

## Children dancing with the MIROR-Impro: Does the reflexive interaction enhance movement creativity?

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### ABSTRACT

We introduce an experimental study carried out with children, dealing with embodied cognition, musical creativity and reflexive technology. The reflexive interaction paradigm refers to a particular kind of human-machine interaction based on the mechanism of repetition and variation. We used a reflexive system implemented in the European project MIROR, the MIROR-Impro, able to imitate the styles of the user which is playing an instrument. Our aim was to investigate whether and how the reflexive interaction with the MIROR-Impro can enhance creative processes and the children abilities to improvise in dance education. The study was conducted in two classes of a primary public school, with 47 children aged 7 to 8. We adopted an experimental design involving two groups, experimental (23 children) and control (24 children). Both groups took part in several musical and dancing activities in the classroom with a keyboard (control group) or with the keyboard and MIROR-Impro (experimental group). Before and after the activities, we measured the children motor creativity by using the Thinking Creatively in Action and Movement (TCAM) test, developed by Torrance (1981). Results revealed no significant differences between the results obtained in the TCAM test by the control and the experimental group in the pre-test. Relevantly, in the post-test there was a significant difference between the two groups. In particular, and in line with our hypothesis, there was an increase in the creativity scores of the experimental group with respect to the control group.

### I. INTRODUCTION

In recent years, a growing number of studies indicated that cognitive processes can be influenced by bodily states, both real and imagined (e.g., Barsalou, 2008). The general underlying idea of such *embodied cognition* view is that cognition relies heavily on bodily states, that is, cognition is grounded in physical context. More relevant for us, the importance attributed to the coupling of perception and action leads to more attention to the role of corporeal involvement within music, which in turn emphasizes the importance of multi-sensory perception, perception of movement (kinaesthesia), affective involvement, and expressiveness of music. In particular, “subjective involvement with music may be partly captured by corporeal articulations that reflect actions. These actions are induced by a mirror system that translates moving sonic forms into motor activity” (Leman, 2007, p. 93). Thus, music and its connection with body, mind, and physical environment, and the role of new media technology become the central point for *embodied music cognition* view. This led us to investigate the relation and the influence between music and body by means of an innovative tool, the MIROR Platform (Addressi, 2013).

### A. The MIROR Platform and the Reflexive Interaction Paradigm

The MIROR Platform is an adaptive platform for childhood music education made up of three components: MIROR-Improvisation, MIROR-Composition, and MIROR-Body Gesture. Each component aims to exploit the paradigm of *reflexive interaction* in the field of technology-enhanced learning (Addressi, 2013). The reflexive interaction paradigm is based on the idea of letting users manipulate virtual copies of themselves, through specifically designed machine-learning software referred to as interactive reflexive musical systems. IRMS were first developed at the CSL-SONY in Paris, for adult musicians (Pachet, 2003; 2006). The subsequent experiments with children (e.g. see Addressi & Pachet, 2005) immediately demonstrated the potential of these reflexive systems for the development of creative musical experiences. In Addressi (2014), we discussed the complexity of the processes enacted during a reflexive interaction such as those observed between children and IRMS. One innovative feature of the IRMS is the creation of a natural dialogue with the child. The mechanism of repetition and variation is, in fact, at the heart of reflexive interaction: the system's repetition of the input given by the child allows the child to perceive the response of the system as a sort of sound image of herself. Moreover, this is the moment when the child shows an absolute attraction towards this other that appears similar to herself. Interestingly, this is not a mere repetition/imitation/echo, but rather a repetition that is constantly varied. It is precisely the co-presence of something that is repeated along with something different that seems to make the reflexive interaction a sort of device of attraction first, and then of stimulation of interest to become involved in the interaction. In the context of the MIROR Project, we proposed to extend the IRMS with the analysis and synthesis of multisensory expressive gesture (Camurri et Al., 2001), to increase its impact on the musical pedagogy of young children. We conceived the MIROR application, called MIROR-Body Gesture, as a means to capture children's movements and convert them into “reflexive” sounds (i.e., sounds with the same characteristics as the related movement, like heavy/light, fast/slow, and so on) (Addressi, 2013). By doing so, children could dance and create music through movement, as well as control their own improvisations and compositions. Therefore, the educational aim of this software was to support children as they discovered the dynamic nature of their bodies and the embodied musicality of their own gestures.

In this paper, we will introduce the theoretical framework of reflexive embodied interaction paradigm, our methodological approach, and the experimental protocol realized with children and the MIROR-Impro in order to

observe the effect of reflexive interaction on children's movement creativity.

