

Children's Interaction with a Musical Machine

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ABSTRACT

Our project deals with an area still under-studied, that of interactive musical systems, and attempts to understand in what way these systems can affect the learning and the musical creativity of children. We chose to study young children, 3/5 years old, because at this age the problem of the interaction between child and machine takes on a fundamental role in the learning process. An experimental protocol was established to observe selected categories of conducts in children confronting an interactive musical system. Following a preliminary experiment, we used a particular system, the Continuator, able to produce music in the same style as a human playing the keyboard (Pachet 2002).

The experiment was carried out with 27 children of 3/5 years, in an Italian kindergarten. We used a Roland ED PC-180A keyboard as the interface for the Continuator. Three sessions were held once a day for 3 consecutive days. In every session the children were asked to play in 4 different ways: just with the keyboard, with the keyboard and the Continuator, with another child, and both with another child and the Continuator. The tasks were given in random order. All the sessions were recorded on video. We also recorded the music played by the children and the Continuator.

The data analysed until now show a certain number of interesting results, relating to the development of musical style interaction between children and system. In this paper, we will provide some general comments about the children's conducts, both musical and interactive, and give a qualitative analysis of 2 case-studies.

Keywords : music education, artificial intelligence, interactive systems, child/computer interaction.

1. INTRODUCTION

The present study deals with an area still under-studied, that of interactive musical systems, and attempts to understand in what way these systems can affect the learning and the musical creativity of children. In particular, we chose to study young children, 3/5 years old, because at this age the problem of the interaction between child and machine takes on a fundamental role in the learning process.

The relationship between new technology and learning is gaining more relevance in the field of music education. The majority of the studies carried out until now regard the new technologies as pedagogical tools (Webster 2002, Gaggiolo 2003), or as "transparent" instruments that allow children, even outside of scholastic contexts, to make and produce music (Folkestad 1996). However, only a few studies have considered the nature of the interaction between children and musical machine (Mazzoli 2001). From this point of view, studies in the domain of artificial intelligence are bringing about interesting results (e.g. Camurri-Coglio 1998).

At the Sony CSL, a system was elaborated able to produce music in the same style as the person playing the keyboard, the Continuator (Pachet 2002). An important consequence of this approach is that the phrases generated by the Continuator are similar but different from those played by the users. This system is based on the notion of Interactive Reflective systems. The core concept of this approach is to teach powerful – but complex – musical processes (such as tonal harmony, improvisation, etc.) indirectly by putting the user in a situation where these processes are performed not by the user (as in the traditional master / slave approach) nor by the machine (as in some ITS approaches), but by the actual interaction between the user and the system. A preliminary study was conducted in Paris with eight children of 3 and 4 years, who were invited firstly to play a keyboard and then the keyboard connected to the Continuator. A certain number of interesting results were

obtained in this experiment, relating to the power of attraction/addiction, the increase in time of attention, and the development of analytical behaviour (e.g. concentration and listening) (Pachet, Addressi 2004).

We trialled a second experimental protocol to observe systematically some interesting aspects highlighted in the preliminary experience, and to study the nature of the interaction between children and system. From a pedagogical point of view, the general aim is to understand in what way the children relate with the interactive musical systems, what kinds of musical and relational behaviours are developed, and how the interactive systems can be used in the educational field to stimulate creativity and the pleasure of playing.

In this paper we will describe the experimental protocol carried out in Bologna in March 2003, the method we are using to analyse the video-data, and some preliminary results. In particular we will show 2 case studies of child/computer style interaction. Finally, we will discuss some conclusions about the project.

2. THE EXPERIMENTAL PROTOCOL

An experimental protocol was elaborated to systematically observe selected categories of "conducts" of children using interactive musical systems. We used the term "conduct" in accordance with the French term "conduite" used and scientifically defined by Pierre Janet, Jean Claparède and Jean Piaget. In the musical field this concept has been used by Delalande (1993).

