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Young pianists exploring improvisation using interactive music technology

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Abstract

The use of music technology in the enhancement of young pianists' musical improvisations has been scarcely explored in instrumental music teaching and learning research. In the present study, 19 piano pupils aged 6–10 from the UK and Greece used an interactive improvisation system called Musical Interaction Relying On Reflexion (MIROR)-Impro for six weeks in order to enhance their improvisational skills. This system engages pupils in a musical dialogue, answering in the same style as the pupil's input, creating a reflection of the user's own musical ideas. Children participating in the study were drawn from a notation-based and classical piano education background, and had various levels of piano expertise. Four case studies are presented here in detail. Results indicate that the system enhances young pianists' capability musically to explore and improvise, and several further questions are raised regarding the possible ways the system can be used in practice in the piano lesson.

Keywords

instrumental learning, interactive technology, keyboard improvisation, young children

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Introduction

What happens when young pianists engage in free play on the keyboard? Many authors have placed value on the informal, aurally-based, creative and largely self-initiated side of music-making for children in a variety of settings (e.g., McPherson, 2002; Sloboda, Davidson, Howe & Moore 1996; Young, 2008a, 2008b), but little has been reported about how, or whether such activities can best be encouraged in the one-to-one instrumental lesson where this article is situated.

Historically, instrumental lessons in the 18th to 19th centuries did not prioritise musical literacy: pupils in general learned melodies and exercises by rote from their teacher (Nettl, 1974). Facility in improvising, composing and playing by ear were expected skills in an 18th-century musician (Gellrich & Parncutt, 1988). Accounts of virtuoso improvisations abound in the literature at this time. After the advent of industrialised printing in around 1850, musical "methods" proliferated, and music lessons changed in focus. In the tradition of western art music, beginners were expected to spend many hours drilling exercises from the new fashionable method books, and music became a reproductive art, arguably at the expense of creative flair. As McPherson pointed out (2002), this endless repetition of exercises that often seemed divorced from actual musical literature was a source of boredom for many students (as caricatured in "Gradus ad Parnassum," Debussy's portrait of a child whose attention wanders while practising a boring study). The focus on the pursuit of technical perfection, at the possible expense of exploration and creative thinking, often persists today.

In the western art context of instrumental teaching and learning most instrumental teachers rely on a classical, notation-based teaching method from the very first lesson (Chappell, 1999). Conventional approaches to learning in music tend to encourage children to learn abstracted, decontextualized small units of rhythm and pitch in the belief that these can be combined into lengthier sections of music. Yet McPherson (2002) stressed that beginner instrumentalists find it very confusing to learn music in this way and suggests that "too early an emphasis on notation can lead to a decreased aural sensitivity for the natural unified patterns that children spontaneously observe when listening to music" (p. 105). Instead, playing by ear and improvising, by focusing on aural perception, can facilitate the early stages of learning and can complement and support notation-learning later on.

In the 20th century, influential European music educators, such as Jaques-Dalcroze (1865–1950), Kodaly (1882–1968) and Orff (1895–1982) proposed musical methods (Dalcroze, Kodaly) and approaches (Orff) that were based on the idea of first experiencing and creating sounds, often using gestures, movement and games, and encountering notation at a later stage, which found some support amongst instrumental teachers as well as in schools, and continue to be popular today (see Young, 2008a, 2008b). Despite these innovations, however, the majority of western instrumental lessons continue to follow a notation-led system, often with little acknowledgement of the importance of developing aural perception skills to support musical understanding.

Several authors have advocated the exploration of aurally-based learning as a part of instrumental learning. Sloboda et al. (1996) noted that the most able young musicians in their study tended to spend a considerable part of their time in "informal" music-making—playing by ear, playing "fun" music from books, improvising, and spontaneous "jam sessions" playing with friends. These young players freely engaged in musical activities that their instrumental teacher had not prescribed for them, but which clearly added to their enjoyment of playing and at the same time increased their musical experiences and broadened their knowledge base and music vocabulary.

This notion of the all-round musician was explored in a longitudinal study of 101 young players aged 12–16 years by McPherson (2002). He sought to examine relationships among five aspects of musical performance: sight-reading, playing by ear, playing from memory, performing rehearsed music and improvising, taking into account 16 environmental variables that previous research had

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indicated might affect development. His theoretical model showed some direct effects: for example, predictably, improvising was directly and positively affected by the ability to play by ear. However, playing by ear also had a positive effect on sight-reading and to some extent on playing from memory and it also had some effect on ability to perform rehearsed music. These important findings indicate the value of improvising and playing by ear to the development of an all-round musician. As McPherson asserted:

> Teachers should recognise the importance of ear playing as an important facet of training that enhances overall musical growth and that provides for more enjoyable and meaningful learning. (2002, p. 109)

According to Kanellopoulos (2007), improvisation encourages children's "imaginative leaps" and openness to music-making and discursive thinking. Furthermore as Ashley (2009) pointed out, improvisation is not an isolated element of human music-making; "it connects musical structure, our bodies and our sense of selves as individuals and members of social units in powerful ways" (p. 419). Learning aurally thus can complement the traditional skills taught in instrumental lessons and provide pupils with extra resources that can support their learning, motivation and musical understanding.

Another possible benefit of a curriculum that includes improvisation was explored by Allen (2013). Working with 36 piano pupils aged between 7 and 18 years, who had reported experiencing performance anxiety, Allen compared groups of students who performed a repertoire piece, an improvised piece or one of each. Results showed that students were more anxious performing a repertoire piece than an improvisation in front of an audience. In a small-scale study such as this, particularly when the participants are to an extent self-selected, statistical results are hard to generalise, but the interview transcripts illustrate the enrichment that the students enjoyed through this intervention. They were highly involved in the improvisation sessions and some were more motivated to practise than after their usual, repertoire-based lessons.

