NEW MUSICAL ORGANOLOGY: THE AUDIO GAMES

THE QUESTION OF "A-MUSICOLOGICAL" INTERFACES

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SUMMARY: This article aims to shed light on a new and emerging creative field: "Audio Games," a crossroad between video games and computer music. Today, a plethora of tiny applications, which propose entertaining audio-visual experiences with a preponderant sound dimension, are available for game consoles, computers, and mobile phones. These experiences represent a new universe where the gameplay of video games is applied to musical composition, hence creating new links between these two fields. In proposing to manipulate what we refer to as "a-musicological"[1] representations (i.e. using symbols not normally associated with traditional musicology to manipulate and produce sound), this creative aspect raises new questions about representations of sound and musical structures and requires new instrumental gestures and approaches to composing music which will be examined. Furthermore, these objects play a role in the rise of a new amateur profile, already put forth by authors like Vilèm Flusser (Flusser, 1996), with regards *to photography.*

After having defined the characteristics and the limits of this field and highlighting a few of the historical milestones (abstract cinema, gaming theory in music, graphic actions and scores), we will study a few examples of musical games and propose areas for further research to devise analytical tools for these new objects.

KEYWORDS: Audio-games, video games, computer generated music, gameplay, interactivity, synesthesia, sound interfaces, relationships image/sound, audiovisual music

[1] We borrow the term « a-*musicological*» from Francis Rousseau and Alain Bonardi (Bonardi, Rousseau, 2003).

1/ Introduction

In this article, we would like to shed some light on an emerging creative field : "Audio Games," a crossroad between video games and computer music. Today, a plethora of tiny applications, which propose entertaining audio-visual experiences with a preponderant sound dimension, are available not only for game consoles and computers, but mobile phones as well. These experiences represent a new universe where the notion of gameplay derived from video games can facilitate the link with musical composition. In proposing to manipulate what we refer to as "*a-musicological*"[2] representations (i.e. using symbols not normally associated with traditional musicology to manipulate and produce sound), this creative aspect raises new questions about representations of sound and musical structures and requires new instrumental gestures and approaches to composing music which will be examined. In an original way, he thus questions the issue of usability with respect to creativity. Indeed, a new organology is emerging, profoundly renewing musical relationships (abstract synesthesiatic representations, 3D manipulations, simulation of physical events like rebounds or elasticity…). After having defined the characteristics and the limits of this field and highlighting a few of the historical milestones (abstract cinema, gaming theory in music, graphic actions and scores), we will study a few examples of musical games and propose areas for further research to devise analytical tools for these new objects.

2/ Definition

A quick search on the Internet gives us many terms describing this new field and its multiple sub-genders : audio-games, music video-games, music memory-games, rhythm-games, pitch-games, volume-games, eidetic music-games, generative music-games… To avoid contention, we prefer to accept the broadest of terms which takes into account all of the situations where games and musical production are combined with the main particularity of the field being the layering of these two universes with points of contact, but also different cognitive objectives. Thus, it is useful to set aside, from the outset, any and all ambiguity by specifying that the object of our research does not directly deal with the field of sound in video games (a field which deals primarily with interactive sound design), but rather a new organology which uses fun video activities to produce sound and extensively uses digital interactivity, creating a new relationship with images. The « audio game », with respect to the dimension of sound, is rooted in a realm between a musical instrument, a music box, and musical automatons. Moreover, the question of balance between the freedoms and constraints of players is crucial to the success of a entertaining sound-based video. Therefore, the richer and more complex the rules are, the more musically interesting the game is, even if it requires a lot of time to learn how to use. On the contrary, the more the constraints are preset, the easier it is for the user to use, managing almost immediately, but with the undeniable risk of producing either mediocre or repetitive sound. A second important characteristic of this new cultural object that we are trying to define is the development of a new relation between image and sound. Indeed, the overlapping of two universes (games and sound production) is materializing in the interface and interactive manipulation which often do not refer to musicology, but rather to rules specific to games (fighting opponents, manipulating objects…). It is above all, and in this case, the use of interfaces that we refer to as "*a-musicological*", as does Francis Rousseau and Alain Bonardi, which appear to be the main originality of this new organology.

3/ Gameplay and Instrumental games

A link exists between video games and sound in the notion of "playing", a notion which deserves our attention. In the world of video games, the terms playability and gameplay are the most often used to describe this dimension. For some (and in Canada in particular), the two terms are considered as synonyms and "jouabilité" is used as the French Translation of "game-play". For others, the two terms refer to different realities, despite being very closely related. The first is considered as a subgroup of the second. The first term refers to the pleasure of playing while the second term represents the principles of the game. Both notions being similar (and each directly depending on the other), we prefer to use the French term of "jouabilité" to describe all of the elements in the ludic video experience: the rules, interface, and maneuverability as well as player appropriation (the pleasure procured and the ease of appropriation). What does the playability of video games and instrumental games have in common? If we define playability as the characteristic of that which is playable, which can be played, we can therefore find a musical link in the notion of musicality, that which is "well composed" for a given instrument and which "sounds" good. We can then speak of "playability" for a piano score in reference to the pleasure procured by the pianist when playing this composition and his or her ability to incorporate, personify, express his or her interpretation. As regards the aspect of applying the rules of the game, there is no direct equivalent of the player that can be found in the traditional roles associated with music : neither a true composer, nor solely an instrumentalist, nor simple listener. Yet, one composer has remarkably shifted how these roles were assigned and enabled the development of a ludic dimension. Indeed, by the end of the 1950s, John Cage (1912-1992) made headway in his research on chance and indetermination by transforming the