The observation was trialled in the Nursery School "La Mela" of Quarto Inferiore (Granarolo, Bologna – Italy), in collaboration with the Istituto Comprensivo of Granarolo. The collaborators were a teacher of the school, also tutor at the Faculty of Education (University of Bologna), two neo-graduates in Education, the other teachers of the school and the parents of the children.

In this phase of the project we observed just a small number of children: this will serve both to obtain some observable and interpretable data and to define the procedure. Later, the observation will involve a larger number of children. Twenty-seven children aged 3/5-years participated in the trial.

Our aim is to observe the children's musical conducts (motion, exploration of the keyboard, listening, music improvisation) and the conducts of interaction (attention span, turn-taking, symmetrical communication, etc.). In particular we want to observe if these conducts change, and how they change, when the child plays the keyboard alone, with another child, or with the keyboard connected to the Continuator, and whether these conducts change, evolve, and how they evolve if the experience is repeated for 3 days. Finally, we intend to describe and analyse the children's musical improvisations, and observe if there is musical learning and an understanding of the musical rules of the systems.

2.1. Method

We used 5 kinds of data collection:

1. *Observation of video recordings and photos*: Taking into

account both the age of the children (3/5 years) and the desire to maintain a setting in which they are comfortable, we chose to use the observation method, which allows us "to describe" the conducts of the children without changing their daily routine. It is possible to make a controlled observation, according to Piaget's "quasi experimental" model, involving the continual and systematic observation of the "conducts" in the field, and based on various hypotheses, with variables to check (Camaioni et al. 1988, Mantovani 1998). The independent variables are the "partners" with whom the children were invited to play (the solo keyboard, the Continuator, another child), the exposure to the experience (once daily for 3 consecutive days), and the age of the children (3-5 years). The dependent variables are the children's musical conducts (listening, exploration of the keyboard, musical improvisation) and the children's interaction with the system.

2. *Audio recorder* of the improvisations played by children and Continuator. From a musical production point of view, both the "process" (i.e. the transformations of the children's musical improvisations that take place during each successive session) and the "product" (i.e. the improvisations themselves) were observed and analysed (Mialaret 1997; Folkestad 1998).

3. *Drawings*: The children were asked to draw the experience one week after the video recording.

4. *Questionnaire*: The parents was asked to complete a questionnaire about the musical taste and experience of their children, and about their interaction with computer, TV and hi-fi.

5. *Profile of the children*: The children's psycho-pedagogical profile elaborated by the teachers were collected.

Equipment

We used the following interactive system: the Continuator, a Roland ED PC-180A keyboard as the interface, a Roland expander, a pair of amplified loudspeakers, computer, video camera, digital camera.

The basic playing mode of the Continuator is a particular kind of turn-taking. This mode is based on a strict alternation of turns using three principles: 1) Automatic Detection of phrase endings: the Continuator detects phrase endings by using a (dynamic) temporal threshold (typically about 400 milliseconds). When a time lapse exceeds this threshold, the Continuator takes the lead, and produces a musical phrase; 2) The duration of this phrase is parameterized: in the present experiment the duration was set to be the same as the duration of the last input phrase played by the child; 3) Priority to User: if the user decides to play a phrase while the Continuator is still playing, then the Continuator will stop, and return to an observation mode, in order to create a possible continuation. These parameters are set without explicitly telling the users.

Procedure.

Preliminary meeting: the observation was preceded by short meetings between the operators and the children. During these meetings game activities were made, also involving the keyboard and the Continuator. The aims of the meetings were to present the staff to the children, to get to know the children, and to prepare the children for the experimental activities.

Video and audio recording: in the following days the video observation took place. Video and audio recordings were made in the small library of the school, suitably equipped. In this

space the keyboard was placed on a table in front of the children. The portable computer was placed on a nearby table. A video camera (not visible to the child) was positioned in front of him/her, in order to record both the hands and face. One collaborator worked with the video camera, while another operator worked with the children and the computer. The sessions were individual (1 child) or in pairs (2 children). The children were supervised in the library by the operator or by the teacher. The operator gave the assignment to the child (if necessary he turned on the computer), and while the child was working, he either stayed in the same room and kept busy (reading, tidying, etc), or left the room. The children were left increasingly on their own until the third session, when they were alone in the room.