Learning aurally thus can complement the traditional skills taught in instrumental lessons and provide pupils with extra resources that can support their learning, motivation, and musical understanding. Additionally, improvising offers pupils a creative space in which to explore their own ideas and develop autonomy: an important point, given the "master–apprentice" pattern of most one-to-one instrumental lessons (see Burwell, 2013 for an overview of this concept).

Technology, improvisation and the MIROR-impro system

Advances in music technology have profoundly affected the research and practice of children's creative music-making (Gall & Breeze, 2005; Nilsson & Folkestad, 2005; Seddon & O'Neill, 2001, 2003), raising questions also about pedagogy, curriculum and ethics (Brown & Dillon, 2012; Burnard, 2007). Classroom applications using technology to compose are amply represented in the literature (Mellor, 2007; Nilsson & Folkestad, 2005), yet the ways in which technology can facilitate other facets of creative music-making, such as musical improvisation, are less explored, particularly with younger children.

As an exciting and emerging area for music education, the use of technology for improvisation is sometimes linked to the creation of novel forms of digital instruments that enable live musical performance, as demonstrated by Savage & Butcher (2008) in their DubDubDub project. An alternative to such applications is the MIROR-Impro system used in the present study, which has been well documented from its inauguration as The Continuator (originally a program for jazz pianists to practise improvisation: see Addessi & Pachet, 2006; Pachet, 2003). In its latest form, as well as improvisation, it offers possibilities for composition and gestural interaction

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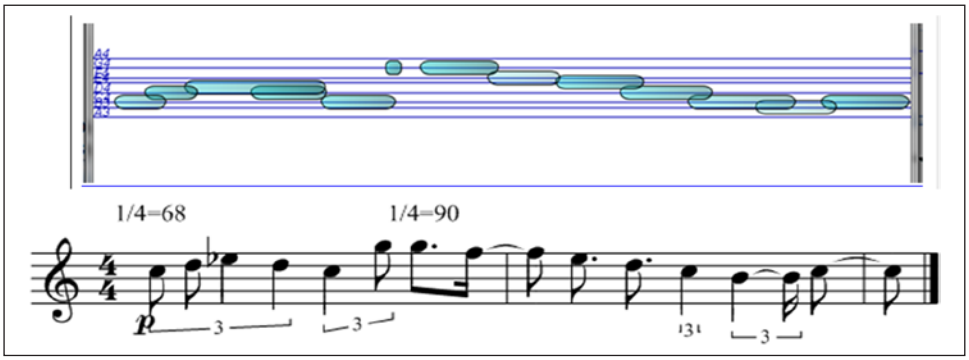

Figure 1. Onscreen visualisation of a short melody. Pitches can be seen on the stave lines. Below it is a notated version of the same melody.

with sound and has been shown to have pedagogical applications (Addessi & Volpe, 2011; Triantafyllaki, Anagnostopoulou & Alexakis, 2012; Volpe, Varni, Mazzarino & Addessi, 2012; Young & Rowe, 2012).

MIROR-Impro (MI) was developed during the EU-funded MIROR project, in collaboration with Sony (Paris). It has been demonstrated at several international conferences, and we include a short non-technical description here. The software runs on a laptop connected to an electronic keyboard. Each time the user plays, the system produces an answer based on the input. MI replicates the musical behavior of the user and the responses evolve alongside those of the user in an organic fashion that the developers have entitled "reflexive interaction." (For a fuller description of the system see Addessi, Volpe, Varni & Newman, 2012.)

As the play session continues, the whole set of inputs is stored combined and recycled by the system using algorithms to generate answers. Whilst the responses are of the same length in seconds as the inputs, it is possible to control the complexity of the system's responses from an exact copy of the user's input to something that may be a rhythmically and melodically fragmented version of small elements from several inputs. The length of time between the end of each input and the start of the response can also be controlled, as can the key of the responses: they can be derived from all 12 transposed versions of the inputs, or restricted to the actual pitches played by the user. There is also a facility to limit MI's responses to just one key (major or minor)—whatever the user has played.

As the user plays, the notes played by user and MI are produced on two staves on the laptop screen, in real time. The relative lengths and letter-names of all the sounds can be shown on screen, as in Figure 1 (below), which can be useful for later analysis, and the music is also stored as data-files and midi-files for each input. The program can also produce a version of the music in traditional notation, though this is unquantized and therefore can look a little unorthodox. A notated version of Figure 1 is added below. Another piano-roll perspective accessed only during real-time child-MI interaction on the laptop screen reveals additional information about amplitude. At the end of playing, the whole session, or any part of it, can be visualised and played back through the laptop in real time, including the small spaces between the end of each input and the onset of the response. The software can produce a considerable quantity of data about each session (number of user turns and MI responses, notes, pitches, durations, clusters, etc.) and these can be exported to Excel files for further analysis.

The MIROR project investigated a broad field: the use of the MIROR software with over 300 children aged 3–10 years in a variety of nursery and educational settings in four European countries. As part of the project, a study by Young and Rowe (2012) describes the interactions of young

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children with no prior keyboard skills with the MI system. Three levels of interaction were identified, the most intense of which seemed to occur when the children were engaged in a kind of gestural, embodied play. However, new to keyboard playing, the children in that study tended to prioritise keyboard exploration over interacting aurally with MI. In response to this earlier study and given the value of integrating improvisation into formal music education, as stressed in the reviewed literature, we decided to explore how children already familiar with the keyboard through piano lessons interacted with the system. This allowed us not only to focus more on the child–system interaction, because the children in this study were already familiar with the keyboard, but also to explore children's musical responses to a technology that essentially would act as a "creative partner" (Brown & Dillon, 2012) that scaffolds children's musical improvisations. Given that participating children were drawn from a notation-based and classical piano education background, this aim seemed all the more important. Four children who were learning piano were sampled as case studies for the current article in accordance with age and level of experience and in accordance with their analyzed sequences of interaction the MI system.

