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Stimulating the Development of Rhythmic Abilities in Preschool Children in Montessori Kindergartens with Music-Movement Activities: A Quasi-Experimental Study

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Abstract
This article examines the effects of Montessori music-movement activities on the development of the rhythmic abilities of 59 children from Montessori preschools, aged between 3 and 6 years. Children were deployed into two experimental groups (EG 1 (n = 20) & EG 2 (n = 22)) and a control group (CG) (n = 17). Our intervention consisted of introducing 15 to 20 min of unstructured movement time, either accompanied by a piano (EG 1) or recording (EG 2), three times a week for four months, whereas the control group carried on the usual Montessori program. We used a quasi-experimental nonequivalent groups design with pretest–posttest. Three tests for measuring rhythmic abilities were used: auditory discrimination of the rhythmic patterns, imitation of spoken rhythmic phrases, and determining the synchronization of movement with the rhythm of the music. The interventions had a positive effect on the development of the rhythmic abilities of children included in the study. The most significant effect was noticed in EG 1, while no effect of non-activity was detected in the control group.

Keywords Rhythmic abilities · Music and movement · Montessori · Preschool

Introduction

Rhythm is an essential element in a child's development. Children respond to rhythm from an early age, and rhythm is widely recognized as a key aspect of development (Pollatou et al., 2013). Several studies have shown that an integrated music and movement program can improve children's rhythmic ability (Marinšek & Denac, 2020; Pollatou et al., 2013; Venetsanou et al., 2014). Those studies' findings align with the music educational guidelines of Orff and Dalcroze, two of the most prominent music pedagogues, who claimed that integration of music with movement is an essential part of the development of music abilities (Da Napoli, 2006). Empowering rhythmic abilities through music-movement interventions offers a variety of transferable benefits; empowerment of rhythmic abilities is essential from a cognitive standpoint, given their strong links to important motor and cognitive processes, including language and memory (Bégel et al., 2017). Furthermore, implementing a rhythm and movement intervention can help preschool children to improve their self-regulation abilities (Williams & Berthelsen, 2019). Summed up, music-movement synchronization significantly affects holistic development in preschoolers and has many effects on learning transfer (Williams & Berthelson, 2019).

In the present study, we focus on the development of rhythmic abilities through music-movement activities in Montessori kindergartens. The Slovene Montessori kindergartens were chosen because we have observed a discrepancy between Montessori pedagogical concepts regarding the implementation of music activities and actual pedagogical practice (Laure, n. d.). Even though Maria Montessori emphasized the importance of music in the development of preschool children (Da Napoli, 2006), there is a lack of structured music activities compared to other activities (e.g., language, math, science) in Montessori pedagogy (Dansereau & Wyman, 2020; Werner Andrews, 2014). Music, as a didactical means with several positive effects on the holistic development (motor, cognitive,

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emotional, social, aesthetic) of young children (Habe, 2020), has not been used optimally in Slovene Montessori kindergartens (Mavrič, 2020).

With our study, we aimed to explore the significance of the implementation of systematic music-movement activities in Montessori preschools. Montessori educators put a lot of emphasis on balance, orientation, and regulation of movement. Children regularly participate in the "walking on the line" exercise that encourages them to walk steadily on a line, marked on the floor with tape, to improve their balance and learn to regulate their movements (Montessori, 1917). However, "walking on the line" is an activity that is, in practice, typically performed without any specific musical accompaniment. It served as a good preparation for our intervention: music-movement activities, where we allowed the children to move freely with music (Montessori, 1917, 1964).

Since there is very limited literature on Montessori music and movement activities in Slovenia, Slovene kindergarten teachers usually do not perform music-movement activities in their work with children but rather just use the activity "walking on the line" without any musical accompaniment. After extensive research of the existing literature in the mentioned field, which is available in rare copies abroad, we encountered two publications that enable the implementation of such activities in Montessori kindergartens. The publication Montessori & Music: Rhythmic Activities for Young Children (Braun Barnett, 1973) contains theoretical starting points for performing music and movement activities and a musical notation of compositions for piano. The second publication is a set of two audio CDs, Klaviermusik zum Gehen und Bewegen auf der Linie (Sulovsky, n. d.), which contains recordings of music appropriate for such activities. Since more than half of the Montessori teachers involved in the research on music in Montessori kindergartens in Slovenia do not have a formal musical education (Mavrič, 2020), we were interested in the impact of the intervention using musical recordings that also allow the teachers who do not play the piano to perform this type of activities.