[2] We borrow the term « a-*musicological*» from Francis Rousseau and Alain Bonardi (Bonardi, Rousseau, 2003).

score into a game with rules that the musician had to incorporate and above all personalize. The score thus changed from *notations of musical parameters* to that of *actions*. For example, in "*Variations I"* (1958), "*Variations II"* (1961) or *"Cartridge Music"* (1960), the notes were written as relative values (the size of the points reflect the intensity and length) on transparent sheets the musician placed over other transparent sheets containing the rules of the game (geometric shapes, a clock face…). The overlapping of sheets containing information on different levels (notes and rules) produces a score which must be interpreted. As shown below, the musician must implement a plan to produce the musical information before playing a single note, a "task" normally reserved for composers themselves. This new role of instrumentalists embodies the two English terms which describe games: "game" and "play". The term "game" refers to the notion of structure (a system of rules which the player must respect to successfully carry out an action), while the term "play" denotes a ludic attitude the player adopts ("actions of the player") (Genvo, 2002). In modifying the role of the musician, John Cage considerably increased the amount of freedom and creativity of the musician, two fundamental elements of a ludic attitude.

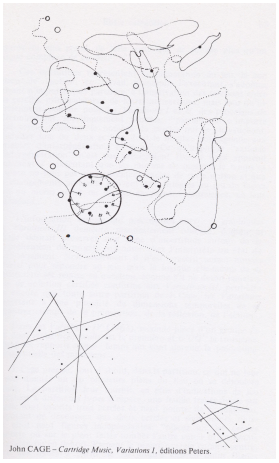

Figure 1 : John Cage (1960), *Cartridge Music*

The link between composition and the theory of games can be more explicitly found in the famous performance "*Reunion*" (1968), featuring Marcel Duchamp playing a game of chess where each move produces musical events more or less randomly.

Figure 2 : John Cage (1968), *Reunion* (featuring Marcel Duchamp in Toronto)

The game theory can be found among other composers such as Iannis Xenakis ("*Duel"* (1959), "*Stratégie"* (1962) and "*Linaia Agon"* (1972)), Mauricio Kagel ("*Match"* (1964) inspired by a game of tennis) or John Zorn (*"Cobra"* (1984)).

If these approaches involve a dialogue between two specialists (the composer and the musician), the ludic video objects are particular in nature in that they mainly address a more general amateur public. This mainstream ludic attitude embodies the work of Vilèm Flusser (Flusser, 1996), on photography, writings which particularly shed light on the particular nature of our research: Flusser in fact defines the camera as a structurally complex toy but functionally simple, enabling you to take pictures without any particular skills, making this activity accessible to a vast amateur public : "*The camera is not a tool, but a toy and the photographer is not a worker, but a player: not "homo faber" but "homo ludens"*. [3]

[3] Referenced above (p.35)

And furthermore: "*While the camera is based on complex scientific and technical principles, it is very easy to operate. It's a structurally complex toy, but functionally simple. In that way, it is the contrary of a game of chess, which is structurally simple, but functionally complex: Its rules are simple, but it is very difficult to play chess well. A person who operates a camera can very well take excellent pictures without necessarily having the slightest inclination of the complexity of the processes that take place when he or she pushes the button".* [4]

This transfer of specialized skills (the photographer or the composer) to an amateur appears to be the founding paradigm of this new class of cultural objects. A paradigm which is part of a broader movement linked to new information technologies. Jean Louis Weissberg (Weissberg, 2001), in his article on the emerging amateur figure clearly shows new intermediary spaces which appear between production and reception, between professionals and amateurs. The author puts forth the notion of graduated skills and highlights the political dimension of these new autonomy improving postures. In transferring this capacity, the user-friendliness of the interfaces is clearly essential. If it facilitates the transfer of skills and endeavors to make complex operations more intuitive, we argue that in the field application of musical composition we are studying, the question of user-friendliness is directly linked to the key issue of the representation of sound and musical structures in its ability to make concrete and visible that which is abstract and sound based.