The children were asked to play in 4 different ways: with just the keyboard, with the Continuator, with another child, and finally with both another child and the Continuator. The operator asked the child to perform the following "musical games":

The child alone:

Game A. "Play the keyboard as long as you like. When you are tired, call me" .

Game B. "Play the keyboard, which will answer back, for as long as you like. When you are tired, call me" (For this task the operator launches the Continuator through the computer)

The child with another child:

Game C. "Play the keyboard together for as long as you like. When you are tired, call me"

Game D. "Play the keyboard, which will answer both of you back, for as long as you like. When you are tired, call me" (For this task the operator launches the Continuator through the computer).

All sessions were recorded on video.

The music played by the children and the systems were recorded by the same system.

After 1 week the children were asked to draw the experience.

At the same time, the parents were asked to complete the questionnaire.

The teachers were asked for the profile of each child.

2.2. Data Analysis

Data analysis will be carried out by means of an observation grid, which is being elaborated by a group of observers. A series of key elements were identified regarding the child/computer relationship, and the child/Continuator interaction, synchronically, that is, independently of the scansion of the three sessions. Finally, two case-studies were selected to obtain more general hypotheses to be tested also on the other children.

3. RESULTS

The data collected were wide-ranging and interesting, and stimulated us to go more deeply into certain aspects, some of which had not been foreseen in the original protocol. They are still undergoing analysis, both qualitative and quantitative.

Some data are discussed in Pachet, Addessi (2004), where the Continuator Project is presented.

In this paper, we report two case-studies, chosen because they present opposing characteristics and allow us to identify more general categories to be used for systematic observation of the data.

To give an idea of the type of data, we will discuss some of the more general aspects that have emerged so far. These should not be taken as final results but nevertheless represent the main categories that will be used to construct the observation grid.

- *Interaction with the system*

The type of interaction observed is sensory-motorial, symbolic (dramatizations, "let's pretend") and rule-based. The children touch and handle all the various objects, they dance, sing, listen, go through different emotional tones, and often express aesthetic opinions. They try to understand the rules of the system. They listen carefully in order to create "musical" dialogues with the system. They also narrate a story while listen to the Continuator.



Figure 1.a: Narrator, player, listener

- Relationship between children and system

Of particular interest are the relationships established between the two children when playing together, and between them and the system: playing, listening, exploring together, watching the partner's reactions, playing separately, alternating, or conflicting.



Figure 1.b: They listen to the keyboard that answers and share perplexity.

- Listening

As already stated, the listening was very careful, both to the

replies given by the system and to their own work. Alberto listens to the system and exclaims: “E’ bellissimo!” (“It’s wonderful”).



Figure 1.c: (c) Listening and ecstasy



Figure 1.d: (d) Listening to the Continuator.

- *Ways of playing, exploring the instrument*
The children explore the keyboard and means of making sound in a myriad of different ways: with their elbows, head, bottom, or forearm, with their hands in their sleeves, chopping, with just one finger, several fingers, the palm of the hand, facing backwards, rubbing, alternating the hands/fingers, etc.



Figure 1.e: (e) with her elbow



Figure 1.f: (f) and his fist.

- *Musical improvisations.* A preliminary analysis of the improvisations revealed rhythmic and melodic patterns, synchronization on the same pulse, forms of song and accompaniment, individual improvisation styles, brief formal constructions based on imitation, repetition, alternance, contrast.

3.1. The “Life cycle” of Interaction:

Two Case-Studies

Generally speaking it was possible to observe an initial dynamic curve that moves from *Surprise* (the *Aha effect*), to a phase of *Excitement*, followed by a period of *Concentration and analytical behaviour*: the “life cycle” of interaction (Pachet, Addressi 2004).

