SOUND CREATION AND MUSIC CONSTRUCTION - DIGITAL ENVIRONMENT DESIGN FOR CHILDREN

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ABSTRACT

This paper introduces the music education experience of Tempo Reale, a musical production, research and education centre in Florence, founded by Luciano Berio. It focuses on the design process of digital tools, which are “tailored” to user needs and educational goals and created for people who have no musical training.

It shows the main features in educational activities: goals, users, context constraints, strategy and the role of technology. Then it shortly describes the learning environment: pedagogical principles, spatial set up, contents and lesson phases.

This paper specifically explains digital environment design for sound exploration, sound creation and music construction, addressed to eight to ten year-old children: each tool is presented in detail with figures and tables, and relations among goals, contents, user analysis, concept, and software solutions (user interaction design, graphical interface design, audio engine design) are highlighted.

Finally, this paper presents software and educational activity evaluation methods and gives perspectives in future research development.

1. INTRODUCTION

Tempo Reale is a musical Production, Research and Education Centre in Florence. Since the Centre’s foundation[1], it has been specifically dedicated to the research, development and use of new technologies in music and has become a national and international point of reference for composers and musicians active in the field.

In a 20-year long activity, a wide experience in digital environment design for music performance and composition has been developed; starting from this, an experimental computer aided music education project has been carried on since 1999: Sound Exploration and Music Creation Laboratories for Children through Digital Tools”[2] [5].

The main goal is to improve children’s taste and sensitivity to sound, and relations among sounds; to promote a musical attitude towards an acoustical environment; stimulate curiosity to any kind of sound, with no previous judgment [10, 11].

In order to reach these aims, an extended music creation experience is proposed: concept, finding rough materials (acoustic sound production and recording), transformation (sound processing), re-organisation in new relations (construction), collective listening and sharing (presentation) and community sharing (final performance).

However, this experience can be too complex for children with no previous, specific knowledge: most of them are not able to play acoustic instruments, do not know any music notation, cannot read a graphical sound representation. Moreover, context constraints have to be considered: at school no more than one hour a week is dedicated to music and only one teacher is assigned to 24 children.

On the other hand, digital technologies offer powerful tools which are interface-based, simple and intuitive, useful for sound processing and music composition, addressed to both trained and untrained users: however, most of them fit a more professional context than an educational one.

For these reasons Tempo Reale decided to conceive, design, and implement an original digital environment by following user needs and educational goals which guide children through the musical creation process.

At the same time new learning environments have been set up in many Italian primary schools: computer laboratories, with original software installed, and trained teachers leading children in sound exploration and musical creation[3].

2. THE LEARNING ENVIRONMENT

Learning environment design is based on the following pedagogical principles principles:

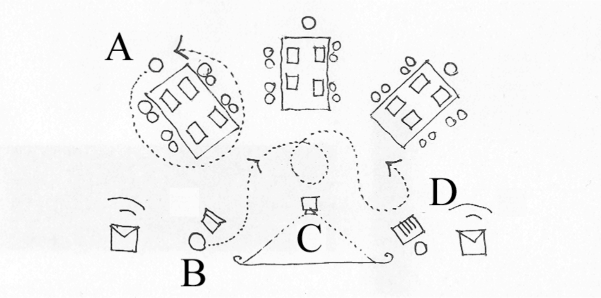
- Knowledge discovery, sharing, exchange are basic conditions for effective learning [2]:

[1] Tempo Reale was founded by Luciano Berio in 1987
[2] The initiative has been promoted by Luciano Berio and developed by Tempo Reale educational work-group, directors Jacopo Baboni Schilingi (from 2000 to 2004) and Michele Tadini (from 2004).
[3] From 2000 to 2006 the Tempo Reale educational work-group developed a hundred software programs, set up 15 laboratories, trained more than 30 teachers, reached more than 1600 pupils.

collaboration and discussion have to be encouraged

- The computer is a powerful tool for knowledge exploration , elaboration, construction [6]
- Music that children want to listen to, first of all, is their own music [3]

The setting is composed of 12 mobile workstations (Apple mobile classroom), one every couple of children : in a radial or circular array, in order to allow visual relations among children, and support collaborative educational formats ; moreover, mobile classroom allows quick set up change, and supports dynamic grouping. In addiction, a digital projector and an audio diffusion system are provided.