4/ A few historical milestones

We can comprehend the recent emergence of "audio-games" by linking it to the closing gap between graphic arts and musical arts which arose toward the end of the nineteenth century and experienced rapid growth throughout the twentieth century (Bosseur, 1998). The scale of such historical dynamics exceeding the framework of this article (Zénouda, 2008), we shall very briefly introduce three :

- "Audiovisual music":

The expression of audiovisual music progressed in the beginning of the 1940s[5] thanks to John Withney[6], who defined the characteristics by studying the question of tempo in relation to specific films (combinations of time and space as well as shape and color). Nevertheless, audiovisual music existed long before, as early as the 1920s, with directors like Oskar Fishinger[7] or Len Lye[8] and is a part of the circle of influence regarding questions of connections between the arts and synesthesia so dear to abstract painters like Kandinsky or Paul Klee. The will of these directors was to find a specific film language "free" of any narration and forms inspired by novels or plays. In doing so, filmmakers strayed from cinema's primary function of recording reality by favoring to use non figurative forms and searching for construction models for their work in music which is the most abstract of arts. With duration and rhythm as a common denominator, these filmmakers sought to produce "completely" synesthetic works playing with the subtle connections between different senses.

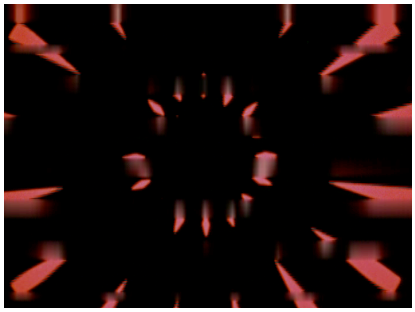

Figure 3 : Jordan Belson (1961), *Allures*
(http://www.mediafire.com/?fy920bhvu6q6b1v)

- Graphic scores:

As we have seen above with the score *Cartridge Music* (John Cage, 1960), the principles of indetermination developed by numerous composers starting in the late 1950s[9] caused us to reconsider the score as a musical communication tool. A new genre appeared as sound and visual arts merged. Composers broadened their range of symbols (colors, shapes, depth, textures…) to express new tones and novel musical processes. These new representations introduced spaces of freedom linked to improvisation and emphasized global musical indications

[4] Referenced above (p.78)
[5] *Five film exercices (*1943 - 1944) (http://www.my-os.net/blog/index.php?2006/06/20/330-john-whitney)
[6] Withney J. (1980), *Digital harmony on the complementary of music and visual arts,* Bytes Books, New Hampshire.
[7] « *Studie Nr 7. Poème visuel* » (1929-1930), « *Studie Nr 8* » (1931) …
[8] « *A Colour Box* » (1935) …
[9] John Cage but also Earle Brown, Pierre Boulez, André Boucourechliev among others….

or voluntarily vague which undermined contemporary music's obsession to control. The composer is responsible for the macro structure (while the musician deals with the details of execution) and communicates other types of information such as sensations, emotions, movements, dynamics.

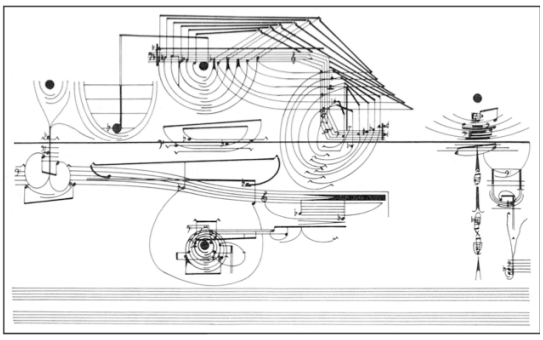

Figure 4 : Cornelius Cardew (1963 - 1967), *Treatise*

- Graphic interfaces for musical compositions :

In the 1970s, the composer Iannis Xenakis, also interested in the connection between image and audio, proposed a graphic interface for the composition of music dubbed UPIC[10] [11]. Thanks to a graphic palette, the composer can draw waveforms and amplitude envelopes and control both the structure of the sound and the general form of the work. More recently, Golan Levin[12], a researcher at MIT[13], proposed a series of instruments[14] which closely combined image, sound, and gestures. A developer of graphic palettes to which he adds real-time computer generated sounds, he associates movement parameters, like the direction and speed of movement or the pressure of an electronic pencil, with sound parameters, like timbre, pitch, panning, and with graphic parameters, like color, the thickness of a stroke or direction. For Golan Levin, the notions of interactivity and generativity are closely linked: Images and sound are produced in real time as the result of a user's movement, hence creating a "*generative and interactive malleable audiovisual substance*".[15] In France, the company Blue Yeti[16] proposes a dual screen musical drawing "*Grapholine*" system based on the transformation of sound samples (via a standard but also customizable sound database) by granular synthesis and offers a large range of manipulations and relations between image and sound (speed of the stroke, transparency, luminosity, color, pencil pressure…). At the UTC de Compiègne, two students[17] in their final year of computer science studies, proposed a virtual reality application (*Immersive Music Painter, 2010*) [18] in which the user, with his or her gestures, draws curves of different colors and thinknesses to which sound or melodies of controllable pitch, panning, and volume are associated.