### **B. Pedagogical Framework of Reflexive Interaction**

We defined the MIROR platform as a "device" to enhance musical and dance creativity and invention in children (Addessi, 2015). In the pedagogical field, the device has been defined as the concrete mediation that the teacher should individuate in reference to the specific situation, in order to allow children to concentrate their attention on the sound and the movements, and on their characteristics (Delalande, 1993). The pedagogical potential of reflexive interaction is based on the fact that it stimulates the participant to undertake a dialogue during which the repetitions and variations stimulate cognitive conflict that the child resolves during the course of the interaction, giving rise to a learning by problem finding and problem solving. It was observed that the IRMS stimulated and reinforced conducts of an exploratory type, during which the child's actions were co-ordinated with the purpose of exploring the new partner, and were characterized by the systematic introduction of new and different elements. Furthermore, the IRMS prompted inventive conducts, where the aim of the child's actions appeared to be to elaborate particular sounds and musical ideas and to undertake a dialogue with the system through the sounds. IRMS seem able to reinforce the children's individual styles, and allow them to develop and evolve. We observed that the "teaching method" is based on *turn-taking* and *regular timing of turns*, on the strategies of *mirroring*, *modeling*, and *scaffolding* (Bruner, 1983; Vygotsky, 1962), and on starting up *affect attunement*, *intrinsic motivation*, *collaborative interaction*, and *joint attention* (cfr. Imberty, 2005; Stern, 2004). We consider it important to emphasize that the educational effectiveness of reflexive interaction derives from the fact that this develops an intrinsic motivation to participate in a musical dialogue: children can express themselves by means of sounds, which is a fundamental need of children. As Baroni writes: "We believe it is possible to maintain a rigid position of principal, that is, the absolute necessity for the pre-eminence of expression over learning: and this is not only because the construction of expressive objects can be considered the principal goal, but also because it constitutes the only valid and persuasive motivation for learning activities" (1997, p. 141). More recently, Leman (2016) lightened the role of expressivity in human-machine interaction.

In particular, as far as the aims of this study are concerned, we noted that the reply of the system generates interesting motor reaction in children. For example, children like to dance while they are listening to the system's reply (Ferrari & Addessi, 2014), and use creative gestures while playing the keyboard with an IRMS (Addessi & Pachet, 2005). This observation led us to consider the MIROR platform as a helpful device for dance education and motor creativity.

### **C. Reflexive Interaction, Mirror Neurons, and Embodied Cognition**

The observation of children playing and listening to the reflexive system raised several further questions: what is the "motor" perception that children have when they hear a reflexive response by the system? What qualities of movement does the child imagine? What kind of sound-gesture does the system's responses stimulate in the child? And what role does this embodied perception play in the

dialogue between the child and the system? We therefore decided to look more deeply into these questions and this perspective through the framework of body gesture analysis and embodied music cognition. In Addessi (2014), we suggest that the idea of mirroring originated in ancient Western culture and now resonates with contemporary psychological theory of musical embodiments, the link between action and perception, and the mirror system. The capacity to replicate the behavior of others is, to a certain extent, grounded on the mirror neuron system, that is a network of neurons that becomes active during the execution and observation of actions of others. Rizzolatti, Fadiga, Fogassi, and Gallese (2002) hypothesized that there is a very general ancient mechanism, named "resonance mechanism", through which pictorial descriptions of motor behaviors are matched directly with the observer's motor representations of the same behaviors. In the field of embodied music cognition, Leman (2007) stresses that "there is evidence [...] that mirror neurons are amodal in the sense that they can encode the mirroring of multiple sensory channels" and, above all, "mirror neurons perform sensorimotor integration and transformation as the basis of imitation" (p. 91). Therefore, a reflexive interaction can stimulate a resonance mechanism in the child who is interacting with IRMS, as it is grounded in motor areas of the brain. We can argue that when children move or dance while listening to the responses of the Continuator or the MIROR-Impro, they are acting as "embodied" mirrors of the musical response, and in so doing are adding an embodied communication channel to the child-machine interaction. This field of study, and its application in educational sciences, including in music education, is still largely unexplored.

### **D. Motor Creativity in Children**

Although recent research in the field of neuroscience and musical communication has begun to highlight the connection between the motor cortex and social interactions, cognition and emotion, it is worth noting that little attention has been paid to the investigation of motor areas associated with creativity. Maestu and Trigo (1995) defined motor creativity as "the intrinsically human capacity of putting bodily life at the disposal of the individual's potential...in the innovative search for a valuable idea" (p. 623). Several experiments have been carried out with children in the field of creative multi-modal technology, where children interact with a machine by means of body movements, listening, and visual feedback (e.g., Friberg & Kallblad, 2008). However, measuring motor creativity remains a challenge. The Thinking Creatively in Action and Movement (TCAM) test, developed by Torrance (1981), could prove to be a useful instrument. The TCAM was designed to measure some kinds of creative thinking abilities of children, i.e. fluency (the number of different, appropriate responses), originality (evaluated according the criterion of statistical infrequency), and imagination (how the individual is able to imagine and adopt the six roles proposed). It has been designed to measure these abilities in preschool and primary aged children ranging ages three to eight. It was developed to test creativity through various movement and manipulation exercises. In fact, different activities are proposed requiring only kinesthetic responses to children, thus avoiding possible difficulties in expressing their thought through language and drawing. More specifically, the test

