 and 3 provide the background information about conceptual blending and biomusic composition, respectively, whereas Section 4 deeps into the world of "Brainswarm", presenting the underlying concepts, their blending axons, and their reflections to the structural and aesthetic characteristics of the work; Section 5 discusses specific aspects of the work, from a reflective point of view; Section 6, finally, concludes the paper.

2. CONCEPTUAL BLENDING

Generating new ideas is often a result of unfamiliar combinations of familiar ideas. Although generating novel ideas, or concepts, by combining old ones is not complicated in principle, the difficulty lies in doing this in a computationally tractable way, and in being able to recognize the value of newly invented concepts for better understanding a certain domain; even without it being specifically sought, i.e., by 'serendipity' [5].

An important recent development that has significantly influenced the current understanding of the general cognitive principles operating during creative thinking is Fauconnier and Turner's theory of conceptual blending [6]. Fauconnier and Turner proposed conceptual blending as the fundamental cognitive operation underlying much of everyday thought and language, and modeled it as a process by which humans subconsciously combine particular elements and their relations of originally separate conceptual spaces into a unified space, in which new elements and relations emerge, and new inferences can be drawn.

Although the cognitive, psychological and neural basis of conceptual blending has been extensively studied [7] and Fauconnier and Turner's theory has been successfully applied for describing existing blends of ideas and concepts in a varied number of fields, such as linguistics, mathematics, political science, discourse analysis, philosophy, anthropology [8], their theory has hardly been used for implementing creative computational systems. Consequently, the theory is silent on issues that are relevant if conceptual blending is to be used as a mechanism for designing creative systems: it does not specify how input conceptual spaces are retrieved; nor which elements and relations of the input spaces are to be projected into the blended space; nor how these elements and relations are to be further combined; nor how new elements and relations emerge; nor how this new structure is further used in creative thinking (i.e., how the blend is "run"). Actually, conceptual blending theory does not specify how novel blends are constructed.

Nevertheless, a number of researchers in the field of computational creativity have recognized the potential value of Fauconnier and Turner's theory for guiding the implementation of creative systems, and some computational accounts of conceptual blending have already been proposed [9]. They attempt to concretize some of Fauconnier and Turner's insights, and the resulting systems have shown interesting and promising results in creative domains, such as interface design, narrative style, poetry generation, or visual patterns. All of these accounts, however, are customized realizations of conceptual blending, which are strongly dependent on hand-crafted representations of domain-specific knowledge, and are limited to very specific forms of blending. The major obstacle for a general account of computational conceptual blending is currently the lack of a mathematically precise theory that is suitable for the rigorous development of creative systems based on conceptual blending.

The only attempt so far to provide a general and mathematically precise account of conceptual blending has been put forward by Goguen, initially as part of algebraic semiotics and later in the context of a wider theory of concepts that he named Unified Concept Theory [10]; Nevertheless, Goguen's account is still very abstract and lacks concrete algorithmic descriptions.

Despite the lack of concrete algorithmic descriptions[1], the aforementioned idea of conceptual blending can be intuitively transferred to the field of music composition as a means of creativity, since it can provide a basis for the development of combinatorial relations of different cognitive spaces into a new, unified, one, in which new evidence and correlations emerge, creating new syntactic and semantic representations, when deployed in those genuinely creative tasks (such as music composition), underlying the sort of abstract reasoning common to many branches of the sciences and the arts. This approach can be seen as a creative challenge that puts concerns and stimulates metacognitive mechanisms in understanding the role of the composer him/herself, both at the individual and social level, in the 21st century.

3. BIOMUSIC COMPOSITION SPACE

Western art music traditions have historically put absented the human body from being seen and heard, i.e., limiting its visibility/audibility, within compositional methodologies and performance practices. Biomusic, in which music is composed for, and derived from, the physiological productions of the body, serves to reintegrate the human body within art music traditions [11]. As such, biomusic induces a renewed understanding of the body, when it is related to traditional modes of composition, performance, and musical analysis.

Biomusic has been used to describe a broad class of biologically created (or even sometimes biologically inspired or related) sounds. The core of the work done in Biomusic focuses on the use of human physiological and kinematic signals, measured directly on the body, to enable precision manipulation of sound in a functional setting. While sonification of biosignals has been a tool for scientists and musicians alike for over fifty years [12], it was necessary to invent new human-computer interfaces in order to enable the use of these signals as a real-time information sources. It is fundamentally the real-time feature analysis and pattern recognition of the physiological signals that enhances the composer's arsenal, providing him/her with the capability of using these complex, seemingly random signals as potential human-music interfaces that define a set of compositional spaces with varying properties and potentialities.