Method

Context

The study took place in two music schools, one in Wells, UK and one in Athens, Greece. While set in diverse educational systems of instrumental music teaching and learning, all participating children's usual piano lessons were based on a traditional "master/apprentice" model, with the teacher taking the lead. Their musical repertoire was mainly classical, rather than popular and many of the children regularly undertook piano examinations, typically involving prepared pieces, scales, sight-reading and aural tests, but not playing by ear or improvising. Technical mastery, or playing it "right," was a priority for these children and their teachers. We assumed therefore that working with the MI system would present children with a change from the formal learning style of their normal piano lessons to an informal discovery type of learning, in which there was not necessarily a "right" way of playing. The notion of "reflexive interaction" was also new to the children, as the child reacted to the system's answers based on the child's own phrases, rather than listening and trying to match the teacher modelling the "correct" way to play.

Participants

The children—ten children in the Greek group and nine in the British group—were all taking individual piano lessons: they had been learning for a varying number of years and had reached different levels of accomplishment, from near beginners to a good intermediate level. Purposive sampling was used to select the children, in accordance with age (between 6 and 10 years) and experience of playing the piano (between 1 and 4 years), which seemed to be related in this sample. We purposefully selected to work with children that had different levels of formal piano tuition experience, in order to explore how those with longer exposure to the formal learning style of their typical piano lessons would compare with those who had had been exposed less to formal piano tuition. Both parental and teacher consent were obtained prior to the start of the study. Out of the 19 children, four are considered here in a case study approach.

Research procedure

The procedure in Athens and Wells was similar: each child was given access to a keyboard attached to a laptop running MI that was set up in a designated room in the two music schools for the study.

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Each child played for about 20 minutes per week for six consecutive weeks. The sessions were not linked to their piano lessons, nor was their instrumental teacher present during the session. The Greek children had six weekly sessions and the British children had ten, the first six of which are considered here.

The children were introduced to the program with the explanation that they would be helping us by testing it and finding out what they could do with it. We did not give them task-based instructions, just supported them with encouragement. In their first session, most children discovered by themselves the responsive function of the MI system but some needed to be coaxed by the researcher to lift their hands in order to receive a response. Thereafter, each child came into the lesson knowing they would be playing for a short time with the keyboard with the researcher present (see below on role of researcher).

Both research teams collected a considerable volume of musical data that was recorded by the MI during each session. This data consisted of re-playable MIDI data, visualisations of children's input/MI's responses as a piano-roll, together with a bank of statistical information about the lengths and ranges of notes and clusters used. Notation of children's musical input was generated in order to assist with the analysis. Occasionally during the sessions, children asked to see the piano-roll type perspective on the laptop screen that was generated on-the-spot by the MI system: this revealed to children information about the duration, pitch, and dynamics of their inputted melodies and the MI's responses, and they would sometimes play while looking at the laptop screen and indeed comment on similarities and differences between the appearance of their input and that of MI.

Other data were collected that reflected the special interests of the researchers in the two teams: the team from Exeter University in the UK canvassed children's opinions of various MI settings, and conducted a final short questionnaire about their experiences of using MI. The original purpose of these questionnaires was to contribute to a spiral collaborative development process with Sony, feeding back the children's perceptions of the usability and applications of the system, but they also produced some useful insights into the children's experiences. Athens collected a large amount of interview data, which were transcribed for qualitative analysis. A semi-structured interview protocol that aimed to access children's perceptions about the musical aspects of their dialogues with MI was adopted. It specifically focused on (a) gaining an insight on children's perceptions of how the MI response compared with what they had played—particularly the similarities and differences, and (b) the children's musical choices thereafter—particularly the musical decisions they made after listening to each MI response. The "after-school" and highly individualized structure of instrumental learning in the Greek music school meant that interviews could be conducted only on an individual basis with each child, either during or after each session with MI.

Role of the researcher

The researchers answered the children's questions and canvassed their opinions about the way the system worked, and occasionally made suggestions if the children seemed unsure about how to progress with improvising. However, both researchers tried to avoid actual teaching, in order to leave the children free to make their own discoveries.

The two researchers who worked with the children were both experienced piano teachers who were able to assess the children's needs and current levels of achievement. As Stauffer (2001) and her colleagues found, it was easy to form a relationship with the young players while they were working, and most of them talked freely about their ideas and MI's responses.

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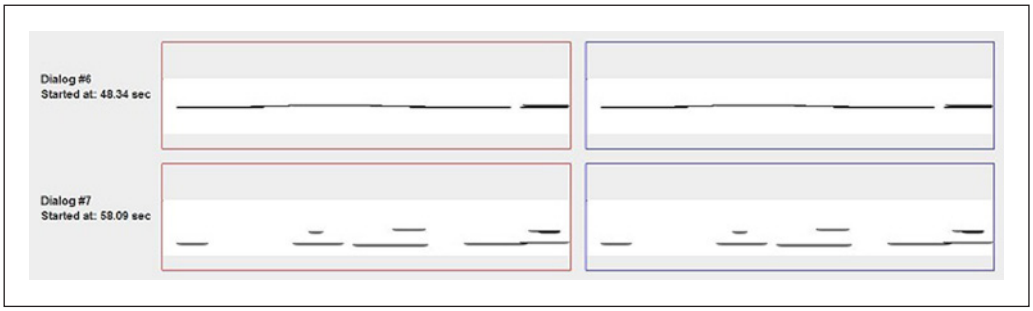

Figure 2. Screen-shot of Child–MI "dialogues."

Analysis

The recorded musical data collected by the MI system in both countries were the main focus of data analysis for the current article. These data consisted of at least six 20-minute sessions for each child. Each session consisted of a series of child's input–MI response–child's response–MI response sequences, as viewed in Figure 2, which we termed "dialogues" in the current study (each dialogue is read horizontally, from left to right). The left hand column represents children's musical input and the right hand column represents the MI's response. Each individual sequence (or two-part sequence) could be played back through the laptop computer. As viewed in Figure 2, this piano-roll type perspective during playback reveals information only about the duration and pitch.