consists of the following four activities: Activity I, “How Many Ways?”, is designed to measure the child’s ability to move in alternate ways across the floor, and it is scored in fluency and originality; Activity II, “Can You Move Like?”, is designed to measure the child’s ability to imagine and assume roles by moving like animals or objects, and it is scored only in imagination; Activity III, “What Other Ways?”, is designed to test the child’s ability to accomplish a simple task in alternate ways, and it is scored in fluency and originality; Activity IV, “What Might It Be?”, is designed to measure the child’s ability to invent a variety of uses for a simple common object and it is scored in fluency and originality. The TCAM is simple to be used, it has good reliability and validity, and it seems not influenced by a variety of factors such as gender, race, language, and culture. Even if one limitation of the test is that since 1981 it has not been renormed or updated (Kim, 2006), it is worth noticing that it represents an interesting instrument to the field of creativity’s measurement, since it allows to examine and measure abilities in young children.

Furthermore, in the field of children’s movement education, the Educational dance inspired by the theory of Rudolf Laban (1879-1958) proposes a model based on the fruitful integration of intellectual knowledge of movement and creative physical activity. In fact, in *The Mastery of the Movement* (1950/1980), Laban did not propose a list of exercises for training movement, but presented several grids of analysis and observation, beginning with the natural, everyday movements of children (cfr. Preston-Dunlop, 1980; Smith-Autard, 1992).

## E. Studying Reflexive Embodied Interaction

In the framework of the MIROR project, we carried out several studies on reflexive embodied interaction using the MIROR-Body Gesture and the MIROR-Impro, following three levels of investigation (cfr. Addressi et Al., 2015):

*User requirements of the reflexive embodied interaction.* Firstly, the UNIBO team listed several requirements concerning the reflexive embodied interaction with the MIROR-Body Gesture, which are: *Mirroring*: during the interaction with the system, the user should have the perception that the sound produced by the system is a virtual copy of her/his movement, *Repetition and variation*: the system should introduce several variations in real time, creating a scaffolding of complexity throughout the interaction. This would allow one to witness a “dialogue” between the child and the system, where each “partner” repeats and varies something, in movement and sound, *Turn-taking*: during the interaction the child should have the possibility to alternate her/his turns with those of the system, *Regular turn-timing*: in the case of turn-taking, the system’s reply should have the same duration as the child’s input, *Adaptive*: the system should “learn” from and adapt, in real-time, to each user. That is, the system learns from the way each child moves her/his body, *Co-regulation* between child and system. The child should not be asked to adapt her/his movements to the system, *Objectives* should be co-invented by the child and the system. The technological partner worked to implement the MIROR-Body Gesture based on the abovementioned requirements, and the pedagogical partner conducted experiments with the children, in order to verify if the requirements were implemented.

*The grid of Sound/Movement Reflexive Connection.* The second level of investigation was the relation between the child’s movements and the sound produced by the system. According to Godøy and Leman, the “analysis of sound, in particular the movements in sound, can therefore be used as a starting point in identifying sound-related musical gesture” (2010, p. 6). In the case of a reflexive system, this means that the related sound and gesture should give children the perception that the sound is a sort of virtual copy of her/his gestures. Aiming to implement a reflexive sound-related musical gesture, UNIBO team created a grid of correlation between Laban movement parameters (Laban, 1950/1980) and musical features (Baroni, 2003). The particular interest of this grid is that the musical qualities were obtained by observing children making sounds, and by interviewing them. For example, in a first exploratory study (Addressi, Cardoso, Maffioli, Regazzi, Volpe, & Varni, 2013), focusing on Laban’s Effort principle of Weight (heavy and light), three 7-to-8-year-old girls were asked to play and describe, in a non-structured interview, the qualities of heavy and light sounds. The Genoa team used these results to implement the sound reply of the MIROR-Body Gesture, and the UNIBO team carried out several experiments to test it with children.

*The Grid of Laban Movement Analysis (LMA) and the TCAM test.* In order to measure the improvement of the quality of children’s movements, we used the TCAM test (Torrance, 1981), as described ahead, and also implemented an original grid, by means of the software Observer based on the Laban Movement Analysis (LMA). The LMA was originally created to analyze movements of dancers, and also had a wider application in the field of dance/movement education. Our grid includes the 6 aspects of the Laban Movement Analysis (1950), that is: Body, Space, Time, Weight, Flow, and Effort (labeled “Behaviors” in the grid). We are currently using this grid to observe and measure the qualities of children’s movements when they use and do not use the MIROR applications, in several experimental protocols.