The main spaces explored in the biomusic field include: (i) physical gesture analysis and control using primarily signals from the muscles, or by distance capturing the

[1] A recent EU FP7-funded research work, namely "COINVENT Project" (`http://www.iiia.csic.es/coinvent/node/1`), has embarked towards such direction.

body movements (e.g., via Microsoft Kinect) and (ii) cognitive control using signals from the brain. Lately, an interest has been grown in recognition of emotional states from physiological states, such as the encephalogram (EEG) signals [13, 14].

Biomusic sees the sounds as the driving substance that informs the realization of the body in relation to itself and to other bodies—social, physical and imaginary ones—that make up complex and unpredictable networks of space and place.

New possibilities of becoming for the body are opened when realizing the body through its interface with sound and space, stretching its old limits and creating new ones. By converging sound, body and space towards a unified perspective, new dimensions of, and sensitivities towards, environments can be engaged, re-imagining and transforming all types of possible relationships to these and to ourselves and each other within these. As a consequence, both experiential stimuli and cognitive concepts could be creatively blended and seen as common denominators, shared by music and biological systems, establishing a symbiotic connection between them. Such an effort is described in the "Brainswarm" case, described in the succeeding section.

4. THE "BRAINSWARM" PARADIGM-BLENDING AXONS

The author's work "Brainswarm" (2013, Op. 88), for bio-conductor soloist and ensemble, Microsoft Kinect, EEG Emotiv, MAX/MSP-Processing live electronics and visuals, belongs to a series of works that derive their content from the site of biomusic, combining information in real-time from the conductor (both from his/her brain and from his/her movements-gestures) with the sound of natural instruments.

In this work, an attempt to simultaneously connect the real with the virtual space is initiated, where each real instrument is mapped to a virtual one, in which 'lives' a swarm. Similarly, the spatial distribution of brain activity by the conductor (as recorded by 14 EEG channels), is assigned to a swarm that guides the behavior of other swarms, placing to them obstructions and/or prays, turning them, occasionally, to detectors, predators and dominators in their environment. Consequently, their spatial variations are mapped to transformations in the sound field, in an attempt to couple the experiential behavior with sound structures.

The bio-conductor directs both real and virtual instruments, activating experiential (brain activity) and cognitive (gestures) procedures, which give him/her the role of the protagonist (soloist) in both spaces.

The work is developed on the axis of the behavior in a symbiosis, in both the real and virtual space, which tends from individuality to social integration, with all the potential consequences of this trajectory. In the following subsections, the blending axons of the work are described in details.

4.1 Real & Virtual Worlds

The setting of the work is organized around the blending of virtual and real worlds. In fact, the former includes swarm ontologies and it is conceived via projection on a screen above the musicians, whereas the latter refers to the physical instruments spanning the physical space, i.e., Flute, Clarinet in Bb (doubling Bass Clarinet in Bb), Piano (incorporating extra material of: 1 Mini jam jar, 1 A4 paper sheet, 1 CD), Violin and Violoncello. In this setting, there is an One2one correspondence between the instruments and the swarm ontologies, with the so-called, bio-conductor serving as the connecting physical link (see Fig. 1).

The technological mediator between the two worlds includes the Microsoft Kinect sensor (`http://www.microsoft.com/en-us/kinectforwindows/`), for capturing the bio-conductor's body movements and hand gestures, and the EEG Emotiv (`http://emotiv.com/`), for real-time capturing his/her EEG signals (see Fig. 2). With this biosensors, a blending of internal (EEG signals) and external (gestures) information sources of bio-conductor is achieved.