A = workgroup (4 notebooks, 8 children, 1 assistant)
B = teacher, C = digital projetor, D = audio diffusion system

Figure 1. Setting.

The activity is composed of of fourteen lessons, one hour a week, dedicated to introducing sound listening (lesson one), sound exploration and ear training (two-four), sound processing (five-eight), music construction (nine-twelve), preparation for the final performance (twelve-fourteen).

Every lesson is divided into three main phases:

Explanation: the teacher introduces contents and concepts, and explains software functions.

Figure 2. Explanation.

Creation: every couple of children work at their task (for example sound transformation), discuss, decide the work process, get a result, comment and prepare a quick presentation. At a higher level, groups of eight children work together on processing sounds and constructing music.

Figure 3. Creation.

Discussion: groups (couple/ group of eight children) present their own result to the class, and the teacher guides discussions on the coherence between intentions, creative process and result.

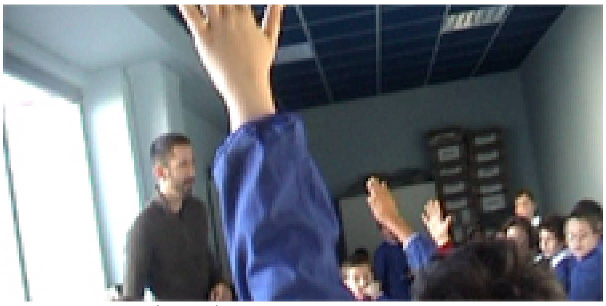


Figure 4. Discussion.

In order to prepare the final performance children organise all sounds into a music piece. With assistance from the teacher, they fix the piece into a sort of simplified music score and then they prepare to play their own sounds using the computer and child-director.

3. SOFTWARE DESIGN PROCESS

Three different digital tools will be presented, and all the steps of design process will be described: user analysis, educational goals, content definition, interaction design, graphical interface design, audio engine design.

3.1. T-mix, music construction tool for 6/8-year-old children

6/8-year-old children are used for a topological perception of space and time, based on principles of inside/outside, near/far, inclusion/exclusion, more than for an Euclidean vision of homogeneous space (and time), based on measure [7]

Moreover, children explore their environment through a sensorial and gestural approach.

The aim is to introduce children to musical form, by experimenting relation between sounds. Children are asked to listen to sounds, find differences and similarities, organize them in different groups; then, put sounds together, working on sequences and overlapping, and finally produce a very short composition.

Sounds are chosen from pre-recorded libraries (ambient or instrumental sounds) and custom libraries, recorded by children themselves.

The concept is a "sound-surfing" environment, where children move the pointer in the defined sound field, and experiment different relations depending on the movement of the mouse: surfing is composing.

The user interface must be simple, intuitive and mouse movement–based. According to cognitive constraints and educational goals, the triggers activating the main relationships are:

- the distance/proximity between object and pointer, object and object
- the quality of the gesture: path (a curve line, a straight line etc), speed (constant, accelerating/decelerating)

Moreover, user can build a personal environment by fixing object position (and proximity relationships) and choosing sounds to explore and compose with.

The graphical interface (under construction) will display a homogeneous background with objects (simple circles) representing sound. The interaction steps are the following:

- first of all, users set up their personal exploring environment, and place all the objects following a simple shape, usually circles, radial shapes, rows[1] ;
- they start exploring the environment, surfing between the objects, following a path (straight lines, curve lines, flowers, spiral…) and listening to the acoustical result, depending on the qualities of movements: the more one gets closer to sound, the more the amplitude increases[2] ;
- they listen again to the recorded outcome and evaluate it.

Here are some examples of user interaction. The following figures describe user interaction on a simplified graphical interface (upper part) and sound outcome (lower part) in amplitude vs time representation; digital graphical interface is under construction.