We carried out two main studies with children to study reflexive interaction in an embodied context: the first study was realised with the first prototype of the MIROR-Body Gesture (cfr. Addressi, Maffioli, Anelli, 2015). In this paper, we introduce the second study realised with the MIROR-Impro. From a pedagogical standpoint, the first aspect that needed to be investigated was the correspondence between movements and sounds. In the first study with the MIROR-Body Gesture, a video archive addressing different parameters of Laban Movement Analysis (Effort, Body, Shape, Space) was created with video-recordings of children performing movements and sounds. The video archive was complemented with informal interviews with children. This study focused on the Weight component of Laban’s Effort ranging from light to heavy. Three young girls were involved (one 7-year-old and two 8-year-olds). Two specialist music/dance educators led the activities and five researchers documented the activities in video format. To stimulate their experiences with concepts of light/heavy, children played games, danced and used musical instruments. Examples included children acting like an object or an animal, reproducing their heavy or light movements, and producing corresponding sounds. These activities allowed us to collect and test various scenarios involving children and the



MIROR-Body Gesture. We were able to analyze Laban's Effort features heavy/light in children, collect videos to be used for subsequent work, test equipment, software, materials and space, as well as share ideas and pedagogical concerns with primary school teachers about the ecological setting for the experiments, the potential uses of MIROR-Body Gesture in schools, and activities for teacher education. Video-recordings were used for automatic analysis and system training by the Genoa team (for more details, see Addressi et al., 2013; Volpi et al. 2012).

The second experimental protocol to investigate the reflexive embodied interaction was carried out in Bologna using the MIROR-Impro, one of the three MIROR applications, to investigate if a reflexive interaction could enhance the qualities and creativity of children's movement.

## II. METHOD

The study was conducted in two primary school classes with 47 children, aged 7 to 8. We adopted an experimental design involving two groups, experimental (23 children) and control (24 children). Both groups took part in several activities in the classroom with a keyboard. The experimental group also accessed the MIROR- Impro. In both cases, one child at a time played the keyboard while the others were invited to dance and move while listening to the music produced by the child (control group) or by the child and the MIROR-Impro (experimental group). Once again, a dance teacher and a researcher led the activities. Children were tested on the TCAM before and after the activities took place. Our main hypothesis was that children who took part in the activities involving the reflexive reply of MIROR-Impro (experimental group) would show a significant increase in the creativity and quality of their movement, compared to the control group.

### A. Equipment

MIROR-Impro v. 3.14; a music synthesizer KORG X50; a notebook; 2 amplifiers M-AUDIO AV30; an USB cable for the connection between the synthesizer and the notebook; a video camera, CANON (recording in HD); a tripod for the video camera; a cd player.

### B. Procedure

Firstly, a *meeting with one of the teachers* was carried out in order to present the MIROR project. The consent forms signed by the parents of the children involved were collected by UNIBO.

1) *Preliminary meeting*: The children and the teachers were invited to meet the dance teacher and the researcher in the room where the protocol would be realized. The activities of preliminary lesson were conducted to allow the UNIBO team to know the children and vice-versa, to introduce activities related to the body movement, and to motivate the children to participate.

2) *Pre-Test and Post-Test*: Before and after the experimental activities, the children were asked to carry out the test. In the room a dance teacher and a researcher were present. The test was leaded by the dance teacher; the researcher prepared the setting and control the equipment, she

did not interact with the children however she replied to them if they question.

3) *Task*: we used a modified version of the TCAM Activity 2 "Can you move like?" of TCAM test (1981), which is designed to measure the child's ability to imagine and assume roles by moving like animals or objects, and it is scored only in imagination. Imagination score is based on a five-point Likert scale, ranging from "no movement" to "excellent, like the thing". This activity allows to measure the child's ability to imagine and assume a role. We decided to administer five of the six tasks proposed in the original test and to add three more items. In addition, we chose to require children to move forward (towards the camera) and, when they arrive on the line, to stand still in the last position they had. In the following we report our modified instructions and questions' list: "Now we are going to do some fun things. We are going to pretend. Sometimes we pretend we are birds, elephants, or horses. Now I'm going to name several things and you can pretend that you are doing them. You don't have to tell me anything. You can just show me.