In the two case-studies presented here we concentrate on the quality of the analytical behaviours and the ways in which the child/computer interaction starts, develops, and ends.

We analyse the *attention span* (the time of every “game”) and the *dynamic profile of interaction*, that is the development of the interaction over the 3 sessions.

3.1.1 Case-study n. 1: Repetition, Variation

G., 5 years 10 months.

In the preliminary meeting, G. was immediately interested in the “keyboard that answers”, and passed quickly from surprise (*Aha effect*) to a more careful and analytic approach, commenting aloud: “It repeats...but isn’t exactly the same”.

The order of the ‘games’ was as follows:

Session	Tasks
I	D
II	A, B, C, D
III	B, A, D, C

Attention span

The longest task is B, i.e. when G. plays alone with the Continuator. His attention is almost identical in sessions II and III when he plays alone without the Continuator (A), and with a partner and the Continuator (D). Nevertheless, G. often gets bored when playing alone, stops frequently and sometimes waits for the system to reply. The length of the game with the partner but without the Continuator (C) is considerably shorter, the children have less fun and do not listen to their own productions so carefully. A preliminary analysis of the attention span would lead us to hypothesize a greater interest on the part of G. in the

tasks involving the system, and a preference for direct interaction with the system, and for playing alone.

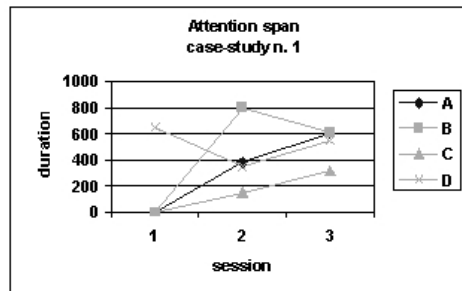


Figure 2: Case study 1: Attention span.

Dynamic profile of interaction

G. starts immediately, displaying concentration and analytical behaviour: he observes and experiments with the rules of the system. In Session I, he plays with his friend and the system (task D). In Session II he asks to start to play alone with the system.

- *Concentration and Analytical behaviour*
Session II, task B. (Fig. 3.a/c).

G. proceeds by trial and error, respecting the turn-taking with the system. He starts by systematically playing first with his index fingers, then two fingers, then with the palm of the hand, exploring the whole range of the keyboard. The procedure develops in a linear fashion, almost going from the simple (one finger, middle register) to the complex (two fingers, the palm etc.; middle, low and high register). He always stops and listens to the system's reply (turn-taking). He listens carefully, unhurriedly, with a concentrated expression. He behaves like an observer introducing variables and trying to understand the results. His relationship with the system is "symmetric" (Fogel 2000): alternation of question and answer between two "frontal" interlocutors.



Figure 3.a.: Session II, task B (a) G. plays with one finger only



Figure 3.b.: Session II, task B (b) then listens to the Continuator



Figure 3.c.: Session II, task B (c) then plays again using all his fingers.

- *Recognition and dialogue*

Session II, task B. (Fig. 3.d/f).

After some minutes, G. plays one note at random (G, *staccato*). The Continuator replies with the same note and adds the octave (G3-G4). G. recognizes his own note like in a mirror: he is surprised and immediately replies with the same note and adds a variation (G-G-A-A-B-cluster). A dialogue based on repetition and variation starts: G. and the system reply and add variations in register, rhythm, modes of playing (G. plays G *staccato*; Continuator: G-G *staccato*; G.: G-G-A-A-B-cluster; Continuator: cluster/rising arpeggio; G.: short cluster; Continuator: cluster, rising 3rd; etc). After around one minute, the repetition/variation disappears, the dialogue ends and G. asks to stop game B.



Figure 3.d: Session II, task B (d) G. recognizes his own notes played by the Continuator



Figure 3.e.: Session II, task B then (e) a musical dialogue starts based on repetition/variation



Figure 3.f.: Session II, task B (f) the dialogue ends.