In the following theoretical backgrounds, we will first present studies regarding the music-movement relationship in Montessori pedagogy. Further, we will focus on the effects of music-movement interventions on rhythmic abilities and their outcomes on holistic development. Later we will shed light on the research outcomes of the music interventions that combine music and movement. Lastly, we will outline the benefits of live vs recorded music.

Music—Movement Relationship in Montessori Pedagogy

Movement is an integral part of the Montessori approach. In Montessori preschools, children can move freely through the prepared environment to explore their interests. Montessori, (1967) believed that the body and the mind do not only have to be linked; rather, they must be treated as one. She argued that without movement, the brain develops in a different way, as if it were cut off from the results of its work. In the Montessori pedagogy literature, much emphasis is placed on the connection between music and movement. The recognition of sensorimotor intelligence as the initial stage of intellectual development led Montessori (1967) to base her method on the principles and laws determined by biological growth. If music is to play an important role in the life and learning of a young child, then musical experiences planned and presented to the children must be based on the same laws and principles. Controlled movement, which has its purpose, is the basis for learning music in the Montessori pedagogy, as children in early childhood learn mainly through actions and movement and not so much by thinking alone (Da Napoli, 2006). In the Montessori approach, music plays the role of a universal language, with the help of which children can learn about their bodies and environment.

Although Montessori pedagogy attaches great importance to music in children's education, music teaching is not given as much attention as other fields, for example, language, mathematics, and science. Montessori was, first and foremost, a scientist. Because of her lack of musical background, she developed basic guidelines for teaching music in the early childhood period together with Maccheroni, (1956) and Braun Barnett, (1973). Several music teaching ideas are grounded in the Dalcroze method (Da Napoli, 2006). Dalcroze's eurhythmics uses movement to teach about rhythm, structure, and musical expression and frequently introduces a musical concept through movement before they learn about its visual representation (Dalcroze, 2007). Montessori and Dalcroze shared the idea that the performance and reproduction of music should occur only after the child understands and experiences music through movement (Abril & Gault, 2016; Dalcroze, 2007; Montessori, 1964). Listening and moving to music in the Montessori concept, therefore, represent an important preparation for other musical activities and the overall holistic development of children.

Children up to the age of 6 are in a sensitive period for movement. This is reflected in their desire to move and express their feelings with their whole bodies (Montessori, 1967). For children to develop the necessary skills to control and regulate their movements and whole body, in Montessori preschools they are invited to participate in a daily activity called "walking on the line". "Walking on the line" is a systematic activity for developing body coordination performed on an elliptical line marked on the floor where children try to keep their balance while stepping on the line, carefully moving heel-to-toe (Vatansever & Ahmetoğlu, 2019). The activity is not directly related to the field of music since it is typically performed without any specific musical accompaniment. The purpose of

this exercise is to acquire a sense of balance, orientation, and to develop graceful movements. In the Montessori literature, "walking on the line" is described as a preparation for music and movement activities, where children could then move freely with music (Montessori, 1917, 1964). As mentioned earlier, the guidelines for performing the music and movement activities were defined by Maccheroni and Braun Barnet, (1973), who reported that after several months of regular exposure and freedom of movement and bodily expression, children develop dance steps that are achieved by adapting the movement to the rhythmic and metrical characteristics of the music they listened to. They believed that since children can develop and learn in a prepared environment, it is crucial that they are exposed to carefully selected music that promotes their development. In each musical piece they suggested, only one rhythmic character pattern dominates, to which the children respond with one type of movement (for example, slow walking, jumping). Despite the very relevant ideas that they presented, the records of music and movement activities can only be found in scarce and old literature that has not been reprinted. Since this literature is not available in the Slovenian area, Montessori teachers do not have the opportunity to implement Montessori music-movement activities at their work with children.