Circle: users place the objects following a simple shape, the circle, then move the pointer starting from the centre and following the shape, at a constant speed. The result is a continuous sound ("A" in the picture) plus a simple sequence of overlapping sounds.

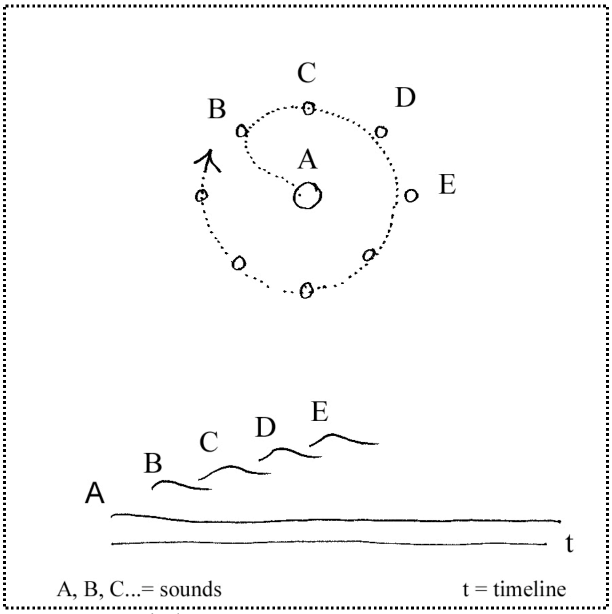


Figure 5. Circle.

Flower: in the same environment, the surfer follows a sort of flower shape: the main sound amplitude envelope is modelled by the movements of the pointer, leaving the sequence of overlapping sounds untouched.

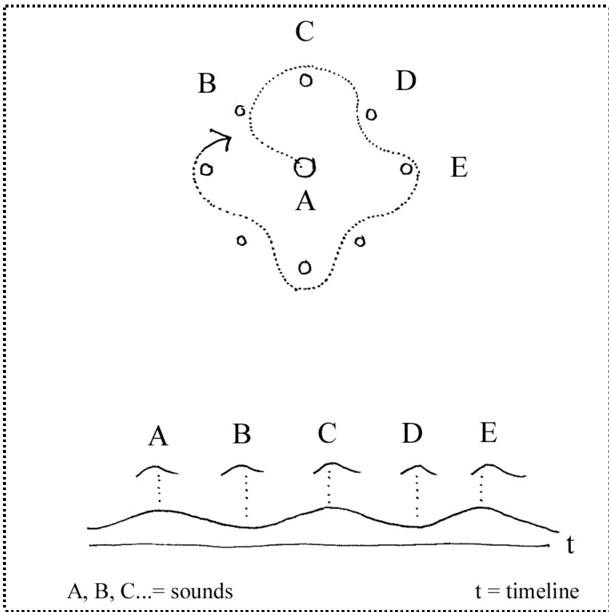


Figure 6. Flower.

Spyral I: the amplitude of the main sound is constantly decreasing while the sequence of overlapping sounds increases and decreases according to movement.

[1] Circle and radial figures are the main visual representation forms in children, [1].

2 In these examples, sounds are continuous.

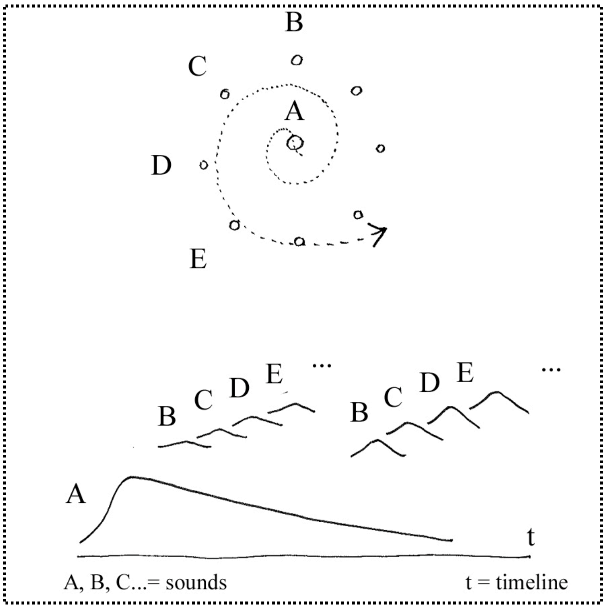


Figure 7. Spyral I.

