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Toddlers Testing DDMM: Evaluation Results and Ideas towards Creating Better Learning Environments for Small Children

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Abstract: Most musical instruments provide children with a rather complex user interface and unfamiliar possibilities of interaction, which do not appear in their daily experience of the world. This complicates the process of creating harmonic melodies and may lead to dissonance and frustration. Thus, the main goal of our reasearch project „Drum-Dance-Music-Machine“ is the development of a toolset for early childhood music education, that facilitates a low-threshold access to collaborative music making. For this purpose, a prototypical new instrument has been constructed, offering the simple interface of a drum, but producing notes and melodies. Furthermore, with this system it is possible to create music by dancing and changing its parameters through movement. Amongst others, this aspect can be used to explain and clarify the meaning of abstract musical terms. During the ongoing development and after further enhancements we tested the system in two phases in order to ascertain our predefined goals. Amongst others, the children were asked to give their mind on their rating of this new instrument and tell if it is easy or difficult to create music with. Furthermore, we collected subjective assumptions from parents and educators, test observations and objective measurement data, combined them and analysed the results in terms of various aspects to verify the suitability of the system for use in early education.

Keywords: music education, early childhood education, evaluation, visual feedback

1. Introduction

1.1 Motivation

There is evidence that musical activities can bring many benefits on children's personal, intellectual and social development. (Hallam, 2016) However, most instruments traditionally used in music education do not have suitable affordances to provide very young children with the possibilities of playfully exploring collaborative music making. In contrast, familiar user interfaces can ease this and motivate children to create music. The simplest interaction even very young toddlers can use is non-target-oriented pounding on surfaces and thus percussive instruments are particularly suitable as a low-threshold entry into music making.(Reifinger, 2006) They are designed for the generation of sounds with less or no defined pitch though and can, in principle, only be used for the exploration of rhythms. Manipulating tones and examining melodies, however, arises a special feeling of success and can thereby motivate to continue in making music. (Koelsch et al., 2003) So the use of a new musical instrument, which offers intuitive input possibilities and at the same time provides an extensive musical sound experience, would be more suited than classical instruments. Since particularly the making of music in groups is challenging in terms of consonance, such an instrument should also take this problem into account. In this connection, the understanding and correct use of musical terms and concepts plays an important role, since they are necessary for communicating about the common procedure. Instead of illustrating these abstract concepts with the aid of theoretical explanations, it would make more sense to *experience* them through direct application while making music. For example, the musical terms could be transferred into the colloquial language and linked with corresponding gestures.

1.2 DDMM Prototype

Based on the above-mentioned motivation, a system, which is supposed to close this gap, was designed within the framework of the interdisciplinary research project "Drum-Dance-Music-Machine" (short: DDMM). In 2015 we developed the first prototype, which turns a PC, a pair of electronic drumpads and a camera into an instrument that can be used by small groups of children.(Becking, Steinmeier & Kroos, 2016) The version we presented describes a modular software system, consisting of several VST plugins, which can be operated and connected in a host application. The main component of this construct is the plugin called *"Music"*, which is, among other things, responsible for the creation of a dynamic composition. Two other plugins receive and analyse data from connected Drumpads and a camera to generate different parameters. So far playing with DDMM is either done by striking the drums in time or by making dance steps respectively. For this purpose, an acoustic incentive is provided in the form of a metronome. The timings of all user actions are then compared with those of the metronome beat and corresponding notes of a melody are played if they match. At the same time, the position of the arms is evaluated by the camera system and passed as a further parameter with which the key of the piece can be changed. Thus, for example, children can explore the difference between major and minor keys by placing their arms in six different positions, which are based on the upper part of the circle of fifths. After all this first prototype contained the basic functions and characteristics required for the project, but an evaluation with children had not yet been done. Also, the planned visual feedback, which should complement the concept, was not implemented at that time.

1.3 Enhancements

Several improvements were implemented after the completion of the first prototype. In particular, the additional visualization should be mentioned here. Instead of using abtract grafics we followed the concept of interactive demonstration to realize this visualization, since it should motivate the user and at the same time give guidance. Therefore, we created a new plugin with virtual companions, who will teach the children what to do. Since we want to find out, if the children would rather use a realistic than a non-realistic form of representation, we furthermore implemented two versions of this new plugin (see figure 1) in order to compare them.