Analytical procedure

Each team of researchers conducted two levels of analysis. The first involved listening to all musical sequences of child–MI interaction, while keeping detailed notes regarding the (a) characteristics of child's input, (b) the MI response, and (c) the development of both throughout each session. This set of notes allowed us to gain an overview of the progress of each child throughout the six sessions. The notes contained information about the session's musical content (e.g., repertoire type, instances of aural-based playing, instances of improvisation) and allowed more detailed sampling of "dialogues" for the next analytical level and formed the basis of sampling the four case study children for this study.

A second level of analysis mined the large cohort of "dialogues" in more detail, focusing specifically on those sequences of child–MI–child "reflexive interaction." These sequences were identified as being able to reveal that the child had borrowed particular musical content from the MI system's response. This borrowing of musical content related to rhythmic motifs, individual notes, or general musical style. Such instances were selected and are presented in this article as case studies in which this musical content was used in particular ways by the child during the sessions (e.g., to "teach" the MI a known tune, to combine known tunes in creating something new).

Supplementary data from field notes and interviews were analysed and compared alongside the system's recordings of the children's interactions with MI and allowed for a more in-depth understanding of children's responses to the system. While the recorded musical data are the main focus of analysis for this article, we include also a few excerpts that we felt highlight the child's understanding of the interaction with MI.

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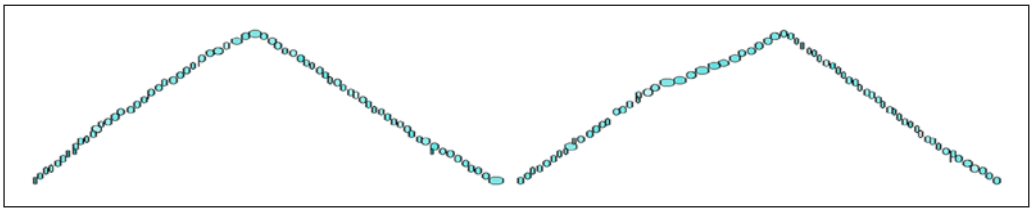

Figure 3. MI's visualisation of glissandi.

Results

Discussions between the Greek and British researchers revealed that the analysis of the musical interactions between the children and the MI system showed several commonalities that seemed related to their level of experience, a factor we had anticipated when purposely recruiting our participants. The youngest children played in an uninhibited, gestural style which resembled that of the 3–5-year-olds we had worked with in previous studies. Two such children—one from the British and one from the Greek cohort, while still being quite elementary pianists (pre Grade 1 Associated Board of the Royal Schools of Music [ABRSM]), had already developed an interest in playing tunes by ear. In this article, we decided to present also the data of two older children, again one from each country, with a greater level of musical experience (approximately Grade 4, ABRSM). These older children's musical interactions with the system were less spontaneous and involved a focus on their examination repertoire initially, gradually leading to more exploratory ways of playing across their sessions. Data from the four children's musical interactions with the MI system are presented now as case studies.

Kevin, 8 years old, learning piano for 4 years

At the start of the sessions, Kevin is a very reluctant improviser. When invited to play whatever he wants on the piano, he plays his current exam repertoire from memory, with fluency and skill. He also plays some scales proficiently. However, he has had no experience of improvising and he does not know how to begin. According to his teacher, his disciplined upbringing would have discouraged "messing about" on the piano. In the first session, he is unable to produce any original music. By the second, he manages a very short sequence, involving skipping melodic intervals of thirds—a feature often met in the children's improvisations that we examined.

During subsequent sessions he continues to prefer to play his exam pieces. However, he really enjoys testing out the system, using a very small number of notes and pointing out what MI is doing. With encouragement he sometimes manages to use his pieces as a springboard for improvisation, taking a bass line or a rhythmic pattern as starting point. At this stage he is not really very interested in interacting with MI. Later on, however, he becomes fascinated with the visualisation screen that MI provides. As he plays glissandi, these patterns (Figure 3) appear on the screen and his face shows excitement. His movements become more animated as he repeats the gesture. The synthesis of the physical feeling of playing glissandi with the appearance of the notes in real time on screen, and the sound that is produced attract his interest. The image that appears on screen is quite dramatic (Figure 3):

He is also fascinated by the different settings for the level of variation—Echo, Similar, Different and Very Different—and enjoys testing them out, sometimes trying to guess which one is being used, and giving his opinions about them. By the fifth session, he plays entirely improvised music,

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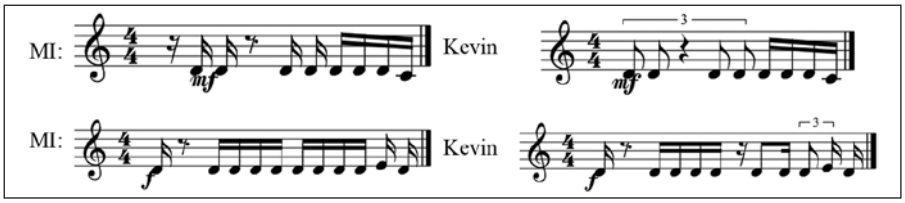

Figure 4. Kevin copying MI.

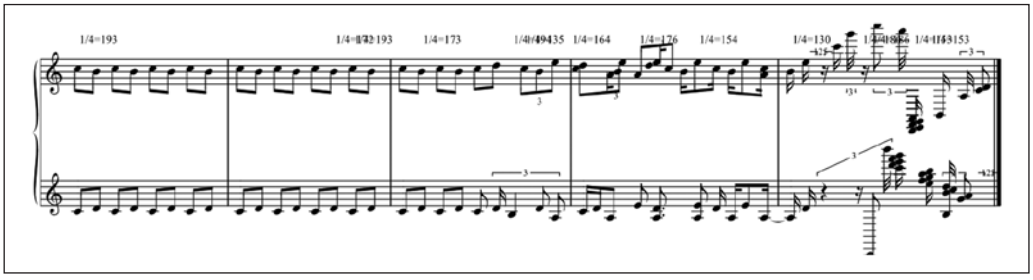

Figure 5. Kevin's cadenza—bars 4–5.

without referring back to his exam pieces. Kevin becomes more confident and on one occasion sets up a game with MI in which he tries to copy its responses. He deliberately limits his range of pitches in order to facilitate the game, which he points out is rather like doing one of the aural tests (singing back a tune) in his music exam. Playing back a tune by ear is more difficult for him than the exam test, but he very much enjoys the challenge: he describes it as playing Follow the Leader: "I was following IT this time!" His imitations are very successful both in terms of pitches and rhythms (the rhythmic differences here are considered negligible, and due to the unquantised scoring of the system (see Figure 4).