Spyral II: the same as Spyral I, but the sequence increases its amplitude level.

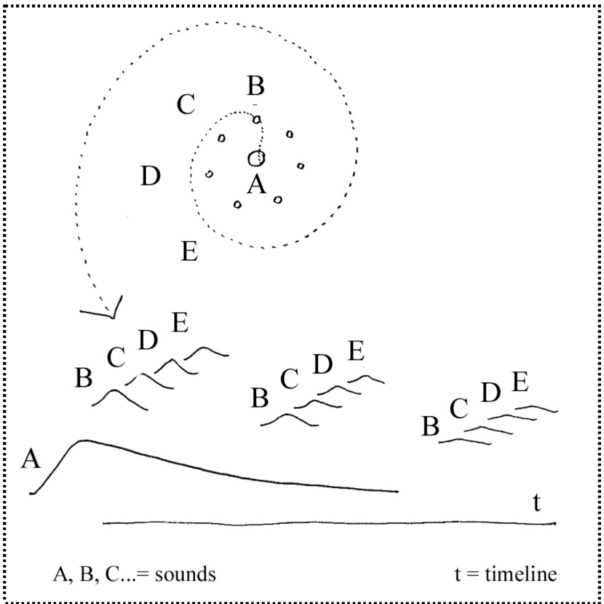


Figure 8. Spyral II.

Rows: the figure is surfed following a simple line, at a constant speed. The outcome will take a symmetric shape according to the nature of the sequence of sounds.

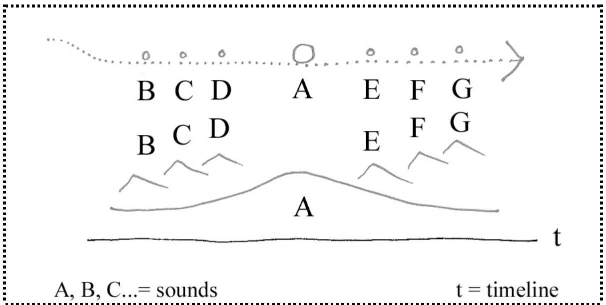


Figure 9. Rows.

Continuous / percussive (figure 6): a sound can have a percussive attack only if the pointer passes over the object. If not, the amplitude envelope will be flat.

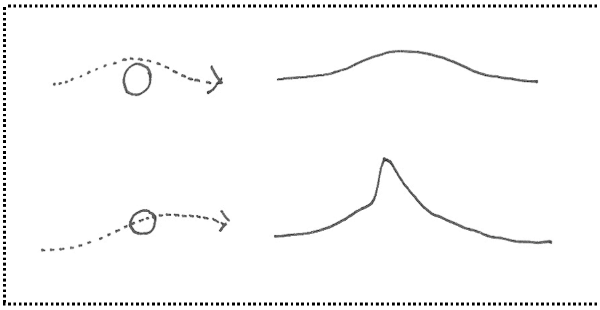


Figure 10. Continuous / percussive.

Audio engine design focuses on relationships between gestures and sounds in order to offer a sort of "physical" approach to sound transformation; an instantaneous "action–reaction" system is implemented in real-time signal processing[1].

There is one control that detects the pointer position on the screen and controls three sound modules: amplitude/envelope algorithm, filtering algorithm, reverb algorithm.

3.2. "Live_8", music composition tool for 10 year-old children

Live_8 is similar to the previous music composition tool: goals and contents are the same, while concept, interface, and the audio engine are different, since users are older.

Children 10 years of age and older, gain understanding of the Euclidean vision of the environment: space (and time) is homogeneous and measurable [7].

However, they are not able to think present, past, and future, as a pre-organised structure; they are strongly attached to what is happening in the present [4].

Live_8 is a live performance environment, where children trigger sounds in real time and focus on their start offset.

User interface is based on two devices: sound triggering with the computer keyboard mapped on basic functions (play/stop, volume) and visual monitoring on a graphical interface, displaying a time-line based sound representation (amplitude envelope).