Figure 1: additional visualisation modules (left: realistic version, right: cartoon version)

The application is controlled by plugin "*Music*" which communicates through a specially defined protocol and so it is possible to let the characters drum and dance in strict time. In addition, the colors of the visualization adjust to the transmitted keys of the melody. As a result, the sky gets darker, when the children switch the tune from major to minor and vice versa. (Steinmeier & Becking, 2017).

2. Related Work

There are also some approaches, such as in the work of Sarasua, which are reminiscent of DDMM's approach and pursue a similar goal. (Sarasua, 2013) However, the overall focus of these projects is usually not on musical education in the preschool age, but rather on older children or people with impairments. Nonetheless, it can be said that there are significant research activities that deal with the investigation of novel instruments and concepts designed to motivate children to practice music making

(e.g. (Hobson Kenney, 2012), (Harriman, 2015) or (Pachet & Addessi, 2004)). The work of Myriam Desainte- Catherine et al. for example belongs to a series of projects, which assume that it is particularly motivating to take up aspects of computer games and connect them with musical activity.(Desainte-Catherine, Kurtag, Marchand, Semal, & Hanna, 2004) Varni et al. Pursue a similar concept, but use on a complete computer game and not just a partial aspect. (Varni, Volpe, Sagoleo, Mancini, & Lepri, 2013) In this game, the children are told a story in which they can interact to help a magician fill the world with sounds that have been lost. The findings of Blaine and Perkis are also interesting for the development of DDMM since they also chose drumming interfaces as the simplest option for collaborative improvised music making. (Blaine & Perkis, 2000) In their study, up to six users are able to play an instrument consisting of several electronic drum pads that are connected to the computer by an *Alesis Trigger* module. In addition to this, they also developed and tested approaches for a visualization, which should provide feedback and motivation. Their concept does not, however, allow each musician to play an individual instrument and instead create a global mixture from their inputs. In this regard Blaine and Perkis argue that some of their subjects had problems identifying their own contribution to the composition. Also the system "WamBam" (Jense & Leeuw, 2015) should be mentioned in this context. In their paper, Jense and Leeuw describe the results of several prototypical development stages: An electronic instrument, which is similar to a drum and designed for the music-therapeutical treatment of patients with severe mental disabilities. Their research confirms, that the idea of making music with the interface of a drum is useful and activating and their results suggest that this aspect will be well received by the children, since it supports their auturgy and perception despite their limitations.

3. Evaluation

In principle, the evaluation of DDMM was divided into two phases. The initial state of the system (the previous prototype) was investigated in a first test run. Based on the observations from this test run and the concept for the further development we implemented the necessary improvements (e.g. visual feedback), which was then evaluated in the second test run. in both states the system was evaluated with children from three different age groups: at first with participants of a voluntary drum group, which is offered weekly at a local elementary school within the framework of the open all-day school (OAS), then in a music-related parent-child group and the last test took place in a children's day-care center.

In order to discover, how children deal with DDMM, to what extent they interact self-determined and whether they have (subjectively speaking) fun, we used the method of open participating observation as the main component of this evaluation. Furthermore, we combined this procedure with other methods in order to reveal further connections. On the one hand, we asked the parents / teachers using a standardized form in order to obtain information on the age and behavior of the children during their everyday life. On the other hand, the children were asked about their opinion on the system, which we did in the form of a group interview after trying and exploring the system. The test phase itself also took place in this group, whereby a maximum group size of 15 persons was selected, since it corresponds roughly to the day care group size. The children knew each other and were able to interact with their usual friends in smaller test groups, while the other children of the group watched or joined in. The tests and interviews were documented with the help of video recordings and afterwards both children's utterances and their behavior were transcribed in an anonymous form, in order to examine them in various aspects. In addition, during each test, the system itself measured the success of the children playing.