The aforementioned blending is practically realized via the concrete roles of the bio-conductor's information sources. In particular, the body/hand gestures are used for conducting at the physical space, but also for interacting with the virtual one. The current EEG channel with the

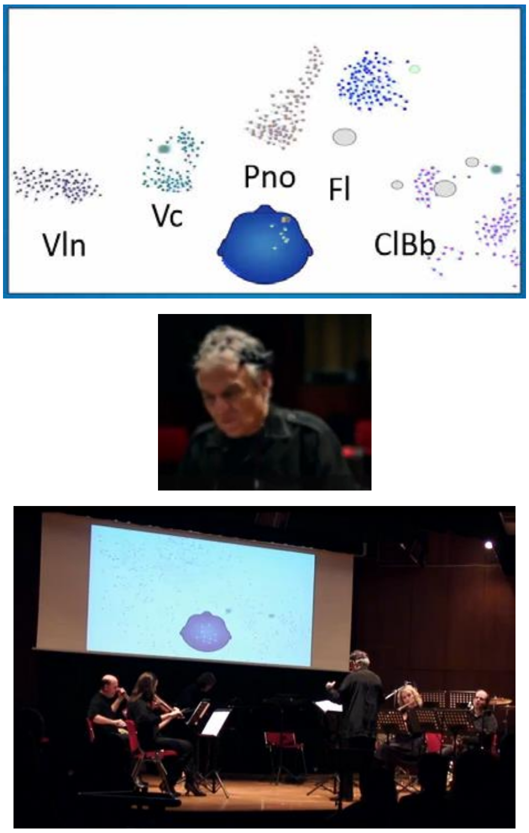


Figure 1. The one2one correspondence between the virtual world (swarm ontologies) and the physical world (instruments), with the bio-conductor acting as mediator in both worlds.

maximum activation (within a time window) produces food generation to the swarm inside the brain, which is then (randomly) reflected to the external swarm space, in a correspondence to the spatial distribution of the EEG recording sites (see Fig. 2-bottm right and Fig. 3). This, in fact, defines the trajectory of the swarms as they react as predators and always seek for food. The latter is interfered with a series of added obstacles (see Fig. 3). In this sense, conducting of the swarms by the bio-conductor's brain activity is achieved.

4.2 Individual & Social Behaviors/Roles

The individual behavior of a swarm is defined by the three main characterstics of its boids (see Fig. 4), i.e.: (i) *separation*: steer to avoid crowding local flockmates (Fig. 4(a)), (ii) *alignment*: steer towards the average heading of local flockmates (Fig. 4(b)), and (iii) *cohesion*: steer to move toward the average position of local flockmates (Fig. 4(b)).

Figure 2. The technological mediators used in “Brainswarm” to capture the bio-conductor's body/hand gestures (MS Kinect-top left) and EEG brain activity via the EEG Emotiv interface (top-right). The way the latter is used and the corresponding recording sites on the brain are shown in bottom-left and bottom-right, respectively.

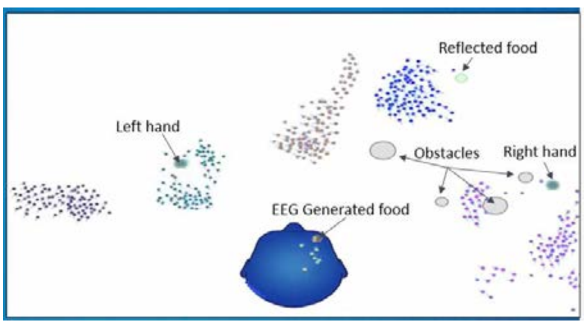


Figure 3. The projected alterations in the swarms' space according to the activation of the bio-conductors hands (left/right), the EEG generated food inside the bio-conductor's brain simulation due to his/her maximum brain activity and the reflected food “provoking” the closest swarm towards it, along with the added obstacles that interfere with the swarms' trajectories.

Each boid has direct access to the whole scene's geometric description, but flocking requires that it reacts only to flockmates within a certain small neighborhood around itself. The neighborhood is characterized by a distance (measured from the center of the boid) and an angle, measured from the boid's direction of flight. Flockmates outside this local neighborhood are ignored. The neighborhood could be considered a model of limited perception (as by fish in murky water), but it is probably more correct to think of it as defining the region in which flockmates influence a boids steering.