- Can you move like a tree in the wind? Imagine you are a tree and the wind is blowing very hard. Show me how you would move by moving forward towards the camera. When you arrived on the line, stand still in the last position you had.
- Can you move like a rabbit? Imagine you are a rabbit and somebody is chasing you. Show how you would hop by moving forward towards the camera. When you arrived etc.
- Can you move like a fish? Imagine you are a fish in a river or pond. Show how you would swim by moving forward towards the camera. When you arrived etc.
- Can you move like a snake? Imagine you are a snake crawling in the grass. Show how you would crawl by moving forward towards the camera. When you arrived etc.
- Can you move like you are driving a car? Imagine you are driving a car on the highway. Show how you would drive by moving forward towards the camera. When you arrived etc.
- Can you push an elephant? Imagine a big elephant is standing on something you want. Show how you would push him to make him move off of the thing you want by moving forward towards the camera. When you arrived etc.
- Can you move like an alga? Imagine you are an alga in the water. Show me how you would move by moving forward towards the camera. When you arrived etc.
- Can you move like you are in the fog? Imagine you are walking in the middle of a dense fog. Show me how you would move by moving forward towards the camera. When you arrived etc.
- Can you move backward? Show me how to move forward towards the camera. When you arrived etc."

4) *Experimental activities*: both groups participated to 4 lessons, one for week. Control Group: In each lesson, the children improvised several body activities by listening to a child playing a keyboard. Experimental group: In each lesson, the children improvised several body activities by listening to a child playing a keyboard with the MIROR-Improvisation. All the activities were video recorded. One example of activities is showed in Table 1.



**Table 1. One example of activity**

Experimental group
<i>1. Warm-up Activities:</i>
- We are all musicians. Ask the musician to freely play the keyboard. The other children sit on the ground in pairs, one child behind the other. Child (A) plays the back of his/her companion as if it were a keyboard, trying to tune in exactly the movement of his/her fingers to the sound he/she hears. Later on, it will be child (B) to play his/her companion's back.
<i>2. Exploration, Production and Improvisation Activities</i>
- On the moon. Ask the group to imagine they are animals, aliens, and rocks of the lunar landscape. The musician produces strange sounds to provide a soundtrack to lunar animals (flying animals during the musician's proposal and creeping ones during the system response), to aliens (walking forward during the musician's proposal and backward during the system response), and to rocks (rolling over during the musician's proposal and freeze into a shape during the system response).
- Stars. Ask the musician to play the music of the stars. The group is divided into smaller groups of 6 children each, arranged in a circle and holding hands; 3 children are bowing and 3 are standing on their feet alternately. During the musician's proposal and the response of the system the children move keeping hand in hand and they trade position (standing and crouching).
<i>3. Wrap-up Activities</i>
- Dance of the pianist. A child plays in a cheerful way and the motion group dances freely in space, imitating with the hands those of the pianist, and playing in the air.
Control group
The same activities carried out with the experimental group, but children moved following only sound proposed by the musician without listening to the system response.



**Figure 1. Children during the activity of exploration of the movements as animals, aliens, or rocks on the moon.**

### C. Data Collected

- Preliminary meetings: video 1, duration 60 min.; video 2 duration 60 min.;
- Pre Test: 2 videos of welcome activities, total duration 10 min.; 2 videos of groups organization and delivery, total duration 20 min.; 18 videos of task execution, total duration 80 min.;
- Post-test: 2 videos of welcome activities, total duration 10 min.; 2 videos of groups organization and delivery, total duration 20 min.; 18 videos of task execution, total duration 80 min.;
- Sessions with MIROR-Impro (Experimental group): 4 videos;

- Sessions without MIROR-Impro (Control group): 4 videos.

### D. Data Analysis

Quantitative analysis of data collected in pre- and post-tests have been carried out. The analysis was based on observational methodology. The software Observer (Noldus) was used for the registration and quantitative analysis of the video analysis and further software for the statistical analysis. Children absent during the pre or post-test were excluded from the analysis. For this reason the final sample consisted of 42 children: 19 children in the Control group and 23 children in the Experimental group. The data of motor creativity were assessed in two sessions, namely during the pre-test and post-test sessions. The activities of pre-test and post-test were analysed in a twofold way, as presented in the following paragraphs.

1) *The TCAM Torrance Test.* The activities of pre-test and post-test were analysed as reported in the administration, scoring, and norms manual of TCAM Torrance test. Each task was rated with a score from 1 to 5, on the basis of the quality, adequacy, and elaboration of each movement. The "Imagination" score was determined by adding the nine tasks. Two judges, i.e. the dance teacher and the researcher who carried out the experimental protocol, were required to independently watch the videos of pre and post-test activities and to evaluate the children performance by using a 5-point scale. They followed the guidelines provided in the Torrance's manual, integrated with some additional indications included by the two judges after preliminary evaluations of the videos. In the following we report the final guidelines. *Criteria for scoring:* Observe the video as many times as you deem useful and assess the child's performance in each activity on a scale of 1 to 5, marking the score on the answer sheet: 1 point is assigned only when the child does not move and is completely unable to imagine him or herself in the assigned role; 2 points are assigned when some effort is made to enact the assigned role but the enactment is grossly inadequate, does not approximate the action called for, or does not meet the requirements. The action is therefore not refined, careless and linked to a stereotypical execution; 3 points are assigned when the enactment is adequate and recognizable, but when there is no interpretation, elaboration, or expansion of the role. Only minimal standards of adequacy are attained. The object, animal or action is recognizable but without a personal interpretation; 4 points are assigned when the enactment exceeds minimal standards of adequacy and when there is some degree of imagination in interpreting and elaborating the role. The object, animal or action is marked by personal elements; 5 points are assigned when there is definite indication of personal involvement, interpretation, and elaboration, and when the action and the movement tells a story beyond the assigned role. The enactment may be accompanied by sound effects, facial expression, etc. there are clear indications of improvisation and variations in the action executed.