The interaction steps are the following:

- Preparation. Users choose sounds (1 –8) from a custom library, by clicking on the sound menu; graphical interface display amplitude envelope – it is possible to do some simple editing, such as selection, crop, fade in, fade

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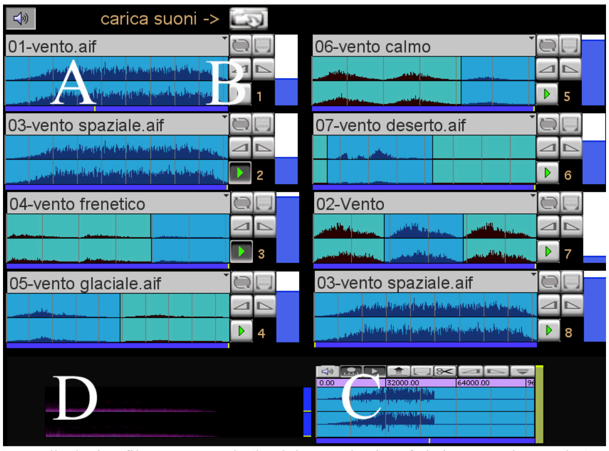
[1] Tools are programmed in the object oriented graphical environment *Max/MSP - Cycling74* [12]

out; users listen to every sound by simply pushing keys on the computer keyboard (1~8)

- Music construction. Users start a live mixing by fixing volumes: they decide which sound, and at what instance, it is to be played; this is the core action, allowing children to experiment basic music relations.
- Recording. The live mixing is then recorded and displayed in a time-line representation (amplitude envelope): users listen to their composition, evaluate it, make a visual edit, and save it.

A Real-time audio engine is composed of three main modules:

- 8 audio playing, displaying, and editing file
- sound mix recording and listening
- keyboard mapping



A = displaying file, B = controls (load, loop, selection, fade in-out, volume, play)
C = recording and editing, D = displaying sound out

Figure 11. Live_8.

3.3. "M_orph", sound processing tools for 9/10-year-old children.

M_orph is a complex environment that includes 11 signal processing tools, based on different real time audio processing techniques.

The aim is to study sound properties by comparing non-processed and processed sound, and to develop children skills in sound morphological modelling, stimulating creativity in producing new *objects sonores* [9]

Since the age of 7-8, children have some notion of the transformation concept and are able to think in both the direct and the reverse process [7].

The concept is a matrix processing environment where users can make a complex transformation by linking simple processing tools.

The interaction phases are the following:

- Setting. Users choose processing techniques, and decide work environment settings (tools and links) by simply clicking on the menu ; moreover, users load the sound to be processed by browsing personal libraries or by instantly recording by an incorporated microphone (input area, I in figure 12).
- Processing . Users start the sound transformation process and control any step by listening to the result on his/her headphones (transformation area, T in figure 12).
- Recording. They record the signal processing output (out area, O in figure 12) by filling different audio buffers (maximum 6)
- Listening. They listen to the recorded outputs, compare the original sound with the processed ones and discuss morphological properties.

Interaction design guidelines are:

- Reversion: users can set up a tool chain (for example, « sound presser », « filter », « reverb »), and take the sound at any processing step (output from « soundpresser, or output from « filter », etc.): reversion allows users to go back to any step, and therefore, to control the transformation process.
- Visibility: step by step, sound graphical representations are displayed (sonogram), in order to help children be aware of the morphological property change.
- Keeping tracks: user can save personal set, and therefore, can re-open a work session anytime, or use the same set to process different sounds; this supports children in repeating experience, comparison, reflection.

User interaction is different, depending on the tool. Here are two examples.

"Sound-presser" (T1, in figure 12), a digital tool for pitch shifting and time stretching, based on a granular synthesis technique.

Interaction is based on the pointer's continuous movement on the screen (see also "T-mix"), and the parameter which triggers the signal processing audio engine is the distance/proximity between the pointer and the centre of the moving area. Therefore, moving along the up-down axis triggers pitch shifting respectively to high/low frequencies; left-right movement triggers time stretching (time contraction and time stretching, respectively).