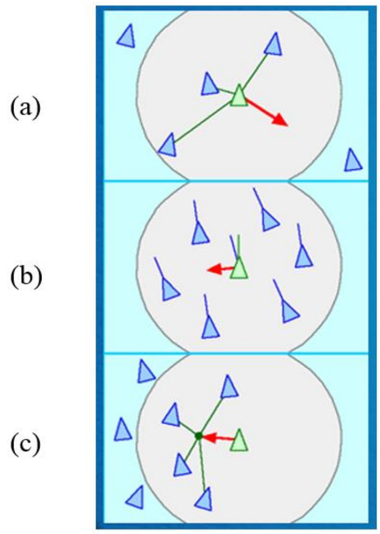


Figure 4. The three main cahracterstics of a swarm boid behavior with its flockmates: (a) separation, (b) alignment, and (c) cohesion.

A series of blended individual and social behaviors at the swarms' space is depicted in Fig. 5, including (from top to bottom) *randomness* (the boids' birth state), *formation* (ontology existence), *blended-existence* (merge/split), *cohesion-existence* (defend clustering), *attack* (hostility), and *domination* (the winner-takes-all).

The blended individual and social behaviors illustrated in Fig. 5 are also reflected at the music score level. In particular, there are (i) *introductory events* (to justify the one2one correspondence through the change of swarm speed), (ii) *interactive events* (reflection at the physical structural section and bio-conductor's behavior), and (iii) *trajectory events* (reflection at the physical behavioral level and bio-conductor's expressive gestures); some indicative examples from score excerpts are shown in Fig. 6.

4.3 Deterministic & Stochastic Structures

Blending procedures also take place at the score space in terms of the indeterminacy level of the events. To this end, a variety of event types co-exist, i.e.: (i) *periodic events* (towards deterministic sound events), (ii) *aperiodic events* (towards stochastic sound events), (iii) *Autonomous events* [flexible durations-autonomous repetitions