2) *The Grid of Laban Movement Analysis.* The Laban Movement Analysis grid, created with the software Observer (Noldus) during the first exploratory study described above, was used for the registration of the observations. Analyses on

observations registered with the Laban Movement Analysis grid are still in progress. In this paper we provide some partial results related to the analyses carried out on the four Effort behaviours (i.e. Flow, Space, Time, and Weight). In the following we report the definitions of the behaviours included in the Effort, elaborated with the software Observer. The definitions are extracted by the book “The Mastery of Movement” (Laban, 1950, 4th edition 1980). *Effort* expresses the way in which shape of movement is executed, it is a mental impulse from which movement originates. From the point of view of Rudolph Laban effort’s theory, there would be four main factors that make up the dynamics of movement:

- *Effort Space (direct or indirect)*: “The Effort element “direct” consists of a straight line in direction and of a movement sensation of threadlike extent in space, or a feel of narrowness. The effort element “flexible” consists of a wavy line in direction and of a movement sensation of pliant extent in space, or a feel of everywhere-ness” (Laban, 1950, p. 73);
- *Effort Time (sustained or sudden)*: “The Effort element “sudden” consists of quick speed and of a movement sensation, of a short span of time, or a feel of momentariness. The effort element “sustained” consists of slow speed and of a movement sensation of a long span of time, or a feel of endlessness” (Laban, 1950, p. 73).
- *Effort Weight (light or strong)*: “The Effort element “firm” consists of a strong resistance to weight, and a movement sensation, heavy, or a feel of weightiness. The effort element “fine touch” or “gentle” consists of weak resistance to weight and of a movement sensation, light, or a feel of weightlessness” (Laban, 1950, p. 73).
- *Effort Flow (free or bound)*: “The Effort element of “bound” or hampered flow, consists of the readiness to stop normal flux and of the movement sensation of pausing. The Effort element of “free” flow, consists of released flux and of the movement sensation of fluid” (Laban, 1950, p. 76).

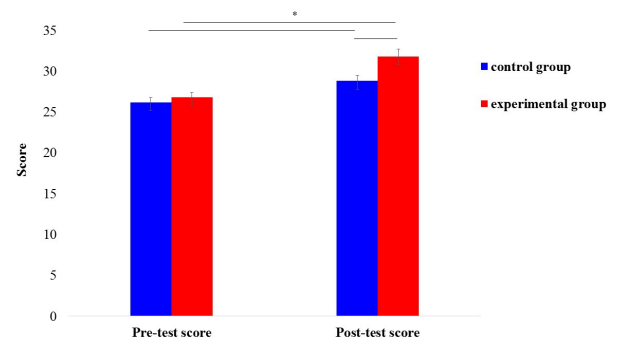
The combination of these 8 possible ways of executing any movement would create the variations in its dynamic. Two independent observers, i.e. the dance teacher and the researcher who carried out the experimental protocol, registered the observation of the behaviours and the modifiers, considering the definitions of behaviours presented above. Before starting with observations, some trials were conducted and then a reliability test within the observers has been realised before starting the registrations. The level of agreement between observers was high ( $Kappa = 0.83$ ,  $p < .001$ ) “.81–1 = almost perfect” (Landis & Koch, 1977) and the cases of disagreement were solved with discussions. Then each observer independently started her own observations: half of the children we reassigned to each observer.

### III. RESULTS

After the scoring, the “Imagination” score was calculated by each judge for each child by adding the nine evaluations. The final “Imagination” score for each child was calculated by averaging the two scores obtained by the two judges and was considered for the statistical analysis. The final “Imagination”

scores, that we considered as a creativity score, were submitted to a 2 x 2 repeated-measures analysis of variance (ANOVA) with the Session (pre-test vs. post-test) as the within-subjects factor and the Group (experimental vs. control) as the between-subjects factor. Newman-Keuls post-hoc tests were also conducted on significant interactions.