These three fields are a part of the aspects of representing sound and interaction with sound and concerns the specialized experimental cinema audience for the first field, and composers and musicians for the latter fields. "Audio-games" add a ludic dimension to these two aspects and in doing so, the question of the user-friendliness and the user-friendliness of the interface; thus making this type of application available to a larger amateur audience, regardless of their knowledge of music.

5/ Typology of "audio-games"

We aim to develop an extremely simple and general typology that incorporates all types of "audio-games" as well as all types of music produced regardless of the style and level user expertis. In doing so, we concentrate on the question of representation (set or dynamic) of both types of sound : the basic elements (paradigmatic axis) and elements created through manipulations (playability) proposed via games (syntagmatic axis).

- The vertical paradigmatic axis pertains to the representation of basic sound elements that the audio-game provides the player. The graphic representation of this basic element range from the classic sol-fa to graphical creations without any direct link to sound in using abstract representations related to synesthesia (and any type of connection with different sound parameters). Note that the distinction between an elementary sound

[10] Unité Polyagogique Informatique du CEMAMu (Centre d'Etudes de Mathématiques et Automatique Musicales)
[11] http://www.youtube.com/watch?v=yztoaNakKok
[12] http://acg.media.mit.edu/people/golan/
[13] Massachusetts Institute of Technology (USA)
[14] « *Aurora* » (1999), « *Floo* » (1999), « *Yellowtail* » (1999), « *Loom* » (1999), « *Warbo* » (2000)
[15] « *an inexhaustible audiovisual substance which is created and manipulated through gestural mark-making* » Golan Levin, *Painterly Interfaces for Audiovisual Performance, B.S. Art and Design*, [LEVIN 1994], p.19.
[16] http://www.blueyeti.fr/Grapholine.html
[17] Camille Barot and Kevin Carpentier.
[18] http://www.utc.fr/imp/

and one that is created depends on the type of game and interaction proposed. Thus, what is considered as composed in one audio game may be considered as elementary in another. The items on this axis may therefore be modified depending on the audio-game that is studied and placed according to their distance or proximity to the traditional sol-fa.

- The horizontal syntagmatic axis pertains to the representation of sound objects created through the game's playability. It regards the representations of second level sound creations. These representations may be set and close to classic musical manipulations (representations of repetitions, transposition, reversals…) or dynamic (representations of simulations of physical phenomena like rebounding, explosions, accumulations) or describe the dynamics of "musicological" or "a-musicological" playability. The first can find direct musical analogies (moving around within space, mirroring….) the second have no musical analogy whatsoever and imply arbitrary and ad-hoc relations linked to the diegesis of the game (fighting games…). As for the paradigmatic axis, the items on the syntagmatic axis can be modified depending on the audio-game studied and will be positioned according to their distance or proximity to the traditional sol-fa.

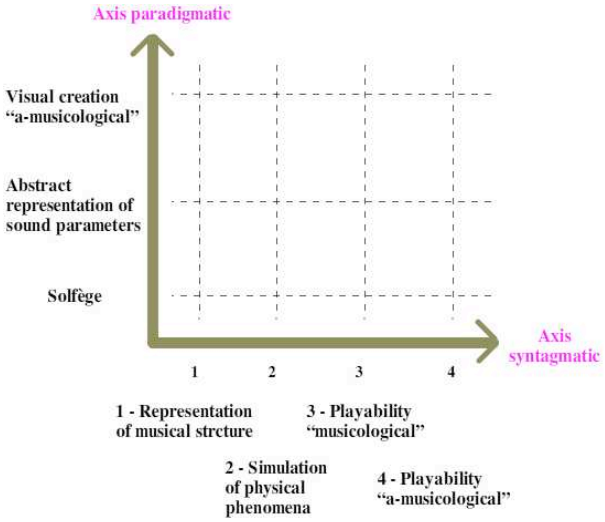

Figure 5 : Typology of « Audio-games »

6/ A brief presentation of a few "audio-games"

- "Aura" (on iPhone and iPad)[19] [2,1][20], very close to the aesthetics of a work of Oskar Fishinger as "*Allegretto*" (1936) or Jordan Belson's "*Allures*" (1961), allows users to create their own melodies over a computer generated musical background. Always in harmony with music in the background, the user can select the notes, timbre and volume using simple colored shapes on the screen. The audio-visual creation process is fluid and uninterrupted. The musical and visual background changes simply by shaking your iPhone. The user produces music and abstract shapes which are presented as an interactive generator of background music (and images) with the touch of a button. An application like "*SynthPond"* [21] (iPhone et iPad) [2,1] allows you to place different shapes on circles of varying diameters. Notes are played when they collide with waves generated by the user or with other nodes. Contrary to "Aura", "SythPond" produces repetitive musical loops making it possible to visually anticipate the output by following the movement of the nodes as they get closer to different junctions. The player can select the pitch, timbre, and tempo of the loops, which thus allows you to produce potentially complex melodies.