Despite the increasing interest in the Montessori pedagogy, very little attention has been paid to the research on the music in Montessori preschools. Based on a review of the relevant literature, we can conclude that most of the attention in the field of music in Montessori pedagogy was devoted to the research on verifying the effectiveness of music-didactic materials that were designed in accordance with Montessori principles (Dansereau & Wyman, 2020; Fitzmaurice, 1971; Miller, 1981). Until today, only a few research articles discussing music in the Montessori approach have been published in Slovenia (Gruden, 2017; Mavrič, 2019; Smrekar & Podgornik, 2017; Zadnik & Koren, 2017). Most of them investigate music education and the Montessori approach in connection with learning musical theory in a music school and focus mainly on the design of didactic materials for teaching the theory of music (Gruden, 2017; Smrekar & Podgornik, 2017; Zadnik & Koren, 2017). There are also very few newer publications (Da Napoli, 2006; Klotz, 2013) that offer a planned and systematic review of the principles of teaching music in the Montessori approach. To sum up, there is a lack of research on music in Montessori, let alone the music and movement activities.

The Effects of Music—Movement Interventions on Rhythmic Abilities and the Outcomes on the Holistic Development

Children intuitively match their physical movements to the music when moving expressively (Eerola et al., 2006). This is based on the ability to align one's movement according to the music as a response to a particular aspect of the music, such as the beat, character or emotional characteristics of the music (Nijs & Bremmer, 2019). According to Leman, (2016), there are two main types of alignment: phase alignment and inter-phase alignment. Phase alignment defines how the expressive flow of physical activities fits the time in between the beats of music, whereas inter-phase alignment shows how movement is synchronized to important time markers in music (Nijs & Bremmer, 2019). To accomplish so, one must recognize crucial moments in music, execute rhythm patterns, and adjust rhythm pattern performance to fit the overall timing framework (Nijs & Bremmer, 2019). According to Clayton et al., (2004), entrainment is a process of adjusting and fixing the two rhythmic processes through their interaction, resulting in a shared phase and/or periodicity. People and music are both affected by this process, as people synchronize their movement outputs with sensory inputs (Ilari, 2015; Large, 2000; Phillips-Silver et al., 2010). When the music's tempo is near to the child's chosen tempo, the process of spontaneous synchronization with music is more accessible (Van Noorden et al., 2017).

When focusing on studies investigating the effect of music-movement programs on children's rhythmic ability, it is revealed that in earlier studies (Blessedel, 1991; Croom, 1998), non-locomotor tasks were utilized for rhythmic ability assessment, while in more recent ones (Pollatou et al., 2013; Zachopoulou et al., 2003), the High/Scope Beat Competence Analysis Test (Weikart, 1987) was used that includes tasks like hand tapping, foot tapping, patting knees or locomotions, such as walking in place/forward/backwards. Children's non-locomotor responses to rhythmic stimuli in the preschool period become more accurate with maturity, but they can be stimulated significantly by entrainment (Venetsanou et al., 2014). Participation in musical activities can bring many beneficial non-cognitive transfer effects of music on a child's emotional, social, and motor development (Hallam, 2010; Zachopoulou et al., 2004). Just listening to music can have various beneficial health and educational effects (Jensen, 2000; Levitin et al., 2018).

Rhythmic entrainment is a process that promotes motor learning, emotional expression, and the improvement of movement performance by synchronization of the movement to a rhythmic cue (Marinšek & Denac, 2020). Thaut et al., (2015) found that entrainment cues enhanced spatial and force parameters in addition to changing movement time. Regardless of the above-mentioned valuable research outcomes, there is a lack of studies exploring the effects of simultaneous music and movement activities on rhythmic abilities (Deli et al., 2006; Denac & Marinšek, 2020).

Development of Rhythmic Abilities in the Preschool Period

Gordon, (2009) describes rhythmic abilities as basic universal musical abilities that are innate and present in everyone. Children are born with musical abilities that can only be maintained through repeated positive exposure to musical experiences soon after (or even before) birth and by the age of nine when the child achieves the stabilization of musical abilities (Gordon, 2009). The perception of rhythm occurs through the recognition and identification of events and patterns, perceptual organization, categorization processes, memory, and attentional processes (Halpern & Bartlett, 2002; Iannaril et al., 2013a). According to Derm et al. (2001), rhythmic ability is the capacity to perform a series of controlled, repeated gross motor activities requiring both spatial and temporal precision. Some authors classify rhythmic ability as a coordination ability (Svobodová, et al., 2016). A fundamental characteristic of rhythmic ability is the capability to translate an aural perception into a corresponding motor behaviour (Iannarili et al., 2013b). The ability to discriminate and reproduce rhythmic sequences reflects a combination of maturation and experience (Iannarili et al., 2013a; Persichini & Capranica, 2004).