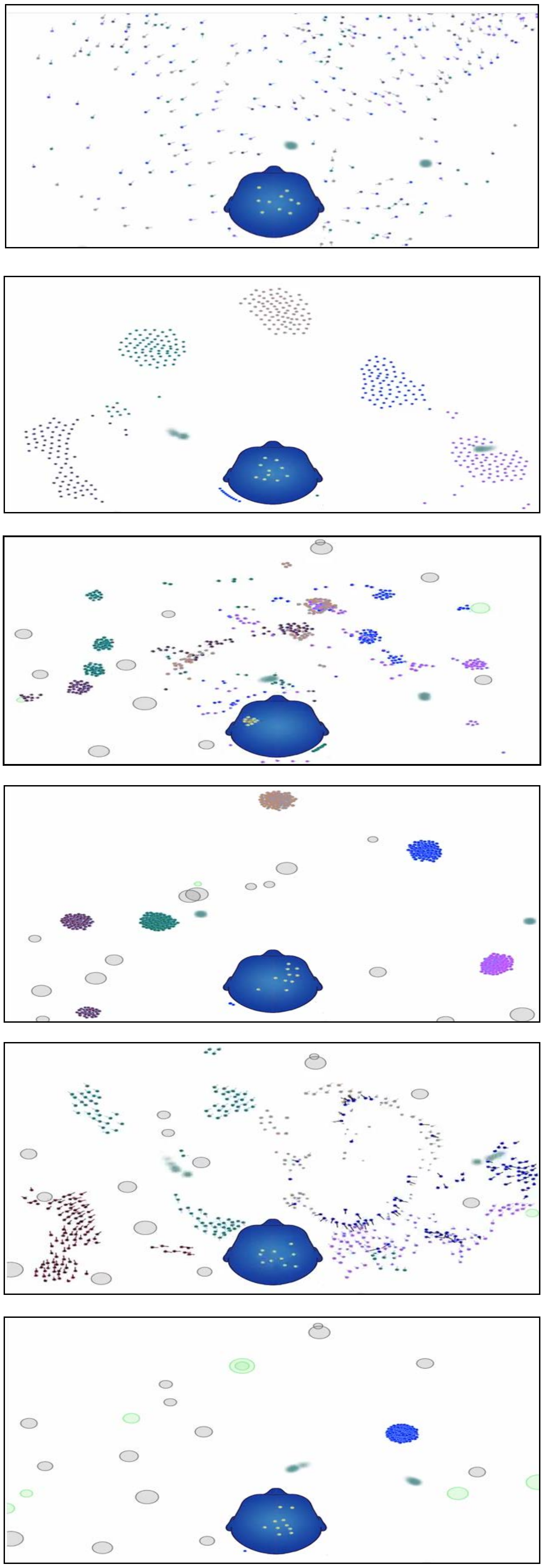
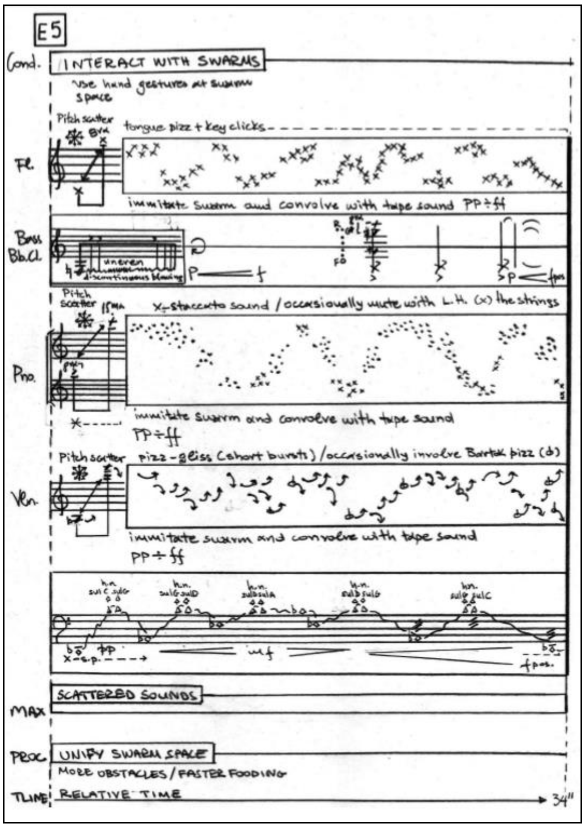
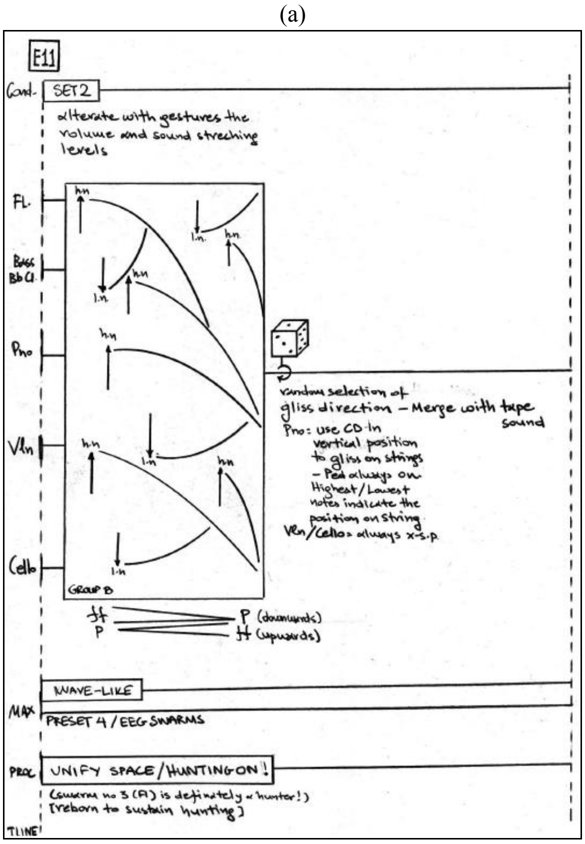


Figure 5. The series of blended individual and social behaviors at the swarms' space (from top to bottom): randomness, formation, blended-existence, cohesion-existence, attack, and domination.



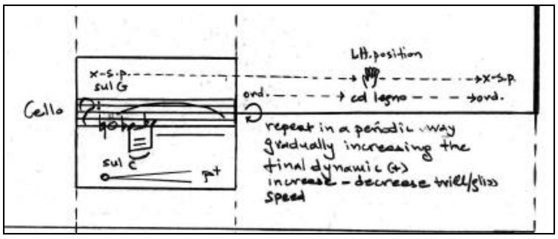
(a)



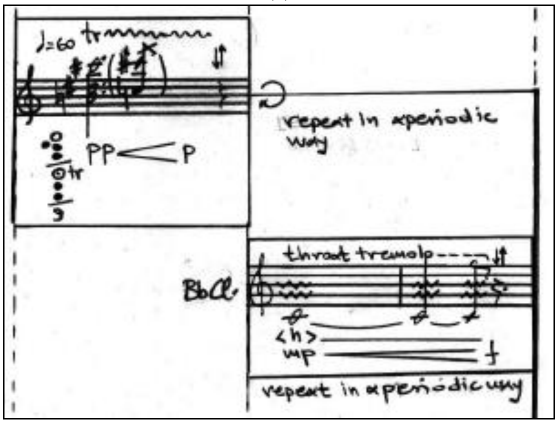
(b)

Figure 6. Indicative examples of blended individual and social behaviors reflected at the score space: (a) *interactive events* (reflection at the physical structural section and bio-conductor's behavior), and (b) *trajectory events* (reflection at the physical behavioral level and bio-conductor's expressive gestures).