- *Attachment*

Session III. (Fig. 3.g/h).

G. asks to start the game alone with the system (task B). He starts a strict dialogue with the system, consisting of exploration, repetition, variation. G. plays the first phrase of "Frère Jacques" (C-D-E-C / C-D-E-C), the system repeats with variations (C-D-E-F-G-A-B...). During the next game, without the Continuator (task A), a sort of "listening automatism" is instigated: G. plays and then stops, automatically waiting for the Continuator to reply, which does not happen because in task A the system is not connected. G. starts playing again alone, but still waits every now and then for a reply (e.g. he puts his hand to his ear). A kind of expectation has been instituted, an implicit anticipation of a reply. The type of relationship that could be explained in terms of the theory of "attachment" (Bolwby, Ainsworth, Holmes 1994).

- *The Observer*

Session III, task D (Fig. 3.i).

The interaction continues in the following task (D). G. plays with another child. This time G. does not only observe the system, but also his friend's interaction with the system: he tells him to play, to wait for a reply from the system and watches his reaction of amazement. In this phase G. shows some moments of excitement.



Figure 3.g.: Session III, tasks B, A and D (g) G. faces the Continuator (task B);



Figure 3.h.: Session III, tasks B, A and D (h) he plays then listens, but the Continuator doesn't reply (task A)



Figure 3.i.: Session III, tasks B, A and D

(i) G. observes the surprise of his friend on hearing the reply of the Continuator (task D).

Drawing

The following week G. draws a lot of instruments, the keyboard, the notes and the "music" (yellow lines) coming out of the keyboard. He writes the notes in a conventional way. In fact, from the parents' questionnaire we learn that he listens to classical music, in recordings and at live concerts.



Figure 4: Case-study n. 1. Drawing.

G. draws many “classical” instruments, the keyboard, the notes and the “music” coming out of the keyboard (yellow lines).

3.1.2 Case-study n. 2: From turn-taking to role-taking

T., 5 years 10 months.

T. is fast and becomes involved in the sound. He interacts “in real time” with all the stimuli that he receives from the system, and from the whole set of equipment. He prefers games with his friend and with the system. The moment of excitement also becomes a moment of learning. He learns how to make the system imitate him and how to imitate the system, passing from turn-taking to role-taking. He reaches the Climax and in the last session relaunches his dialogue with the system.

The order of the games was as follows:

Session	Tasks
I	B, A, C, D
II	D, C, A, B
III	A, B, D, C

Attention span

Task D (with another child and the Continuator) is the one that lasts longest. Unlike G., T. prefers the interaction involving three participants: him, his partner and the system. Task B is not very long, but is very significant, because we can observe a passage from turn-taking to role-taking.

The attention span increases also in the tasks without the Continuator.

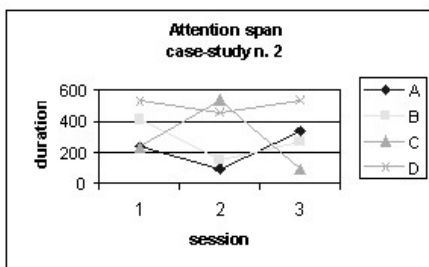


Figure 5: Case-study 2. Attention span.

Dynamic profile of interaction

- *Aha effect, Surprise*

Session I, task B. (Fig. 6.a/c).

T. plays a few notes, the Continuator replies, T. recognizes the repetition. The next reply of the Continuator is much longer than expected, T. shows disappointment and says “It never ends”. He nevertheless waits for the system to stop before playing again, thus respecting the implicit rule of turn-taking. There follows a series of improvisations during which T. uses various styles and listens. At a certain point the Continuator begins to continuously repeat the same note, as if the machine were stuck (maybe actually due to an error in the working of the system); T. notices something is wrong and blocks his ears with an expression of annoyance.