Research on the range of rhythmic ability in the general population is limited. Three factors are believed to be the independent causes of individual differences in rhythmic ability in the general population: short-term memory capacity, sensitivity to the presence of stable temporal structure, and musical training (Grahn & Schuit, 2012; Tierney et al., 2017). Auditory short-term memory capacity relates to reproduction, discrimination, and synchronization in relation to rhythm (Bailey & Penhune, 2010; Wallentin et al., 2010). Even though research outcomes show that there are several factors that can have an impact on the development of rhythmic abilities in preschool children, musical training is considered to be the factor that can be most easily manipulated within the educational process; therefore, we chose to focus on this variable in our study.

Differences Between Live and Recorded Music

Since the dawn of time, music has played a significant role in human activity and has typically been experienced in a live setting. There are numerous studies that highlight the importance of the human element inherent in live music. Contrary to listening to a recording, where there is no chance for an audience to directly impact what a performer has previously made, every live performance is unique in that events develop spontaneously and unexpectedly. Many listeners associate their favourite musical memories with live performances (Gabrielsson, 2011; Lamont, 2011). Live performances also provide listeners with a chance to interact directly with the performer. Live performances might differ acoustically and energetically from those that are recorded in the studio since performers can be impacted by the audience's presence as well (Bradby, 2017; Yoshie et al., 2016; Zajonc, 1965). In contrast to listeners at a pre-recorded performance, audience members feel more relaxed when a performer is there than when they are only listening to a recording (Shoda et al., 2016). Research shows that when artists connect with the audience and display their own enthusiasm, audiences are more likely to enjoy performances (Brand et al., 2012; Pitts & Burland, 2013; Pitts & Spencer, 2008; Radbourne et al., 2013). Although it has not yet been studied how live vs recorded music affects preschoolers' rhythmic development, some studies suggest that audience members at a live performance show stronger entrainment with the musical rhythm (Shoda et al., 2016). Furthermore, infants in pediatric critical care might respond better to live music interventions than recorded music interventions for lowering pain and anxiety (Arnon et al., 2006; Malone, 1996). Despite different views on the effects of live music, there seems to be a consensus in the literature that live music performances provide a unique experience that cannot be obtained through recorded music (Bradby, 2017; Brand et al., 2012; Gabrielsson, 2011; Lamont, 2011; Pitts & Burland, 2013; Pitts & Spencer, 2008; Radbourne et al., 2013; Shoda et al., 2016; Yoshie et al., 2016; Zajonc, 1965).

Taken together, the studies presented thus far support the notion that live music has a powerful impact on listeners of all ages, from infants to adults, and that it can be used to foster connection and entrainment with musical rhythms. Therefore, a study examining how a music-movement entrainment intervention affected preschoolers' rhythmic ability with an element of live performed music versus a recorded version is needed to further understand the impact of live music on developing rhythmic abilities.

Present Study

As discussed previously, research suggests that children who are exposed to music-movement activities develop skills like balance (Zachopoulou et al., 2004) and learn to regulate their movements (Pollatou & Hatzitaki, 2003), skills that are important in Montessori classrooms given the "walking on the line" activity that is often performed (Braun Barnett, 1973). Children in Montessori preschools in Slovenia have limited access to music-movement activities, given the scarce music-movement resources and professional learning opportunities available to teachers (Mavrič, 2019). Thus, we sought to examine how a music-movement entrainment intervention affected pre-schoolers' rhythmic ability. Furthermore, we added an element of live performed music (a music teacher was accompanying the rhythmic activity of children on the piano). Our research context was set in

Montessori kindergartens, where the significant inter-relatedness between music-movement is one of the fundamental orientations in teaching music.