(stochastic sound events)], and (iv) *random events* [random selections combined with autonomous events (stochastic sound events)]; some indicative examples from score excerpts are shown in Fig. 7.



(a)



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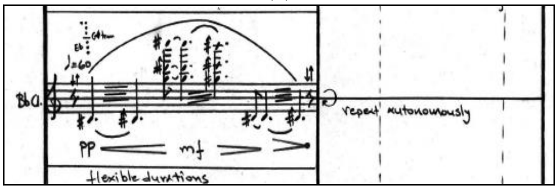
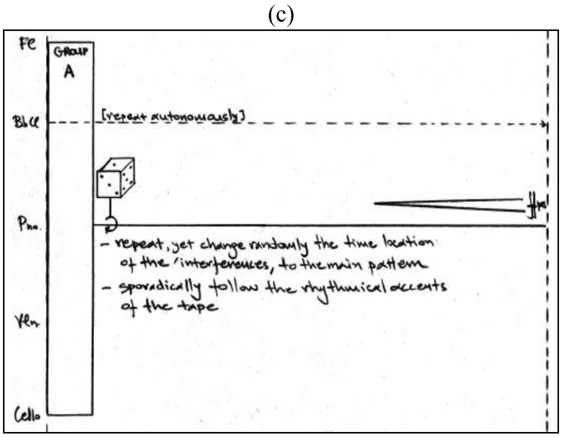


(c)



(d)

Figure 7. Indicative examples of blending procedures that take place at the score space in terms of the indeterminacy level of the events: (a) periodic (b) aperiodic (c) autonomous, and (d) random events.

4.4 Conventional & non-conventional sound sources/signals

4.4.1 Blending

The blending at the source level involves instrumental sound sources as conventional ones and biosignals (14 channels EEG), body gestures signals, swarm gestures signals, unorthodox instrumental soundings-use of external material, and electronic sounds (AM/FM, granular, buffered sounds) as non-conventional ones.

4.4.2 Handling

The handling of the non-conventional sources is realized through a working interface implemented in MAX/MSP 6.1 (`http://cycling74.com/`), as shown in Fig. 8. From the latter it can be seen that the score is embedded within the interface, which has a specific structure that monitors the functionality of the biosensors (MS Kinect and EEG Emotiv), along with the characteristics of the swarms (see Fig. 9), the bio-conductor's body mobility and brain activity (see Fig. 10) and the series of automation events (see Fig. 11), facilitating the real-time control of a multitude of parameters, that otherwise it would be extremely time-consuming and cumbersome.

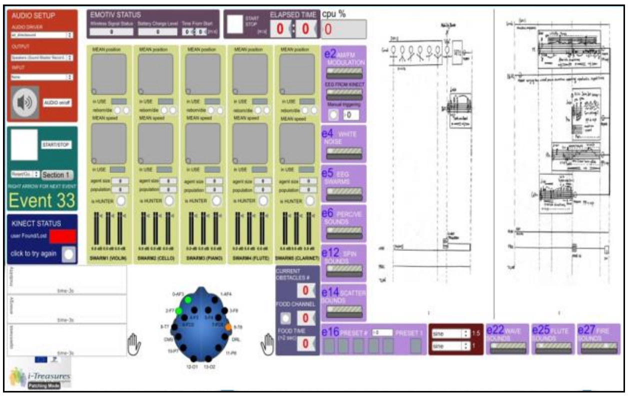


Figure 8. The MAX/MSP 6.1 interface for handling the non-conventional sources/signals.