Figure 6.a: Session I, task B. (a) T. recognizes his own notes played by the Continuator (Surprise and excitement)



Figure 6.b: Session I, task B. (b) T. listening to the long reply by the Ctor: “Non si ferma” (“It never ends”) (Turn-taking)



Figure 6.c: Session I, task B. (c) T. puts his fingers into his ears when the system repeats the same note like a blocked machine.

- *Excitement and Learning by “Immersion”* Session I, task D. (Fig. 6.d/i). T. teaches his friend the rules: play, wait and listen to the reply, as the keyboard “plays by itself”. An intense moment of interaction begins: they play and listen, bringing their ears closer to the speakers, they play with their hands, head, bottom; they even introduce the ringing of a cell-phone into the game.

- The rules apply, but also listening, touching, discovering, playing, having fun, provoking amazement, pleasure etc.. T. often imitates his friend.

They discover that the system repeats what they play and learn how to make the system imitate them: the most exciting game is to produce strange sounds (brief sequences of strong, fast and irregular clusters) for the pleasure of hearing the

Continuator repeat them: just like to laughing making funny faces in the mirror. *The moment of excitement also becomes the moment of learning* (learning by “immersion”, Maragliano 1999).



Figure 6.d: Session I, Task D (d) T. stops his friend and teaches him the rules of the system and turn-taking: “Suona da sola” (“Plays by itself”);



Figure 6.e: Session I, Task D (e) They use the ability of the system to imitate the sounds they produce in order to enjoy themselves: they play funny sounds with the aim of



Figure 6.f: Session I, Task D (f) exciting and sharing the excitement, listening to the equally funny reply by Continuator.



Figure 6.g: Session I, task D. Session II, task D. Various interactive conducts of T. and his friend.: (g) They listen to the speakers.



Figure 6.h: Session I, task D. Session II, task D. Various interactive conducts of T. and his friend.:(h) play the keyboard, with the Continuator and the phone;



Figure 6.i: Session I, task D. Session II, task D. Various interactive conducts of T. and his friend.: (i) they both play using their head in synchronization.

- *Concentration and Analytical behaviour. From turn-taking to role-taking.*

Session II, task B. (Fig. 6.l).

T. plays with more concentration and analytical behaviour and tries to understand the system also by looking at the screen of the computer. He plays short musical improvisations. He doesn't explore, he creates music with the Continuator: they play short rhythmic and melodic patterns, repeat and elaborate them, then play short but complex musical phrases. At a certain point he moves towards the lower register and plays C1. The system responds with C4-A5. T. recognizes that the system has played the same note as he had but at a higher register and says "High"; he then goes to the upper register and, imitating the system better than the system had done with his proposal, plays C5, and then goes away saying "Finished". While the Continuator plays B-A.

T. has understood the system, has played with it, has learned to make it imitate him and to imitate the system. It is here, then, that we observe a transition from *turn-taking*, the alternation between two interlocutors, to *role-taking*, the moment when one of the two interlocutors produces his music while also taking the point of view of the other into consideration (Emiliani, Carugati 1985).

- *Climax. From Exploration to Invention.*

Session III, task B. (Fig. 6.m)

T. begins playing energetically, the Continuator relaunches softly and delicately, T. responds with soft and slow notes. For a while they adapt to each other, not with exactly the same notes, but adopting the same "mode" of playing and following the sequence of question, answer, relaunch. Then the dialogue becomes more and more intimate. T. gets up, jumps from the computer to the keyboard, and his movement is mimicked in the music he and the system play. Delightful and amusing to see. It is truly a moment of genuine creativity. T. is no longer exploring the system: they are making music together. A real jam session.

- *Relaunching.*

Session III, tasks C, D (Fig. 6.n).

T. relaunches the repeated notes that the Continuator had played in the first session which had made T. cover his ears, repeating the interval of a minor second like a blocked machine. A three-sided interaction is set up based on this technique. This is followed by a relaunching of the previous explorations, interspersed with pauses when they discuss what to do. Finale (Task C): the Roland expander, with its lights, becomes a bomb to be defused (task D, Fig. 6.n).