Even though the importance of music-movement intertwining in enhancing musical development in preschool children, especially rhythmic abilities, is commonly known, there is a lack of empirical studies investigating it (Marinšek & Denac, 2020; Pollatou et al., 2013; Venetsanou et al., 2014).

Our study hypotheses that there will be a significant increase in all three measured rhythmic abilities in both experimental groups compared to the control group. Furthermore, we predicted that live music would have a more significant effect compared to pre-recorded music.

Method

The research was conducted using a pretest–posttest quasi-experimental non-equivalent groups design. We used a one-factor experiment with classrooms as comparison groups. The research work occured in two experimental groups (EG 1, EG 2) and a control group (CG). We studied the effect of the intervention on the development of rhythmic musical abilities of children enrolled in Montessori kindergartens. Random assignment at the student level way was not feasible due to the possibility of disrupting classroom routines. Random assignment was therefore performed at the classroom level.

Participants

Fifty-nine children from the three units of Slovene Montessori kindergartens, aged three to six years ($M = 4{,}08$, $SD = 0{,}89$), participated in the study. The sample was comprised of 32 boys (54.24%) and 27 girls (45.76%). The participants were divided into two experimental (EG 1 = 33.90% (n = 20) and EG 2 = 37.29% of children ($N = 22$)) and one control group (CG) ($N = 17$).

Intervention Programs

With the intervention, we aimed to develop the rhythmical abilities of children from Montessori preschools. Our intervention consisted of introducing 15 to 20 min of unstructured movement time, either accompanied by a piano or recording, three times a week for four months. The control group carried on the usual Montessori program, whereas the experimental groups performed the previously mentioned music-movement activities accompanied by piano or recording. The intervention in experimental group 1 was performed by a teacher playing the piano and using the *Montessori & Music: Rhythmic Activities for Young Children* (Braun Barnett, 1973). The intervention in experimental group 2 was executed using the music recordings *Klaviermusik zum Gehen und Bewegen auf der Linie* (Sulovsky, n. d.). The interventions were carried out by Montessori teachers working in these groups.

When discussing what other musical activities are happening in the classrooms it is important to highlight that in Montessori kindergartens, activities are not planned in the same way as in traditional kindergartens (Vatansever & Ahmetoğlu, 2019). If in public kindergartens, the educators carefully document all the activities that they carry out, this is not the case in Montessori kindergartens, where such monitoring does not take place. In Montessori pedagogy, teachers must be able to give children the opportunity to lead their own learning (Montessori, 1964). Progress in the Montessori approach is founded on an understanding of each child and on careful consideration of their unique needs and interests. The foundation of the Montessori approach is the belief that, given a learning environment that is developmentally appropriate, children are capable of teaching themselves by choosing activities that interest them (Montessori, 1967). Therefore, it is impossible to determine how much time and what kind of musical activities each individual child participated in.

The experimental activities were conducted in the morning during continuous provision (children have spontaneous access to activities through the use of Montessori didactic materials). Some children immediately stopped what they were doing and happily began to move to the music; others, more cautious, observed for some time before joining in. In each piece, only one rhythmic character pattern predominated, to which the children spontaneously responded with one type of movement (e.g., walking, running, hopping). The teacher did not correct or direct their movements. In the beginning, the children were introduced to contrasting musical pieces that stimulated contrasting movement responses. Because of the length of the pieces and children's natural affection for repetitive patterns, we repeated them several times without a break. Such musical activities included about eight to twelve songs and lasted between 15 and 20 min. The program of each intervention included music in contrasting moods, tempos, and rhythms.

Procedures and Measures

Firstly, the permission of the kindergarten principal to conduct the research was obtained, and the written and informed consent of the parents of the selected children who participated in the research. This research study was conducted in accordance with the Declaration of Helsinki (World Medical Association, 2013) and the Code of Ethics and Q4 Conduct of the British Psychological Society (2018). The University of Maribor's Research Ethics Committee granted ethical approval for data collection.