[19] http://www.youtube.com/watch?v=rb-9AWP9RXw&feature=related
[20] [2,1] = 2 on the paradigmatic axis and 1 on the syntagmatic axis
[21] http://www.youtube.com/watch?v=mN4Rig_A8lc&feature=related

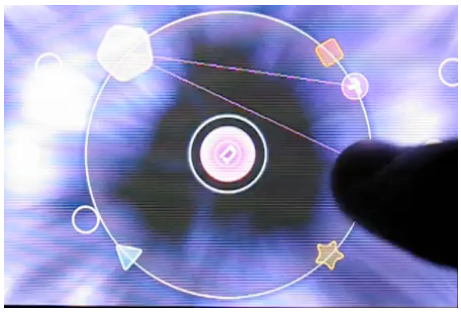

Figure 6 : « *Aura* »

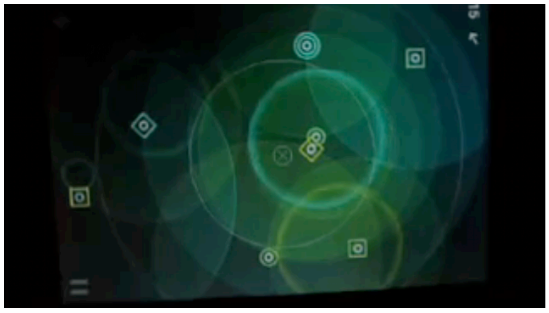

Figure 7 : « *Synthpond* »

- "*Rez*" (Tetsuya Mizuguchi, 2001, Sega)[22] and "*Child of Eden*" (Tetsuya Mizuguchi, 2010, Xbox360)[23] [2,4] are more similar to traditional games in that they preserve a significant sound dimension. "*Rez*" is like a fight in which the musical elements are dynamically created by the player's acts. Each time the player's or enemy's vessel shoots, a sound is produced which adapts in rhythm and in harmony. The game experience is therefore quite original, the ludic mission (to destroy the enemy vessels) is the source of the images and sound that is produced. The arguments of the designer referring to Kandinsky and synaesthesia link this game to those previously mentioned. To increase the quest for synaesthesia, the multiple simultaneous sensations are brought on by the vibration of the joystick when the images and sound synchronise. In the "Child of Eden", Tetsuya Mizuguchi continues to improve playability by generating sound using state of the art technological innovations (HD images, 5.1 surround sound, Kinect motion sensors which enable you to play without a mouse or joystick). Motion detectors enable direct interaction with images as well as new types of interactivity (for example, clapping you hands enables you to change weapons during the game). The visual aesthetics are far more dazzling and psychedelic that in Rez and the ludic mission is to eradicate a virus which jeopardizes the project to recreate a human within Eden (the archive of humanity). Each level corresponds to a step in this archive of humanity and the last stage incorporates the personal contributions of players with pictures of their happiest moments.

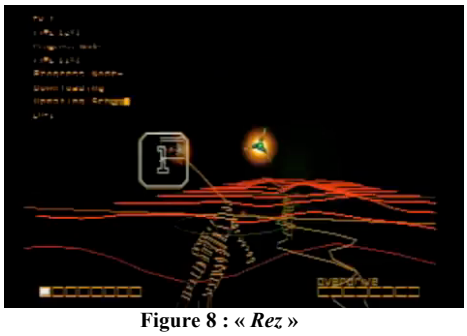

Figure 8 : « *Rez* »

Figure 9 : « *Child of Eden* »

- "*Metris*" [24] (Mark Havryliv, Terumi Narushima, Java Applet) [2,3] adds a musical creation dimension to the famous game "*Tetris*". A synthetic bell sound is generated in real time each time a block is moved. When the player moves or rotates blocks the pitch changes. They way in which the blocks fit together produces different chords. All of the different possibilities enable players to produce sophisticated micro-tonal compositions without losing the interest of the original "*Tetris*" game.

- "*Pasy02*" [25] (iPhone and iPad) [2,2] is laid out as a grid that you can reshape and stretch as much as you would like and which comes back to normal with an elastic effect. These physical modifications influence the pitch, tempo, timbre of the musical loop played by a synthesizer with waveforms (sine, triangles, squares, sawtooth) that can be chosen by the user to produce diverse melodies. The simple application offers an original and live production of sound.