The main effect of Session was significant [ $F(1, 40) = 59.71$ ,  $MSe = 5.05$ ,  $p < .001$ ]. The creativity score was higher in post-test ( $M = 30.3$ ) than in pre-test ( $M = 26.5$ ) session. Most important, the interaction between Session and Group was significant [ $F(1, 40) = 5.68$ ,  $MSe = 5.05$ ,  $p < .05$ ]. Data are shown in Figure 1. Post-hoc test revealed that in the pre-test session there was no a significant difference between the control and the experimental group ( $M = 26.1$  vs.  $26.8$ ,  $p = .62$ ), whereas in the post-test session there was a significant difference between the control and the experimental group ( $M = 28.8$  vs.  $31.8$ ,  $p < .05$ ). In addition, from the pre-test to the post-test session there were statistically significant differences, for both the experimental and the control group (both  $ps < .01$ ).

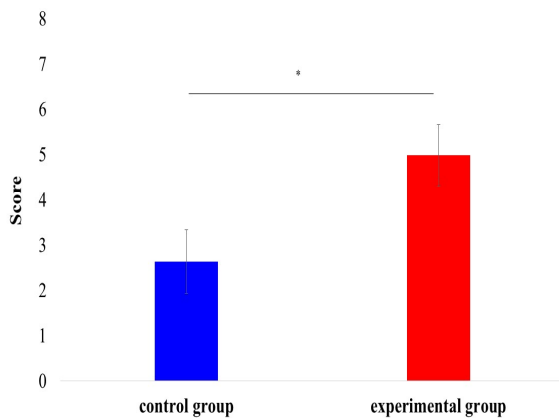


**Figure 1. ANOVA on final “Imagination” scores. Significant Session and Group interaction. Asterisks indicate statistically significant comparisons. Bars are SEM (standard error of mean).**

In order to better understand these results, we calculated for each child a score subtracting the post-test score to the pre-test score and then we submitted these new scores to a univariate ANOVA with Group (experimental vs. control) as between-subjects factor. The effect of Group [ $F(1, 40) = 5.67$ ,  $MSe = 10.09$ ,  $p < .05$ ] showed a significant difference between the two groups as far as the score. More specifically, the experimental group obtained a higher increase in this score ( $M = 4.98$ ) with respect to the control group ( $M = 2.63$ ), (see Figure 2).

#### A. Laban Movement Analysis

Analyses on observations registered with the Laban Movement Analysis grid are still in progress. In the following we provide some partial results related to the analyses carried out on the four Effort behaviours (i.e. Flow, Space, Time, and Weight) on tasks 6 and 7. We considered the two levels for each Effort behaviour separately (i.e., Flow: bound and free; Space: direct and flexible; Time: sudden and sustained; Weight: heavy and light). We carried out separate analyses, considering the total numbers (i.e., the number of times the selected event occurs in the observations related to each group in each session) and percentage on analysed duration (i.e., the percentage of time length of an event calculated over the total



**Figure 2. ANOVA on scores obtained by subtracting the post-test score to the pre-test score. Significant Group effect. Asterisk indicates statistically significant effect. Bars of error are SEM (standard error of mean).**

duration of the analysed observations, related to each group in each session) of each behaviour level. The total numbers of each Effort behaviour level were submitted to chi-square tests, considering Session (pre-test vs. post-test) and Group (experimental vs. control). Total numbers and chi-square results are shown in Table 4. When total numbers are 0, the chi-square test cannot be executed. The percentages on analyzed duration of each Effort behaviour level were submitted to a 2 x 2 repeated-measures analysis of variance (ANOVA) with Session (pre-test vs. post-test) as the within-subjects factor and Group (experimental vs. control) as the between-subjects factor. Fisher's LSD post-hoc tests were also conducted on significant interactions. When variance of percentage on analysed duration is 0, the ANOVA test cannot be executed (in Table 5 these cases are indicated with "N.E."). In the following we only reported significant results.

- Task 6, behaviour Effort Flow – bound: the significant main effect Group [ $F(1, 40) = 4.74$ ,  $MSe = 2110.7$ ,  $p = .04$ ] showed higher percentage in experimental ( $M = 81.2$ ) than in control ( $M = 59.3$ ) group.
- Task 6, behaviour Effort Time – sudden: the significant main effect Group [ $F(1, 40) = 4.32$ ,  $MSe = 1286$ ,  $p = .04$ ] showed higher percentage in control ( $M = 21.8$ ) than in experimental ( $M = 5.4$ ) group.
- Task 6, behaviour Effort Time – sustained: the significant main effect Group [ $F(1, 40) = 14.83$ ,  $MSe = 1790$ ,  $p < .001$ ] showed higher percentage in experimental ( $M = 87$ ) than in control ( $M = 51.3$ ) group.
- Task 6, behaviour Effort Weight – heavy: the significant main effect Group [ $F(1, 40) = 4.07$ ,  $MSe = 2032.3$ ,  $p = .05$ ] showed higher percentage in experimental ( $M = 84.8$ ) than in control ( $M = 64.9$ ) group.
- Task 7, behaviour Effort Flow – free: the significant main effect Session [ $F(1, 40) = 7.98$ ,  $MSe = 1167.9$ ,  $p < .001$ ] showed higher percentage in pre-test ( $M = 77.2$ ) than in post-test ( $M = 56$ ) session.
- Task 7, behaviour Effort Flow – free: the interaction between Session and Group was significant [ $F(1, 40) = 7.16$ ,  $MSe = 1167.9$ ,  $p = .01$ ]. The Fisher's LSD test revealed that the control group in pre-test session registered higher percentage with respect to the control group in the post-test

session ( $M = 94.7$  vs.  $53.5$ ,  $p < .001$ ), to the experimental group both in the pre-test ( $M = 94.7$  vs.  $59.6$ ,  $p = .01$ ) and in the post-test sessions ( $M = 94.7$  vs.  $58.4$ ,  $p = .01$ ).