From an unpromising beginning, Kevin gains confidence, first through his technological interest in testing out the system to find out what it does. By playing with MI his inputs become more extended and by the sixth session the entire input is improvised and there are no scales or exam pieces.

After several sessions with MI, we see a new development when he begins by playing a long series of dialogues with MI, based on rapid repeated notes: these still sound as if they are based on finger exercises, but gradually gain in freedom. MI's responses reflect his repeated note patterns, but in a more random fashion, and Kevin starts to bring in more variety to his playing: changing pitches and varying the number of repeats. After several bars of repetitive trills, Kevin abandons exercise patterns in favor of a rapid and original cadenza, his own "Gradus ad Parnassum" moment (see Figure 5).

Peregrine, 7 years old, learning piano for 2 years

Peregrine, although playing at a much more elementary level than Kevin, shows a more natural musicality and an interest in playing by ear, often trying to pick out melodies of film tunes. As well as free improvisations, Peregrine includes elements from known tunes which he has worked out by ear— the "Narnia," "Harry Potter," and "James Bond" themes all make appearances. His performance of these

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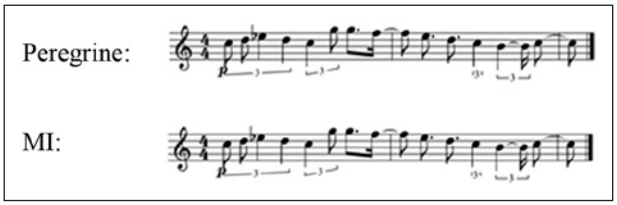

Figure 6. Peregrine's first dialogue.

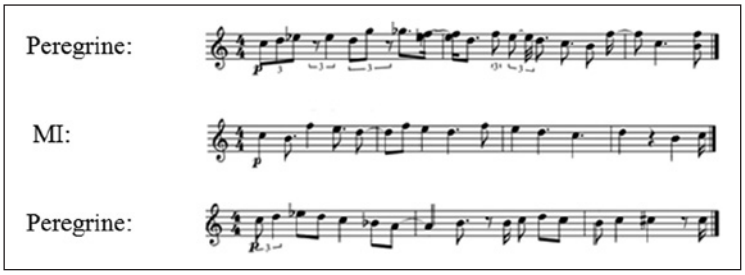

Figure 7. Peregrine and MI "jazzing."

is notable for having a basic left-hand accompaniment that Peregrine has worked out by himself. He thus shows an interest in playing music from outside his piano lesson repertoire and he frequently points out when an improvised phrase sounds like a familiar tune.

Whereas Kevin feels the need to refer back to his piano-lesson experiences, Peregrine seems to be more open to experimenting with sounds and listening to MI's responses. In the following transcript, his playing has a jazzy style, "doodling" around a small note-range, with frequent appearances of a "blue" note. He stays on a C minor chord, and includes a perfect cadence. MI's first response is an exact copy (Figure 6).

But then MI begins to move away from Peregrine's idea and he responds to this (Figure 7).

These short exchanges show Peregrine interacting with MI much as an adult jazz player would play with a partner, albeit with the technical limitations of a beginner pianist. He improvises freely over the next few sessions making some gentle sustained sounds using both hands, but from Session 5 onwards he begins to try to suppress MI's responses, by interrupting them with a single short note. He says this is because "it isn't adding anything to my ideas." Perhaps he is moving on to a more independent way of working, or has become too engrossed in his own ideas to welcome any interruptions. Certainly by the last session he is able to produce an extended solo (45 seconds) using two hands, based on a simple jazzy idea and a very simple left-hand accompaniment.

Konstantina, 9 years old, learning piano for 4 years

Nine-year-old Konstantina has already been playing the piano and the violin for four years. She is taught by her mother, a piano teacher at her music school that focuses on 18th- to 19th-century composers. In her first session, Konstantina is reluctant to improvise/play her own tunes. She is playing in a concert the following day and when asked to play "her own music," she immediately runs through her examination repertoire. When the MI system echoes her playing in a slower tempo she attempts to imitate this slower playing. She then gets frustrated and tells the keyboard to stop imitating her.

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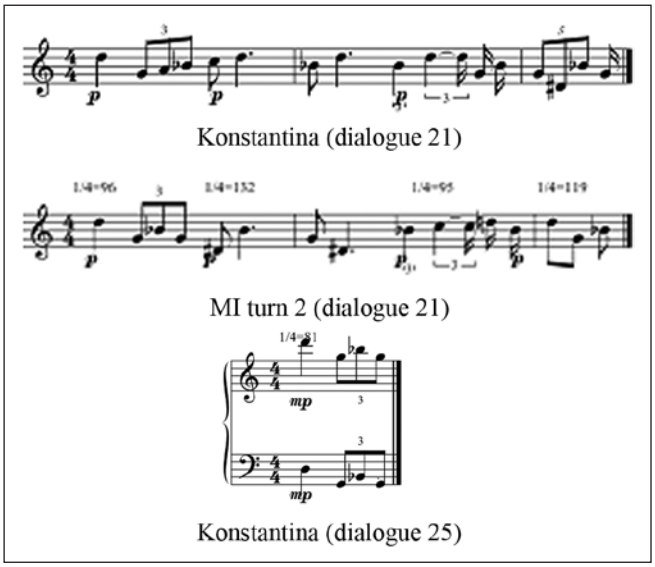

Figure 8. Konstantina teaching MI her repertoire.