[22] http://www.youtube.com/watch?v=2a1qsp9hXMw
[23] http://www.youtube.com/watch?v=xuYWLYjOa_0&feature=fvst
[24] Havryliv Mark, Narushima Terumi, « *Metris: a game environment for music performance* », http://ro.uow.edu.au/era/313/
[25] http://www.youtube.com/watch?v=JmqdvxLpj6g&feature=related

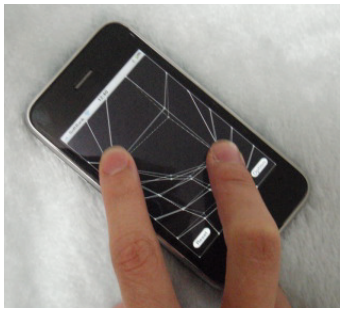

Figure 10 : « Pasy02 »

- "*Elektro-Plankton*"[26] (Toshio Iwai, Nintendo) is an emblematic game which offers ten different plankton themed interfaces with various musical situations enhanced with ludic graphics. Certain interfaces emphasize the strong link between musical gestures and pictorial gestures. Furthermore, with "*Tracys,*" [3,3], the player draws lines (straight or curved) the plankton follow while playing piano notes in rhythm with the graphic shapes created. Yet, others display a labyrinthine and rhizomic dimension of music (using a complete range of possible notes): with "*Luminaria"* [3,3], several plankton move around on a grid of nodes and links, each link following the arrows. The player can change the connections between the nodes and hence change the direction the plankton take. In doing so, the player modifies the notes that are played. Others use a device which is close to what could be referred to as a sound installation. The "*Hanenbrows"* [3,2], for example, are projected on the screen and produce musical notes when they bounce off leaves. In changing the angle of the leaves, the player can influence the melodies that are produced. Each time a leaf is hit, it changes color and the sound it makes. A screen like "*Nanocarps*" [3,2], uses plankton, each with their own behaviour and direction. A sound is produced when the plankton hit a wave and using the microphone allows the player to reorganize them. In the same way, the application "*Volvoice*" [3,1] uses a computer microphone to record sounds which can then be modified (pitch, speed, filter) as much as you'd like by simply changing the shape of the plankton on the screen. Finally, the screen "Sun-Animalcule" [3,1] proposes for you to plant plankton anywhere on the screen. The musical note depends on where you plant it. The light produced by a day/night cycle hatches the seeds and produces the corresponding musical note. As the plankton embryos get bigger, their musical behaviour changes.

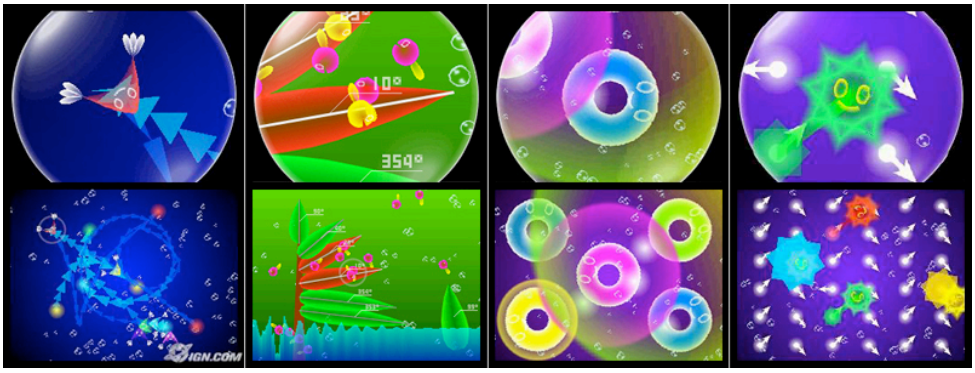

Figure 11 : « *ElectroPlankton* »

- "*Flying puppet"* (Nicolas Clauss, painter)[27] [3,4] : Nicolas Clauss' website proposes numerous "interactive screens" where visual aesthetics is clearly figurative, seeking a multi-sensorial experience without any objectives or particular missions. While sound is extremely important, the images never reflect any logical representation of the sound. The two modalities have creative autonomy and produce new sensorial experiences. For example, the triptych *Legato*, *Cellos* and *Moon tribe* uses dancing stick figures. Using the same graphical elements, each of the three productions make use of a particular aspect of music: *Legato* uses audio mixing of melodic lines on a particular theme in a loop, *Cellos* aligns different preset melodies, *Moon tribe* allows you to synchronize rhythmic loops.
The structure itself of the interaction is copied or transposed on aspects of music such as harmony, counterpoint, melodic structure, synchronization of rhythms. The graphics possess their own aesthetic coherence and arbitrary sounds. In the same way, each visual and audio mode, possesses its own tempo. The tempo of the graphics and that of the music do not always perfectly overlap. They produce visual and audio temporal loop delays. The gesture does not merge the two modes, but coordinates

[26] http://www.youtube.com/watch?v=aPkPGcANAIg
[27] http://www.flyingpuppet.com/

them. It's the junction, the border between the two worlds. If this relationship leads to sensory fusion, it is only elusive, unambiguous, and subject to interpretation that varies greatly from one user to another. It is not directly a part of the technical process, but rather accomplished in the course of an untimely gesture, as a better user appropriation. It is impossible to say whether our gesture is guided by our interest in producing sound or pleasant visual graphics. We imperceptibly emphasize one or the other, thus combining the three dimensions: visual, audio, and gestural.