Initial and final state data were collected using a quantitative data collection technique, with measurements of rhythmic hearing development, which consisted of three tests: Test 1: Identification of identical and different rhythmic patterns, which was summarized after the standardized test "Primary Measures of Music Audiation" (Gordon, 1986), Test 2: Imitation of spoken rhythmic phrases (Denac, 2002), and Test 3: Determining the consistency of movement in the rhythm of a composition (Marinšek & Denac, 2020). Gordon, (1986) states that the coefficient of reliability of the "Primary Measures of Music Audiation" test is between 0.72 and 0.86, and the values for the reliability of retesting for the rhythmic subtest are between 0.60 and 0.73. Denac (2002) carried out a validation study of her instrument; factor analysis with varimax rotation showed two factors following the Kaiser test and the Scree diagram. Validity was ensured by factor analysis, which found that a high percentage of variance (0.71–0.83) explains the factor of rhythmic ability. The ICC correlation coefficient (0.71—0.83) was used to calculate the reliability of the first test and retesting, and Cronbach's coefficient α (0.63—0.94) was used to calculate the internal compliance (Marinšek & Denac, 2020). More thorough description of instrumentation can be found in the online appendix.

Due to the scarcity of educators who possess knowledge of both music pedagogy and the Montessori methodology, one of the authors had to be involved in the assessment in order to maintain the regularity of the Montessori classroom and to cause as little disturbance to the routine as possible. As a result, one of the authors was not blind to the experiment/control condition of the children. The pre-testing was conducted one week before the implementation of our intervention (15 to 20 min of unstructured movement time either accompanied by a piano or recording) in the experimental groups. The quasi-experiment lasted 4 months, followed by the post-testing the week after the experiment ended. Test 1 was administered in small groups of 3–5 children, Test 2 individually and Test 3 in an entire classroom group. Testing conditions were selected according to the instructions manual of each test. Testing took place in a pre-prepared room, and the measurement procedures were determined in advance. Each task was demonstrated and explained to the children before the measurements were taken. The implementation of the experimental program and the testing of the initial and final state took place in three units of one Montessori kindergarten in Slovenia. Data was obtained through structured observation with predetermined indicators, and the development of children's rhythmic abilities in relation to the performance of musical tasks was examined. A camera was used to record the children, and their best attempts were evaluated based on the recording. Each test also included a trial task. After evaluating the measurements, the recordings were deleted, and anonymity was ensured by guiding the children with randomly selected numbers.

Results

Firstly, we tested the assumption of homogeneity of variance with Levene's F-test and thus had the conditions for analysis of variance (ANOVA). Based on the results of these tests, we were able to conclude whether there were statistically significant differences between the comparison groups. The difference between children's development of rhythmic abilities from the experimental and control groups was then checked by parametric tests. Because we had baseline and endpoint data, we used the t-test for two dependent samples. To calculate the size of the effect, we used Cohen's d. This was followed by an analysis of the difference in progress between the CG, EG 1 and EG 2. We checked again with Levene's test of assumption of homogeneity of variances and by ANOVA to determine whether there were differences in the development of rhythmic abilities. We also calculated the correlation coefficient and determined the magnitude of the effect.

Initial Condition Analysis

The assumption of homogeneity of variance was justified ($p > 0.05$). We thus had the conditions to test the differences in the state of development of rhythmic abilities between individual groups using ANOVA. The results in Table 1 show no statistically significant differences in the development of musical abilities between the groups in the initial state ($p \geq 0.956$).

Differences in the Progress of Rhythmic Abilities Between the Groups

Figure 1 shows the differences in the measurements of the development of rhythmic abilities between the initial and final states of the control group, experimental group 1 and experimental group 2.

The differences between the arithmetic means of the initial and final states between the groups can also be observed in Table 2; in the experimental group 1, children achieved better results in the final test (*diff.* > 1.454) than children in the control group (*diff.* ˂ 0.294).

The assumption of homogeneity of variance was not justified in one case, so we refer to the Welch F-test, while in other cases, the general F-test is used and thus, the justified assumption of homogeneity of variance. In Table 2, we can observe statistically significant differences between the experimental groups and the control group in the development of rhythmic abilities in tests to identify the same and

Table 1 Differences in the rhythmic abilities between the CG, EG 1 and EG 2 in the initial state (pre-test) of the experiment