In the next sessions, Konstantina rarely steers away from her lesson repertoire, and tries to "teach" the MI system to play as she does. For example, in Figure 8 we notice that the system does not re-produce Konstantina's piece (MI turn 2), which leads her to convert back to a slower rhythm of playing and to focus on only a short part from her piece to see if MI will follow suit (user turn 5, dialogue 25). This type of responding behavior is typical of many children, who often play louder or slower to see whether MI will follow. It could be thought of as a kind of technique that children use to "teach" the system their own music. Not surprisingly, perhaps, it takes place when children are playing their lesson repertoire, rather than their own music.

Konstantina continues to start each of her sessions with her examination repertoire, reluctant to move away to playing her own tunes until her fourth session. In the dialogue exchange below (Figure. 9) we see her adding a left-hand accompaniment to one of her piano pieces, playing in parallel fifths for simplicity, followed by a break-down or simplification of the tune, after the system's response (Konstantina turn 2, MI turn 2),which is continued for two more dialogues.

Subsequently, Konstantina begins a short exchange with the MI system for six dialogues, after which she improvises her own short piece (user turn 2, dialogue 20). We see that she stays on C, favoring melodic intervals of thirds, while the left hand provides a basic accompaniment, with a more independent movement than before (Figure 10). This is one of the few times Konstantina develops impromptu a "whole" melody (rather than short motifs).

In the final two sessions, Konstantina does not leave the comfort of her examination repertoire, which she often returns to during the middle or end of her session. She does, however, wander away from her repertoire during the sessions in order to be able to interact more with the system, which she seems to enjoy.

Miltos, 7 years old, learning piano for 6 months

Seven-year-old Miltos, although at a much more elementary level than Konstantina, reveals a natural tendency towards playing by ear, yet this was not evident from the first couple of sessions,

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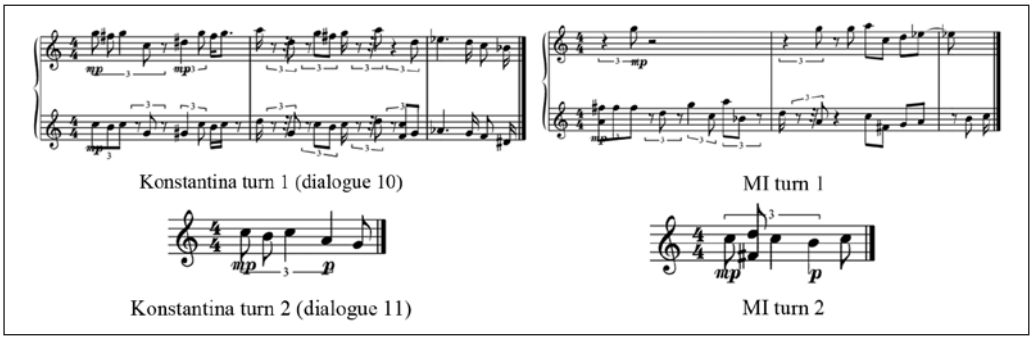

Figure 9. Konstantina teaching MI her repertoire.

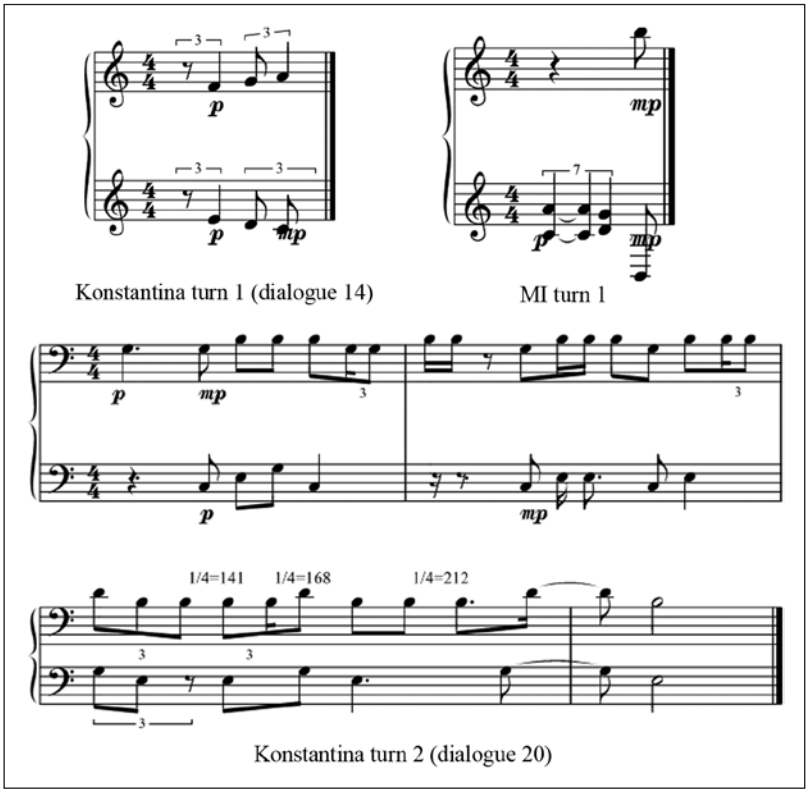

Figure 10. Konstantina improvising her own tune.

where he often said "I can't think of anything else to play, I usually have the piece in front of me when I play" and would usually wander back to playing scales. One skill he begins to develop from his fourth session is combining bits of his repertoire to make a new melody:

R. *What did we do last time?*
M. *We played various tunes and the piano would combine them.*
R. *Combine them? What do you mean?*