3.1 First Test Run

In general, the structure and process of evaluation is similar in all facilities so that the comparability of the results is given. However, there are minor differences in available space or group strength. We arranged the components of the system in the room so that observation is possible from several sides. After the technical setup, the further course is then divided into three phases (introductory phase, test phase and interview phase). It could be observed, that most children reacted to DDMM with great joy and very enthusiastically and they urged to test the system right from the start. In only a few exceptional cases the children did not dare to try DDMM themselves and preferred to look. It was also observed in

all groups how attention and concentration were lost towards the end of the test phase. Thus, the first test runs were much more careful and explorative than the last ones. Furthermore, it could be observed, that the children usually played in strict time by chance rather than coincidentally and it appeared, that they play the drums uncontrolled. In many cases, they did not hit the beat over several bars. Among the dancers, it was often observed that the children danced rather freely (breakdance, couple dance). Altogether, only a small part of the children tried to produce music by stomping and only a few tried to change the tune with their arms. At the beginning, it was basically the case in all facilities, that most of the children were drumming and only a few wanted to dance. This changed in the course of the evaluation and towards the end, more children wanted to dance than do the drumming. In the following interview the children in all the tested facilities agreed, that they would describe the machine as "goooood" or "niiiiiice". Regarding the question if whether drumming or dancing was easier, there was a clear tendency towards drumming, but in each group at least one child thought dancing was easier.

A total of 19 girls and 16 boys from 3 to 8 years of age took part in this test, with more than half of the children in preschool age. Further analysis of the data from the questionnaire shows that all children at least show interest in making music regarding individual aspects. According to the data of educators and parents more than 80% of the children sing songs on occasion and almost 90% play on an instrument. The comparison of subjective observations with questionnaire data also shows a similarity: the children (mostly girls) who occasionally dance in their everyday life often also raise their hand for the role of the dancer during the test of DDMM. In order to evaluate the log files generated during our tests, an analysis program was coded, which maps the information given by the text based log files (eg. child has hit in strict time / not hit in strict time or not hit at all) as numerical values and writes them into a table. Figure 2 shows the graphical representation of the data from one test group during both iterations:

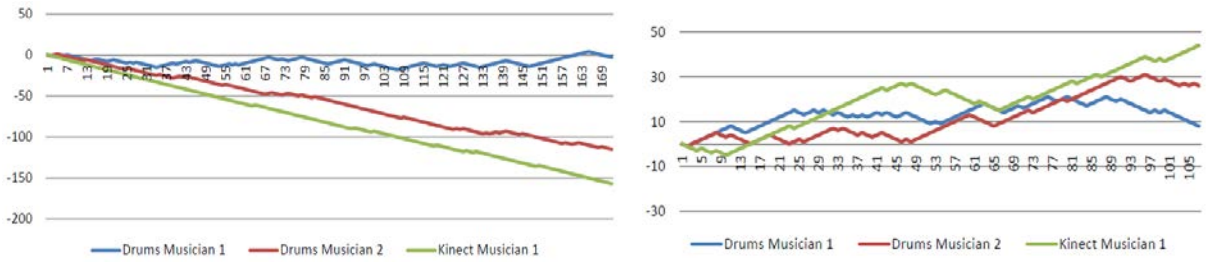

Figure 2: Measured data from one exemplary test group (left: first iteration, right: second iteration)

This and the other diagrams often show a similar picture: the curve of the dancers (*Kinect Musician*) drops almost constant in most cases, while the drummers' curves (*Drums Musician*) often take course around the zero baseline. The few exceptional points of the curve show the moments when the children were stomping and temporarily matching the metronome. These objective values also coincide with the subjective observations. In many groups the children, as already described, made quite different dance movements and accordingly the results of the measurements were to be expected. The same applies to the frequency of the key changes provoked by the different arm positions. Based on the observations we made, it should also be noted that the kindergarden children were already familiar with this practice in a didactic-methodical learning environment. Thus, their participation was more calm and concentrated than during the tests with the children from OAS and parent-child group. This allows the conclusion that certain groups need a clear setting for working with DDMM, such as, for example, a manageable group size adapted to the age structure, to prevent longer waiting times for this activity, avoid unrest and increase the concentration. Likewise, an intensive introduction such as trying out drumming, dancing and stomping movements, elaboration of rules for social behavior (eg. the passing on of the drums) and the motivation for self-control of the child by the pedagogues can be helpful.