	Pre-test		Levene's test		ANOVA	
	M	*SD*	*F*	*p(F)*	*F*	*p(F)*
Identifying the same and different rhythmic patterns (IDENT)						
CG	6.294	1.993	2.959	0.060	0.15	0.985
EG 1	6.228	1.343				
EG 2	6.200	1.795				
Imitation of spoken rhythmic phrases (IMIT)						
CG	4.059	2.106	0.290	0.749	0.45	0.956
EG 1	4.091	2.022				
EG 2	4.250	2.268				
Determining the consistency of movement in the rhythm of music (DET)						
CG	2.824	1.845	0.219	0.804	0.002	0.998
EG 1	2.863	1.935				
EG 2	2.850	1.755				

M arithmetic means, *SD* standard deviation, *CG* control group, *EG* 1 experimental group 1, *EG* 2 experimental group 2

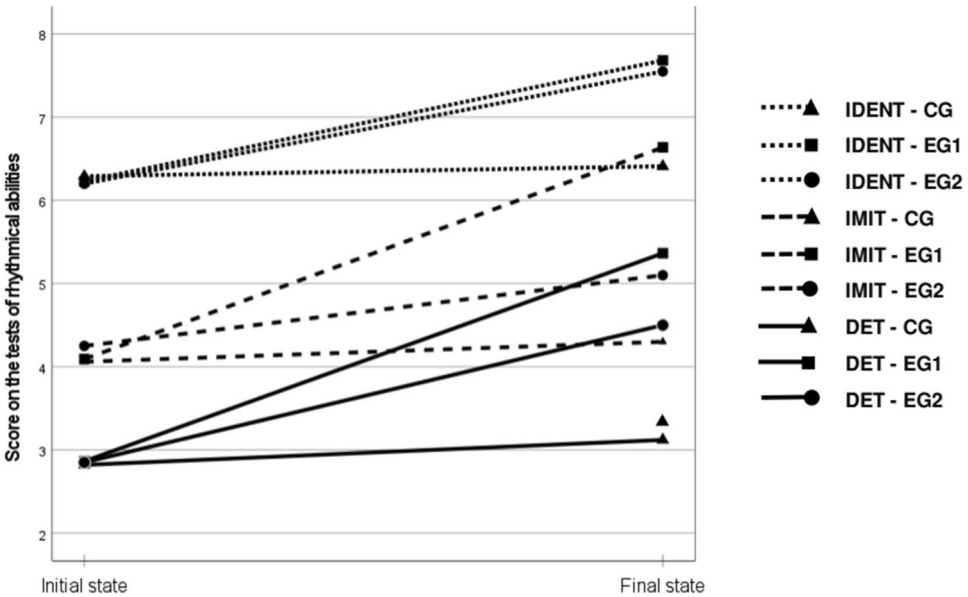

Fig. 1 Progress between the comparison groups

different rhythmic patterns ($F=7.579$, $p=0.001$, $\eta^2=0.21$), imitation of spoken rhythmic phrases, ($F=10.589$, $p<0.001$, $\eta^2=0.23$) and determining the consistency of movement in the rhythm of music ($F=8.952$, $p<0.001$, $\eta^2=0.24$). We can also observe the activity's effects in all tests ($\eta^2>0.15$). In all three tests, the children from experimental group 1 were the most successful, followed by the children from experimental group 2.

We performed a t-test for two dependent samples and found that in all three tests, there were no statistically significant differences between the initial and final state ($p\geq0.206$) of the control group, and the effects of the activity between the two measurements were small ($d\leq0.17$). The control group made the most significant progress in the test of imitation of spoken rhythmic phrases, and minor progress was made in determining the conformity of movement in the rhythm of the music. In Table 2, we can also observe statistically significant differences in the measurements of rhythmic abilities between the initial and final states of experimental group 1 ($p<0.001$). This group's experimental program significantly affected the task of imitating spoken rhythmic phrases ($d=1.552$), where the children in the final state scored 2.55 points more than in the initial test. The significant effect of the activity is also shown in the task of determining the conformity of movement in the rhythm of music ($d=1.371$), where the children achieved 1.45 points more on the final test than on the initial condition test. The effect was slightly smaller but still prominent in identifying the same and different rhythmic patterns ($d=1.252$), where

Table 2 Mean (standard deviation) scores before (Pre-test) and after (Post-test) the Intervention Program and the Difference in Rhythmical Abilities scores (diff.) between the control group (CG), experimental group 1 (EG 1) and experimental group 2 (EG 2)