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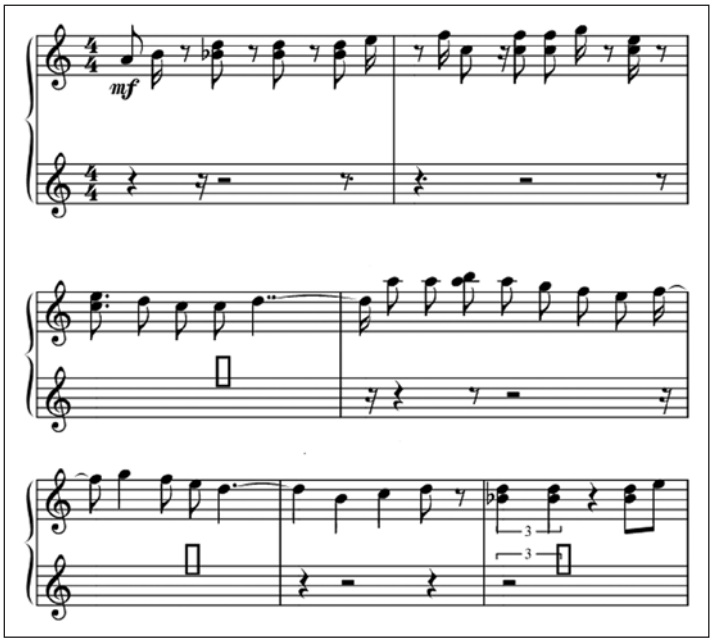

Figure 11. An excerpt from Miltos' piece combinations.

M. *It played some pieces and joined them together and made its own music. […]*
R. *So when you play and listen to the piano responding does it play the same?*
M. *In the beginning yes, but then it continues the piece and combines the two.*
R. *So what does this combining mean?*
M. *So that it puts some notes from all the pieces I've played and I understand where they come from, I mean from which pieces they are from …*
(Interview excerpt from session no.4, 30 November 2012)

Miltos then acts on this by trying to combine in a similar way three tunes—film music, a Christmas song and a finger exercise that is viewed in Figure 11.

However, although Miltos does attempt to make up his own tunes from what he perceives as arising from combinations of tunes from the MI system, it is not until his very last session that we see him more directly taking up specific musical elements from the MI responses. Various examples can be viewed in Figure 12, beginning from a simpler response (dialogue 2–3) whereby a minor melody is turned into a major melody by Miltos in order to match to the MI response. He also keeps the perfect cadence on C, as well as the downward motion from the fifth (G) to the tonic.

In Figure 12, Miltos attempts to copy not just notes, but also the rhythm of the MI turn1. A series of user–system dialogues follows until dialogue 10 (Example 3) whereby Miltos produces a more complete combination of the above two examples, including both E flat notes (Example 1 and 2) and a faster, jazzy rhythm, like in Example 2.

Discussion

This study sets out to discover how young pianists would interact with the MI software across a series of sessions. The children were all familiar with the layout and some of the sonic possibilities

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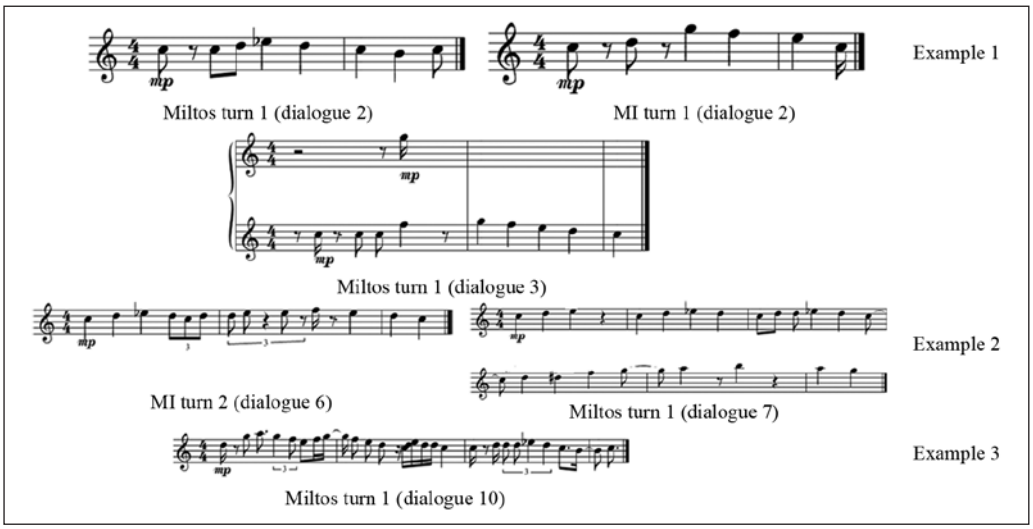

Figure 12. Examples of Miltos responding to the MI (session 6).

of the keyboard but many of them had never previously "made up" their own music, either during their weekly lesson or at home. In previous studies with this software, very few of our "naïve" players had any knowledge of how notation is used and they were therefore more prepared to go straight to the keyboard and play (Young & Rowe, 2012). However, the naïve players did not know in advance what kind of sounds they were going to produce: what they were doing was an exploratory exercise or sometimes an incidental result of a physical gesture (Young, 2003; Young & Rowe, 2012). The pianists in our study understood the capabilities of the piano, and those with well-developed aural skills had the advantage here: they could anticipate the kind of sounds they were going to make. This is a key aspect of improvisation, as it enables some forward planning to take place (Azzara, 1993; McPherson, 2002).

Peregrine and Miltos, although beginner players, seemed to match this profile. Both were keen to make up their own tunes, although relatively reluctant at first, and both were enthusiastic with the "ideas" provided by the MI system for use in their "own" music. Indeed, literature on formal instrumental music tuition and its effects on creative music-making suggests that research participants with experience of prior formal instrumental music tuition show fewer exploratory strategies than do participants with little or no formal music tuition (Folkestad, Hargreaves & Lindstrom, 1998; Hewitt, 2009; Scripp, Meyaard & Richardson, 1988). The other pair of children (Kevin and Konstantina) as able pianists should have been more than able to interact with the MI system, yet they both found it initially difficult to move beyond their known repertoire. Indeed, both children began to show evidence of more independent and reflective approaches in their playing from their fifth session onwards, by initiating their own ways of interacting with MI, e.g., by "teaching" it their known pieces or by testing out and playing with the visualisation screen. For these children, it was a matter of starting from a safe place: music that they had already learnt and could play from memory.