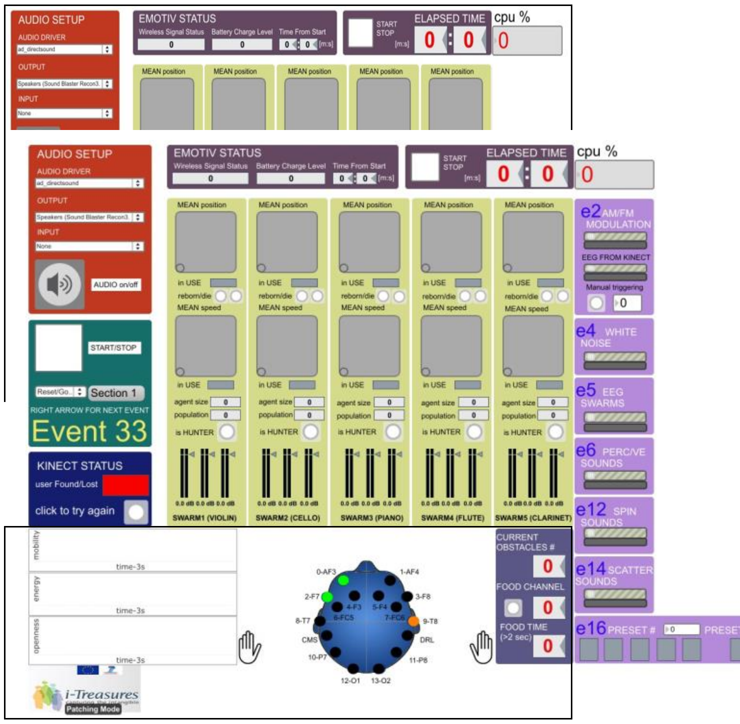


Figure 10. The part of the MAX/MSP 6.1 interface that monitors the bio-conductors' body mobility and brain activity, along with the food and obstacles parameters.

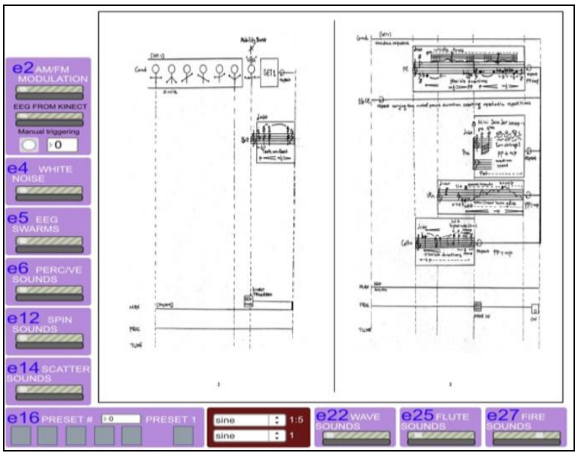


Figure 11. The part of the MAX/MSP 6.1 interface dedicated to the artistic control through a series of automation events, accessed by the right-arrow of the laptop keyboard.

4.5 Blended notational approaches/timestamp levels

The final axon of blending relates to the combination of conventional and graphical representations at the notation level and the adoption of relative and absolute timestamps. In this way, both the visual perception of the music and its flow variations across time become an integral part of the way the blending becomes more functional, both at the level of the performer (internal space) and the level of the audience (external space that gradually establishes an internal (individual) one).

5. REFLECTIVE DISCUSSION

Deeping into the underlying aesthetic intensions and characteristics of the "Brainswarm" paradigm presented in the previous section, the followings could be noted.

The idea behind the work[2] is to create a kind of soloist bio-conductor capturing his/her gestures via Kinect and brain activity via the Emotiv, when s/he mediates between real and virtual instruments. The bio-conductor is aware of the integral of the music in his mind and during the performance, through his experiential and cognitive expressions, s/he transmits the derivative (via the time segments) to the performers and the audience, which, in turn, they construct again the initial integral of the music (as thought by the composer and identified by the bio-conductor), yet with a more personal experiential and cognitive way. The conducting of the virtual instruments is achieved by the spatial correspondence of the brain activity sites (14 from Emotiv according to the 10/20 EEG recording system) to the available space limits of each swarm. This means that the spatial distribution of the brain activity, which clearly correlates with the brain functionality during the conducting (e.g., C3/C4 sites for hand movement, Fp1/Fp2, F3/F4 sites for emotional activation, Ti for aural stimulation, Oi for visual), conducts the swarms, as they are programmed to always hunt for food, when exists. The use of EEG is not limited there, but it is used in the electronics part in MAX/MSP interface, where the sounds, generated either by generators or samples, are affected (e.g., the characteristics of granularity changes, the pitch stretching, the speed and so on) by the EEG signals. This is also combined with the signals from MS Kinect, providing a merging at the gestural, expressive and experiential levels. Moreover, there is a behavioral change at the swarms level, where they are in a sense of white noise at the beginning, they are then starting formulating, then framed, then co-exist, then get defensive, with high cohesion, get aggressive with domination and extinction behaviors, in the sense of living organisms at a social context. The use of real instruments is also affected by the concepts described above, with a lot of combinations of periodic, aperiodic, stochastic and random events organized in subjective and objective timelines.