"Sound-slicer" (T2, in figure 12) is a 256 band filter which, based on the FFT analysis-synthesis technique, works as a spectrum shaper by reducing/increasing energy.

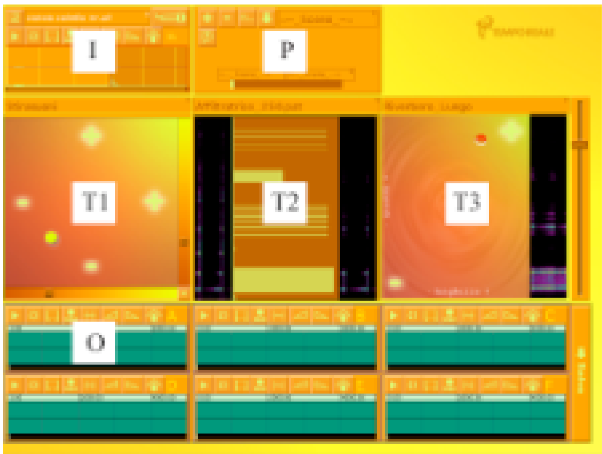
Users interact on a visual representation of the filter displaying 256 sliders, each controlling a filter band: the lower the slider, the more a corresponding spectrum energy is reduced.

Since all sliders are part of just one graphical object, filter shaping is just a quick and simple gesture.

Moreover, there is perfect correspondence between original sound visual representation (sonogram), filter visual representation (set of sliders) and processed sound visual representation (sonogram): filter action is evident and the user is supported in sound processing awareness.

Audio engine is composed of real time signal processing modules, as many as tools are [8]:

- "sound-presser" module, for pitch-shifting and time stretching, based on granular synthesis
- "sound-slicer", a 256 band filter, based on FFT analysis-synthesis
- "reverberation"
- "freezing", freezing technique based
- "echo", based on delay-harmonizer techniques,
- "sound-surfer", based on granular synthesis,
- "sound-cross", based on Vocoder techniques.



I = Area input (here, a sound produced with a knife on a glass bowl is displayed)
T = processing area (here, T1 = "sound-presser", T2 = "sound-slicer", T3 = "reverb)
O = area output, P = preset area

Figure 12. M_orph.

4. EVALUATION

Software evaluation can hardly be separated from the evaluation of educational activity that they are designed for.

Items to observe are:

- Qualty of the children's interaction - machine: how much time children spend in completing tasks, how many questions they make about software functions, before starting to use it correctly, level of interest and involvement.
- Quality of interaction among children: level of autonomy in discussing results and realization processes together, ability to criticize other works, ability to improve their own work following other children's suggestions.
- Quality of products: complexity of results, coherence between result and intention.

Children's interview, teachers' interview, on site observations and specific monitoring interventions are the main actions for obtaining information. Then, educational teams and school teachers meet together, elaborate the information and evaluate it.

Main observation results are the following.

Children improve their listening skills by listening to sounds in detail and describing them with proper terms; moreover, positive results have also been noticed in other matters, such as language dictation.

Children become judgmental of their own work and that of other pupils, are responsible for their own creation, improve their own self-esteem.

For all children, the sound creation experience in a collaborative environment is an opportunity to express themselves and change their vision of each other; particularly, children with social and learning problems can can reveal a hidden part of their personality

Final performance in theatre is the opportunity to develop solidarity, team spirit and self-control.

5. CONCLUSIONS

Feedback from people involved is extremely positive. Children are quite enthusiastic: they often ask to go on creating sounds and music over the lesson-time. Parents, teachers, observers and school managers think this experience lets children grow up since listening skills, self expressing power and social relations are enhanced.

For these reasons the educational activity is welcome in primary schools, whose mission is a global growth of the child, and in music academies that consider it a first step towards traditional music studies.

In the future, new research will start concerning the recovery of physical gestures on acoustical instruments in a digital sound creation experience, the connection between traditional music education practice and an innovative one, teacher training for making it possible for schools and academies to develop the activity on their own.

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