Figure 6.l: Session II, task B; Session III, tasks B and D (l) from turn-taking to role-taking: T. plays the C5 just played by the system in reply to the C1 played by T. : he imitates the system better than it imitates him (Session II, task B);



Figure 6.m: Session II, task B; Session III, tasks B and D (m) (Climax): T. plays and moves quickly between keyboard and computer (Climax) (Session III, task B);



Figure 6.n: Session II, task B; Session III, tasks B and D (n) T. and his friend are defusing the "bomb" (Roland expander) under the table. They play and watch the lights on the screen of the expander (Session III, task D).

Drawing

The following week T. draws the table, the computer, the wires, the expander/bomb. But not the keyboard.

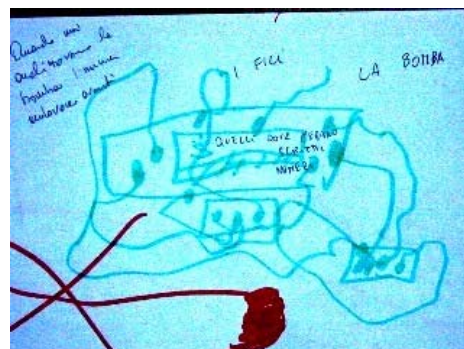


Figure 7a: Case-study 2. Drawings. (a) The page is divided into two parts. In the first column we see the table, the computer, "little men playing", the speakers connected to the computer, the "footprints of the little men" going to play. In the second column T. draws a "free drawing" with water, a ladder, and xylophone.



Figure 7b: Case-study 2. Drawings. **(b)** T. draws the “bomb”, i.e. the Roland expander used for the experiment.

4. DISCUSSION

In the two case studies presented we can observe an interaction between the children and the system that builds up over time, passing through various dynamic states which do not necessarily follow a linear order. We shall now underline the significant aspects of these two cases, interpreting them on the basis of certain theories on development and musical development in children.

- Nature of the interaction

The Continuator stimulates the children to adopt conducts that are very similar to those of humans. The interaction based on repetition/variation allows the children to organize their musical discourse, passing, as in the case of T., from exploration to genuine musical invention. In particular, we note that the moment of climax arrives when the two partners adapt to each other's “mode” of producing sound, and accelerate the times of the turn-taking; once this has been achieved the interaction is concluded, almost like a gesture of liberation from the accumulated tension. A similar structure based on repetition and variation, and temporal dynamics has also been observed by Daniel Stern in the vocal relationship between mother and child, and by Michel Imberty in the field of music. To define this phenomenon they use the term “affective syntonization”.

The very fact that the interaction is so similar to that of humans may perhaps explain why the children find it so exciting: just like in cartoons, where the thing they like most is that “it seems real because is fake” (Mazzoli 2001).

- Learning styles

In the first case G. learns the rules of the system in a “linear” way, from the simple to the complex, by trial and error; in the second case T. learns to use the system by putting all his senses into his involvement with the system and other instruments, and the moment of excitement and that of learning coincide. We are witnessing two different styles of learning, which have been defined as “linear” and “by immersion”. The former is more typical of the “technologies” associated with writing, such as books, while the latter is more linked to multimedia technologies (Maragliano 1999, Mazzoli 2001).

In both cases the system has stimulated a learning strategy for problem solving: during the interaction the children not only

identify the problems of interacting with the system, which also concern the rules governing musical language, but discover the solution to these problems too.

- Styles of interaction

G. proceeds systematically trying to understand the system: he observes it, and observes the reactions of the other children when interacting with the system. He has also made contact with the system, waits for it, and when the reply does not arrive he is disappointed. He is displaying a form of *attachment* (Holmes 1994): when I am close to the one I love I feel good, when I am distant I feel anxious.