It should be noted that the monitoring of the different brain regions could be of almost conscious control of the conductor only if s/he follows a kind of training with the piece and reaches this skill in a statistical way (from a mean point of view after many performances). This gives a kind of convergence of the brain information to a specific behavior pattern, which in fact in this piece is *not* the goal. On the contrary, the brain spatial information varies clearly due to dynamical change of bio-conductor's experiential factors (i.e., how s/he perceives the whole performance across the time *during* the realization of the performance itself in his/her functional, cognitive, emotional spaces). This allows the abstract approach of the bio-conductor's experiential state, providing him/her with an extra degree of freedom to feel and react as s/he wants in this field, while conducting. Moreover, at the compositional space, this freedom is not corresponded to a specific value, but to a range of them (as the extension of deterministic-Aristotelian-binary true to the fuzzy concept of true (justifying Bart Kosko's saying "everything is a matter of degree" [15])), so the effect on the compositional material is not collapsed when the EEG signal does not get a specific value due to a variation in the bio-conductor's reaction, but it is still there, influencing with a degree the pre-composed timelines. In addition to this, the raw data of EEG are preserved in the sound space via generators that produce real-time sound cloud material. A more deterministic approach is provided by the gestural information via Kinect, where the influence is again both at the pre-composed material and in the generation of a new one, but its coding in the score is more concrete via the graphical lexicon provided to the bio-conductor as a guideline.

This is the third work in the biomusic area the author has written, with the previous two being more focused at the emotional space, as the latter is reflected in the brain activity (`http://www.youtube.com/channel/UCpbGVgxo4NIZnlaU6AFgMag`). There, stimulations are created (like specific text to the actor from F. Kafka's "The Metamorphosis" work where s/he has to feel the underlying emotion and reflect it through the EEG sig-

[2]The video of the world premiere of "Brainswarm" is available at `https://www. youtube.com/watch?v=f53eXf4Q0gI`

nals, considering the brain of the actor as the emotion-instrument of the ensemble); hence, activating specific brain sites in an organized plan. Almost the same, yet in a more emphatic way, is foreseen in the "Common Brain" work, where the structure of the brain itself is the form of the piece (starting from the simple neurons, leading to their proliferation and connectivity, center formation, interaction with the environment and text inputs from F. Pessoa and, finally, emotional activation and learning, using stimulation of P. Ekman's face photos of the six basic emotions, `http://www.paulekman.com/`).

As a bottom line, different contemplations of the core idea of cognitive and emotional information retrieval facilitate the generation of the structural elements of the three pieces. The intrusion of the devices employed to the bio-conductor and the ensemble has been kept minimum, as the communication is wireless and the stage setting is almost trivial. Finally, due to the interaction between the real and virtual spaces, a feedback path exists that transfers the sound focus from one space to the other or exposes both of them, with the bio-conductor's information (captured through these devices) playing an important role in the definition of this feedback path. In fact, there is a clear causality in the co-existence of the ensemble and the devices as the whole design actually builds upon this relation and forms a new space, allowing for more experimentation and variation in the aesthetic expression.

6. CONCLUSIONS

The intuitive use of conceptual blending, as it was materialized within the biomusic composition space, has been presented here. The basic ideas and objectives of these two fields have been touched and exemplified through a paradigm, consisting of a relevant, recent compositional work of the author. Specific realization, organization and aesthetic issues have been explored and discussed in details. Apparently, the proposed compositional trajectory paves the way for a more explorative, yet still almost unknown, formation of a blended version of the creative momentum, which calls for further understanding of the functional mechanisms of the human body and brain.

Acknowledgments

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