Figure 12 : « *Moon Tribe* »

These examples fit into our typology as follows : « *Aura* » [2,1], « *SynthPond* » [2,1], « *Rez* » [2,4] , « *Child of Eden* »[2,4] , « *Metris* » [2,3], « *Pasy02* » [2,2] , « *Tracys* » [3,3], « *Luminaria* » [3,3], « *Hanenbrows* » [3,2], « *Nanocarps* » [3,2], « *Volvoice* » [3,1] , « *Sun-Animalcule* » [3,1], « *Flying puppet* » [3,4]

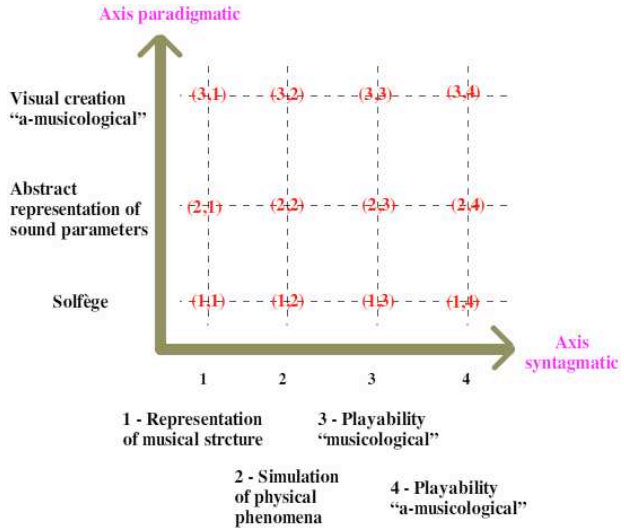

Figure 13 : Typology of « Audio-games »

7/ Towards an analysis grid for "audio games"

In addition to a classification table of these new objects, we propose some ideas for developing a grid analysis of "audio-games" :

- The Distinction in relations between image and sound: Three modes interact and slide from one to another within the same ludic audio video production. Sound for the overall benefit of images (derived from traditional sound and audiovisual illustrations), images for the overall benefit of sound (derived from computer-based music where images aim to represent and manipulate sound), images and sound of equal importance (more specific to "audio-games" and hypermedia) producing perceptible fusion effects between the two modes.

- The Distinction between sound producing modes: Some sounds are produced by direct intervention of the user. For example, when the user moves the mouse, clicks on or goes over an icon. Other sounds are automatically generated by the system without any user intervention, such as automatic background sounds. Yet others are generated automatically by the system but linked to user intervention, like a particular path in the application or an amount of time spent on an interaction. These different means for producing sound have a tendancy to interfere with each other and lead to a certain degree of confusion. Thus, studying precisely how the

author manages the untimely audio mixing of the different layers of sound is essential for a detailed analysis on the relationships between images and sound in an interactive situation.

- Taking graphic/audio/gestural tripthych into account: expressed with the notion of mapping (transcribing information that has been received in one register, the movement or graphic manipulation, into another register such as musical in this case). Several types of mapping can generally be distinguished: the relationship in which one parameter of a field corresponds to the parameter of another (one-to-one), the situation in which the parameter of one field is associated with several parameters of the other (one-to-many), and finally the relationship in which several parameters of one field are associated with one parameter of the other (many-to-one). In these multisensory associations, the choice in associating the different parameters of each modality at stake and the manner in which they are associated is essential. Indeed, we note which audio and visual dimensions are affected by the interaction and what perceptible effects they produce. Regarding the sound: the note (pitch, length, intensity), the timbre (envelope, frequency…), the rules of manipulating musical structure, the audio mixing of several tracks, the general parameters like tempo… and to which graphic parameters these are assigned to (color, shape, opacity, sharpness, frame, level of iconicity…). What sensory effects are produced by the multiple combinations of image/sound/ gestures ?

- The analysis of different cognitive objectives: "Audio-games" present specific situations where a user's gesture controls and produces images and sound at the same time while taking part in another logic, the game itself (for example, destroying space vessels in "Rez" or placing obstacles to manage how balls rebound in "Elektroplankton"). We have demonstrated this specific situation produces perceptible complex effects where the effects of synchronisation and fusion of images and sound are enhanced by gestures and different cognitive stakes. The main difficulty is associating these two levels (a game and musical production) in a meaningful way (neither a confrontational relationship, nor one that is too distant or anecdotal). Ideally, the ludic layer would give rise to new meaningful instrumental gestures in sound production and ultimately innovate music. To obtain optimal results, the game's rules and missions must therefore clarify the musical structures when played while keeping their impact and coherence as a game. We can be seen here, the difficulty of this desired balance.