Analysing the actual music of the improvisations has been quite revealing, and a necessary step towards a deeper understanding of the nature of children's improvisations. Some general remarks arising from the music analysis of the improvisations are that participating children in general preferred to play in C major, probably because, as elementary players, this is the key that many of

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their piano pieces are written in, and also because many children we observed had a preference for playing on the white keys. As described above, it is possible to limit MI's responses to a given key if required, or to limit it to actual notes the player has input, or to use all 12 transpositions of each input. We tried out all the settings with the children, but they preferred to play in C. They created actual cadences in C, which are learned melodic patterns for closure. They also experimented with intervals of thirds, as again it is an interval widely used in their familiar pieces, as observed by the researchers.

How then, did this interactive software support children's early steps in improvising? It is not possible to assert that MI was the only factor that affected their actual playing, because the researchers played a supporting role in the sessions and an increasing familiarity with the idea of improvisation may also have played a part. We believe, however, that with the experience of hearing the MI responses as examples, these participants were able to take an idea, such as a rhythmic or melodic feature from their known music and explore it. Here we list some of the activities that emerged from these pianists' sessions with MI.

- Find a rhythmic or melodic pattern and repeat it, taking turns with MI and on hearing the free and sometimes quite quirky nature of MI's responses, gradually become more experimental themselves. Peregrine's and Kevin's playing both show examples of this, as shown above.
- Start from known pieces (either played from memory or by ear) and develop (often by melodic sequencing or by repeating rhythmic patterns) or combine features or motifs from the pieces. Again, through observing how MI "plays" with the themes, the pianists gradually move into playing original sounds, as Kevin and Konstantina showed.
- Find something that makes an attractive visualisation on-screen and develop it: for example making "wave patterns" of different sizes by playing various glissandi (as Kevin did), or by experimenting with different sized interval leaps or clusters to make patterns on-screen.
- Simplify their known pieces in order to receive a satisfactory response from the system; this is achieved by extracting short motifs from the key theme of the piece and reproducing it in a slower tempo and/or by playing solely the right-hand melody, as we observed in Konstantina's case.

Playing with MI provides an opportunity for the children to experiment with an uncritical electronic partner that reflects back not only their thematic material, but also the expressive qualities of their playing: lively and mischievous, slow and sustained, fierce or gentle, rather as a human playmate might do. Beyond the simple "copycat" effect, however, the children are able to identify when MI includes elements from their earlier inputs alongside their most recent ones (as Miltos explained) and thus they may begin to gain a broader perspective of their musical style and identity.

Implications for practice

As an algorithmic system capable of making adaptive choices in real time, the MI system essentially aims to enhance players' capability to explore (musically) their own "repertoire" of tunes. The case studies show that MI can be used to encourage keyboard improvisation with pianists at different levels of experience. However, many questions are raised about the possible ways in which MI contributes to the children's experience, and which form the path for future research: is the system providing a kind of simulated improvising experience for learners, or is the experience musically worthwhile in its own right? We saw that Peregrine was able to work with MI as if with

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another human player, in a jazz idiom. Do we envisage MI as a learning tool, a means to an end? If teachers adopt MI as a tool in their piano lessons, what roles could it take?

Our impression is that there are many applications for this technology, depending on the context, the stage of instrumental learning, or the age of the child. It can be used for musical goals, in quite a structured and controlled way, as an aid to learning to improvise, or to develop certain aural or technical skills. Dean's (1989) introduction to improvisation techniques shows how small motifs can be manipulated to provide starting points for creative development: MI provides children with similar initiation stimuli. It also has the propensity to contribute to more "child-centred" goals, as a way of supporting their musical explorations, introducing new ideas and sounds, while retaining something of their own playing style as a basis, revealing a portrait of their personal musical identity. This reflection of the child's style can have a positive effect on a child's confidence and the beginning of a sense of musical identity as Addison (1988) found in interactions between child and adult. This seemed to be the case for Miltos, who, at first reluctant to engage in exploratory play, concluded his sessions with a flair for combining known tunes in constructing his "own" music. Upitis (1992) describes how her pupils use their experience as composers to re-construct their known repertoire pieces, thus enriching their learning: "And in so doing they are constructing knowledge, making meaning, inventing ways of understanding" (p. 149).

By providing "musical visualisations" of the sessions, MI offers teacher and pupil an opportunity to reflect, together or individually, on the process of learning to improvise, either by looking on-screen in real-time or later at its recording. In this way it is also a useful research tool, giving permanence to a process that is normally ephemeral, and also providing a log of the development of the child's musical improvisations across time. An additional aspect of MI that Kevin in particular found attractive was the opportunity to interact with technology and explore its possibilities. For 21st Century children, an easy relationship with technology is essential, and MI provides interesting and entertaining opportunities for children to manipulate and to some extent control musical events. Through the variety and unpredictability of its responses, perhaps because it does not always play the kind of answers a young player might expect to hear, it offers new possibilities for improvisation and for developing aural awareness.

Our study indicated, unsurprisingly perhaps, that improvisation skills are not sufficiently encouraged in these children's instrumental lessons. There may be many explanations for this: teachers' unfamiliarity with improvisation techniques and how to teach them, time pressures, and the absence of such requirements from most examining boards' curricula. (An exception is the ABRSM's Jazz piano syllabus, now available in many different countries). Moreover, in higher music education institutions in both participating countries, improvisation workshops rarely form part of music curricula that are predominantly focused on the western art tradition.

Perhaps one of the most important aspects of integrating such technology in the classroom relates to the student–teacher relationship. The MI system deconstructs and re-invents the top-down teaching and learning environment of the one-to-one instrumental lesson (Hanken, 2000; Rostvall & West, 2003) by taking the role of a musical partner that provides stimuli for exploring musical improvisation and by placing learning in the hands of the child and encouraging autonomy, reflection, and independent thinking during the lesson.

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For more information about the MIROR Project, please visit
http://www.mirorproject.eu/.

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