3.2 Second Test Run

In principle, both a similar structure as well as a nearly identical procedure is used in the second test iteration. In this test run, the variances regarding the structure are mainly due to the additional placement of a screen, which is used to display the visualization application. Based on the impressions of the previous test run, there are also some minor changes for the process. Since it was noticed that some of

the functions and properties of TTMM could not be perceived by the very free approach in some cases, more information and suggestions regarding the handling of the system should be given during this test iteration. As for the visualization, at first the cartoon version is used and then replaced by the realistic designed scene after a few test groups. In the last passages, the children are finally allowed to dictate which version should be used.

On the one hand, it could be observed that by means of the structured procedure with advices and instructions the children could be better informed about their actions. On the other hand, the dance behavior of the children also changed due to the visualization. It was observed that there was less free dancing and much more stomping, since the children tried to copy the behavior of their visual guides. Due to the color changes of the visualization, the children were also strongly encouraged to try different arm positions and analyse the resulting changes. Like in the first test iteration, at the beginning none of the children wanted to dance. However, this changed after the first group. Since some of the children from the kindergarten group already knew DDMM from the first iteration, during the subsequent interview phase it was possible to ask whether they think the system is either better with the new visualisation or if they would not need it. Everyone agreed that making music with the help of the additional visual guidance and feedback was better and easier.

A total of 17 children from four to seven years of age took part in this second test run and, as in the first run, more than half of the children participating were in the preschool age. In the first review of the evaluation results of the questionnaires it can be seen, that the diagrams of both institutions differ significantly from each other this time. Regarding the behavior and the measured success of the dancers, a significant improvement could be achieved instead. While the children in the first test run rarely managed to stomp in time, the graphical evaluation of the second test run shows much more success. In two cases, the curve of the dancer even takes course above the two drummers' curves (see figure 2). Looking further at the data, the average number of changes in the position of the arms shows that with the use of the visualization not only the frequency of the stomping movements but also the amount of arm movements increased. On average, children change the tune of the composition three times more often than during the first test iteration. Both of these changes can also be seen in the measurements. In contrast, however, no changes can be measured with respect to the drummers: their curves are very similar to those of the first test run. From this it can be deduced that the process of drumming was self-explanatory to them and further aid would not have been necessary.

4. Overall Results and Conclusion

The additional optical feedback was intended to motivate the children to an even greater extend. In the two test runs, both development stages were therefore investigated and the most important results and observations were presented in this paper. We were able to show that the general approach of motivating children to create music together through the use of a novel system is well received and can lead to the desired success. Similar results were obtained from the evaluation of the further developed version, whereby it could also be measured and observed that the visual feedback motivated children to dance and explore DDMM even more. Unlike we feared, the occasional lack of acoustic feedback - when the children do not play in strict time, meaning they hit the drum but produce no sound - does not seem to lead to great confusion and frustration. With regard to the question of research we wanted to answer, it can thus be concluded that the system appears to be suitable for the use in early music education. However, the extent to which the application has a learning effect that is actually usable should be examined in further, more extensive investigations. A further result of the two test runs are the opinions of the children on the question of what else could be added to the system. Furthermore, from the observations some other possibilities of improvement can be derived, such as an additional free dance mode and a further development of the drum.

5. Future Work

The feedback from the institutions as well as the results of the evaluation show that it might be useful to carry out further test runs and possibly also to analyse the already collected data regarding other aspects.

Thus, further questions, such as the achievable learning effect or the suitability of the system for even younger children, could be investigated. Since the results of the previous tests have shown, among other things, that a more structured approach can lead to better results, a detailed pedagogical concept should be developed beforehand. Additionally further enhancements, based on the observations we made, with a subsequent evaluation is planned for the future. For example, recently an additional DDMM plugin was developed by other students, which offers the possibility to query different areas of a drum. Thus it would be feasible that drumming children could have a greater influence on the design of the common piece of music. This also enables the important educational goal of self-determination and self-efficacy of the child. (Schwarzer & Jerusalem, 2005) In addition, the project is supposed to lead to further research projects, particularly in the field of curative education. However, this is in principle only one of many possible applications in which the system we developed can be used.

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