- These new objects thus stress the necessity of developing multimodal semiotic approaches of analysis which simultaneously take into account what can be seen and heard as well as gestures. A few tools might help us to make headway :

- In 1961, Abraham Moles[28] proposed a *scale of iconicity* with thirteen levels for ranking images according to how closely they resemble the real object they represent. This progressive axis went from the most concrete and figurative representations to the most abstract representations like natural languages or artificial languages (mathematics etc.). This scale of iconicity can be applied to sound by developing two axis: that which goes from concrete to musical and that which goes from recorded to simulated (computer generated sound).

- Inspired by Peirce's sign theory, the composer, François Bayle[29] defines three properties of sound linked to the attention of the listener: the "icon" (isomorphic image or im-sound): the object is indicated by all of its characteristics, the "index" (indexed images or di-sound): certain graphic traits denote the object, the "symbol" (a metaphore or me-sound): the image represents the object with associative properties. These three kinds of signs give rise to three levels of hearing: one in which sounds are heard as corresponding to directly identifiable referents of reality (*quality* : *quali-sign*) ; one in which the relationship is more abstract, the sound becomes a significant element of something. Specialized listening: Sounds are heard as having been transformed (filtering, transposition, insert…), indications of musical composition (singularity: syn-sign); and finally, one in which the sign is governed by a known law which is independent from the sign itself (rebounds, oscillation…), listening which is oriented towards a sense of organisation, formal law…(*stability: legi-sign*).

- Conceived by a team of musical researchers in Marseilles, an *Unité Sémiotique Temporelle is "a musical segment which, even out of context, possesses a precise temporal signification thanks to its morphological structure"* [30]. Nineteen USTs were identified and labelled: A word or a literary expression which most directly describes the manner in which the energy of sound is deployed over time[31], most often with the help of a "*morphological appellation, a qualifier which often refers to something extramusical.*[32] This extramusical reference is a first step towards a generalization of these labels to other modalities. In this way, we can emphasize that all of these labels refer to an energetic or spatial movement which naturally connect them to gestures and images.

[28] Moles A. (1972), « *Théorie de l'information et perception esthétique »,* Denoel-Gonthier, Paris.
[29] Bayle F. (1993), *Musique acousmatique : propositions ... positions*, Buchet Castel, Paris.
[30] MIM, *Les UST : éléments nouveaux d'analyse musicale*, [MIM 2002], p°18.
[31] Chute, Contracté, Etendue, Elan, En flottement, En suspension, Etirement, Freinage, Lourdeur, Obsessionnel, Par vagues, Qui avance, Qui tourne, Qui veut démarrer, Sans direction par divergence d'information, Sans direction par excès d'information, Stationnaire, Sur l'erre, Suspension-interrogation, Trajectoire inexorable.
[32] *Ibid* p. 36.

8/ To conclude: Towards what new instrumental and compositional gestures?

It is currently difficult to foresee new instrumental and compositional gestures resulting from these types of interfaces. Nevertheless, we can note that they are part of a general movement which is creating completely new situations of musical interaction: real-time musical devices are transforming musical gestures by increasing or reshaping them, which results in separating gestures from the sound produced. Professional computer generated sound software[33] more and more frequently add network representations, physical simulations (rebounds, soundclouds…), shapes moving through labyrinths of notes, and ludic approaches to their traditional representations (treble clef and bass clef scores, midi data note grids, player piano music rolls, displayed waveforms…) (Vinet, 1999). « Audio-games » play a role in renewing musical gestures as well as the representation of sound and their musical structures. They make playing and composing music easier for a broad audience regardless of their knowledge in music. They make the musical gestures of musicians on stage more visible and comprehensible. Furthermore, they are likely to make the relationship between audiences and composers more explicit thanks to interactivity.

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RECOMMENDED WEBSITES :

- *http://www.centerforvisualmusic.org/*
- Allures : http://www.mediafire.com/?fy920bhvu6q6b1v
- Golan Levin : *http://acg.media.mit.edu/people/golan/*
- Blue Yeti : *http://www.blueyeti.fr/Grapholine.html*
- Aura : *http://www.youtube.com/watch?v=rb-9AWP9RXw&feature=related*
- Synthpond : *http://www.youtube.com/watch?v=mN4Rig_A8lc&feature=related*
- REZ : *http://www.youtube.com/watch?v=2a1qsp9hXMw*
- *Child Of Eden : http://www.youtube.com/watch?v=xuYWLYjOa_0&feature=fvst*
- Trope *: http://www.youtube.com/watch?v=dlgV0X_GMPw*
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- Sonic Wire : *http://www.youtube.com/watch?v=ji4VHWTk8TQ&feature=related*
- Electroplankton : *http://www.youtube.com/watch?v=aPkPGcANAIg*
- Audio table : *http://www.youtube.com/watch?v=vHvH-nWH3QM*
- Nicolas Clauss : *http://www.flyingpuppet.com*
- Cubase : *http://www.steinberg.fr/fr/produits/cubase/start.html*
- Nodal : *http://www.csse.monash.edu.au/~cema/nodal/*

[33] Like Cubase or LogicAudio…