In case 2 we see that the child passes from turn-taking, which is the basic playing mode of the Continuator, to role-taking, a term used to imply the ability to consider the point of view of the other (Emiliani, Carugati 1985). These aspects show how, despite the apparent simplicity of the mechanism, the Continuator generates very complex reactions, where the children are expected to form judgements about “Self” and “Other”, and to assume the point of view of the Other in order to judge their own Self. In the Literature these passages are considered crucial for the building the child's Self: the Continuator, or other similar musical systems, could be said to represent the construction of a “musical” Self.

- The rules of the system

The children learn the rules of the system: it replies by playing alone, it replies when you stop playing (turn-taking), repeating what you play, repeating with variations (or “errors”), it is capable of establishing a dialogue made up of repetition/variation, it does not always respect the rules, you can teach the system, the rules of the system can be taught to others. During this process the children pass onto role-taking, and react if the system does not respect the rules: T. shows disappointment when the system plays longer than expected, not respecting the turn-taking; he covers his ears when the system begins to repeat the same note like a machine that is stuck; he corrects it when it repeats inaccurately what he has played. In the end, though, he relaunches exactly what he had considered an error of the system: the repeated notes. He treats it like a teacher would treat an “intelligent error” made by a pupil.

- Musical improvisations

We have seen, especially in case case-study 2, a transition from *exploration* (of the instrument, of the sounds, of the rules of the system) to the *invention* of music (actual improvisation, musical creation for its own sake). It is important to analyse from a musical point of view the processes called into play for this transitional passage and the way the system intervenes, as well as the musical skills developed by the children. In case study 2, in fact, it is the system that has taught the child to play with it, by guiding him from exploration towards musical invention, just like a real teacher.

Both in the exploration and in the improvisations, we can see personal styles in the ways of producing sounds, in the rhythmic and melodic patterns that each child prefers, in the construction of longer sequences. The Continuator, by means of its mirror effect, reinforces these individual styles, and allows them to develop and evolve.

- Rock or classical: the stylistic competences

The way the children play also reflects their musical background: T. plays standing up, moving a lot, his sleeves

pulled down over his hands, often pressing them down on the keyboard, displaying an intense physical relationship with the instrument; G. always plays seated, composed and he draws traditional instruments, with the notes on the staff. The questionnaires tell us that T.'s father is an expert in rock music, whereas G. listens to classical music.

- Listening

The listening conducts are particularly rich and varied: concentrated, analytical, but also symbolic. The children often "dramatize" the sounds they hear, giving them a narrative form or an expressive representation. An important aspect is the quality of their listening to their own productions, heightened by the interaction itself that encourages the children to listen carefully so as to compare their own pieces with the reply and relaunch of the system, and to identify repetitions and differences. As has already been reiterated many times in the world of teaching, listening to one's own musical productions is one of the main objectives of music education (Delalande 1993, Frapat 1994).

- Continuator as a Flow Machine

Finally, the processes observed can be interpreted in terms of the creativity theories of Csikszentmihalyi (1996). A full discussion of this aspect can be found in Pachet, Addessi (2004). Here we shall limit ourselves to pointing out that in case study 2, during the phase of musical invention, it is possible to recognise the conditions described in the Theory of Flow by Csikszentmihalyi (pp.111-113): distractions are excluded from the consciousness, action and awareness are merged, there is immediate feedback to one's actions, step by step, the activity becomes autotelic. Generally speaking we can say that in both case studies a balance between challenges and skills is achieved.

5. CONCLUSION

The two case studies provide some important categories for observing and interpreting data and make it possible to formulate various hypotheses about the nature of the interaction between children and interactive systems. The data analysed until now would suggest that the Continuator, as well as similar interactive systems, is able to develop interesting child/computer interaction and creative music behaviours in young children. We are now preparing an observation grid to analyse systematically all the children that took part in the protocol, and to check the categories established so far, as well as the influence of age. Observation of a larger sample would give more significance to the results. For these purposes a comparative project is being planned that will involve other European countries, and will also include an investigation about the stylistic competences and musical tastes of the children.

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