- Task 7, behaviour Effort Space – flexible: the significant main effect Session [ $F(1, 40) = 7.31$ ,  $MSe = 132.9$ ,  $p = .01$ ] showed higher percentage in pre-test ( $M = 77.6$ ) than in post-test ( $M = 56$ ) session.

- Task 7, behaviour Effort Time – sudden: the significant main effect Session [ $F(1, 40) = 23.58$ ,  $MSe = 1233.2$ ,  $p < .001$ ] showed higher percentage in pre-test ( $M = 61.3$ ) than in post-test ( $M = 23.97$ ) session.

- Task 7, behaviour Effort Time – sudden: the interaction between Session and Group was significant [ $F(1, 40) = 6.49$ ,  $MSe = 1233.2$ ,  $p = .01$ ]. The Fisher's LSD test revealed that the control group in pre-test session registered higher percentage with respect to the control group in the post-test session ( $M = 78.9$  vs.  $22$ ,  $p < .001$ ), to the experimental group both in the pre-test ( $M = 78.9$  vs.  $43.7$ ,  $p = .01$ ) and in the post-test sessions ( $M = 78.9$  vs.  $26$ ,  $p < .001$ ).

- Task 7, behaviour Effort – Time sustained: the significant main effect Session [ $F(1, 40) = 7.89$ ,  $MSe = 1412.2$ ,  $p < .01$ ] showed higher percentage in post-test ( $M = 39.8$ ) than in pre-test ( $M = 16.68$ ) session.

#### IV. DISCUSSION AND CONCLUSION

The present research was aimed to investigate how the MIROR-Impro can enhance creative processes and the children's abilities to improvise and compose, and how reflexive interaction can enhance creative processes and motor skills in children. Results on TCAM Torrance test revealed that while in the pre-test session the control and the experimental group registered a similar performance, in the post-test session a significant difference emerged between the two groups. In particular, even if both groups increased their performance from the pre-test to the post-test session, a higher score on creativity was registered in the experimental group. This result suggest that, even though the two groups started from the same level of creativity (as demonstrated by the absence of differences between the two groups in the pre-test session), the experimental group showed higher scores in the post-test after the completion of a program based on reflexivity and creativity. As far as the analyses conducted with the Laban grid on the observations, since these are preliminary results, regarding few behaviours and only two tasks, in this paper we aimed to provide some examples of how we will conduct further observations and the related analyses. In order to make broader considerations on the results related to the Laban grid, we'll first need to complete the analyses.

We have suggested several music and movement/dance activities to be performed in a reflexive environment, showing the educational potential of the MIROR applications and the originality of our approach to technology-enhanced learning for children's music and movement education. In the proposed activities, children experience reflexive interactions by making music or by means of listening and body movements. These experiences allow the child musician to invent music, dialogue with sound, and strengthen her/his musical ideas, while dancer/mover children refine the quality of their motor experiences and perceive the embodied qualities of music.



The mechanism of repetition and variation, in turn, gives rise to a process of co-regulation between the children and the machine (see learner-centered learning in Bruner, 1983). This creates a novel kind of child-machine interaction that has a particular impact in teaching and learning processes.

From a psycho-pedagogical point of view, the MIROR platform acts as a “device” (Delalande 1993) that the teacher can use to guide students from spontaneous actions towards musical and motor creativity. In the reflexive environment, the role of the teacher is to strengthen the reflexive interaction between the child and the machine through cognitive and affective “scaffolding” (Bruner, 1983; Vygotsky, 1962), and to motivate children to explore and invent with the music and with his/her own body, alone and together with others.

In such environments, the teacher learns and adopts the principles of *reflexive pedagogy*, that is observing, suggesting, mirroring, and uses the MIROR application to enhance children’s music and movement skill and creativity (cfr. Maffioli, Anelli, Addessi, 2015; Maffioli & Anelli, 2015). With this work we have proposed a basis for an original technology for children’s embodied music and creativity, implemented a spiral approach to research, and designed new qualitative and quantitative experimental methods. In the near future we plan to continue this research by implementing a new MIROR application called MIROR-MultiModal, which will also involve children’s visual perception.

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