	Pre-test	Post-test	diff	p(t)	d
Identifying the same and different rhythmic patterns (IDENT)					
CG	6.294 (1.993)	6412 (1,064)	0.118	0.756	0.074
EG 1	6.228 (1.343)	7.682 (0,945)	1.454	0.000	1.531
EG 2	6.200 (1.795)	7.550 (1,234)	1.350	0.000	0.877
	ANOVA: F = 7.579, p = 0.001; $\eta^2 = 0.21$				
Imitation of spoken rhythmic phrases (IMIT)					
CG	4.059 (2.106)	4.295 (2.085)	0.235	0.466	0.113
EG 1	4.091 (2.022)	6.636 (1.136)	2.545	0.000	1.552
EG 2	4.250 (2.268)	5.100 (2.198)	0.850	0.000	0.380
	ANOVA: F = 10.589 (Welch), p = 0.000 (Welch); $\eta^2 = 0.23$				
Determining the consistency of movement in the rhythm of music (DET)					
CG	2.824 (1.845)	3.118 (1.616)	0.294	0.206	0.170
EG 1	2.863 (1.935)	5.364 (1.706)	2.500	0.000	1.371
EG 2	2.850 (1.755)	4.500 (1.606)	1.650	0.000	0.981
	ANOVA: F = 8.952 p = 0.000; $\eta^2 = 0.24$				

p(t)—Significance of paired t-test, d—Cohen's d, ANOVA—One-way analysis of variance, η^2—eta squared

children scored 2.5 points more on the final test than on the first test.

Finally, in Table 2, we can observe statistically significant differences between the initial and final states of rhythmic abilities of experimental group 2 (EG 2); after performing the t-test, we found that in all three tests, there were statistically significant differences between the measurements of the initial and final states of rhythmic abilities of children ($p < 0.001$). The intervention in EG 2 generally had a slightly smaller effect than that in EG 1; the highest was in the task of determining the conformity of movement in the rhythm of music ($d = 0.981$), where children achieved 1.65 points higher results on the final state test than on the initial state test. The effect of the activity was slightly smaller ($d = 0.877$) in identifying the same and different rhythmic patterns, where the children scored 1.35 more points on the second test than on the first test. The effect was relatively small in the task of imitating spoken rhythmic phrases ($d = 0.380$), where the children achieved 0.85 higher results on the final test than on the initial condition test.

Discussion

This current study has documented the impact of music-movement activities on developing rhythmic abilities in preschool children aged three to six. Furthermore, the significance of live music performance was confirmed.

The progress in rhythmic abilities in both experimental groups, in which the movement activity of walking on a line was combined with music, was expected, as we performed interventions that targeted children's rhythmic abilities by integrating music and movement. The results from our research are in line with several previous studies (Marinšek & Denac, 2020; Pollatou & Hatitaki, 2001; Pollatou et al., 2013; Venetsanou et al., 2014; Zachopoulou et al., 2003, 2004). Similar findings to our results were reported by Zachopoulou et al. (2003), who studied the effects of a 10-week music-movement program based on the music-pedagogical concepts of Orff and Dalcroze that share similar features with the Montessori concept. Blessedell, (1991) compared the effects of two programs based on the music-pedagogical concept of Dalcroze and Laban in three- to four-year-old children and found that both programs helped children develop the ability to move more harmoniously with the rhythm of the music. The latter was also confirmed by Croom, (1998), who found that five- and six-year-olds who attend musical activities with rhythmic locomotor movement could synchronize their bodies better with rhythm than their peers who received music education without such activities. This indicates that different kinds of musical and movement activities may induce the development of rhythmical abilities in young children. This idea is relevant for all teachers who work in different educational settings, regardless of kindergartens' pedagogical principles. The findings of our research and its related research can thus be used by a wide range of teachers who want to contribute to the development of children's rhythmic abilities with a relatively simple and undemanding activity.

Moreover, the current study confirmed the significance of live performance compared to pre-recorded music. A limited amount of research has been done on the differences between live and recorded music. According to Swarbrick et al. (2019), every live performance is unique, with events unfolding spontaneously and unexpectedly, with apparent beneficial effects. The heartbeats of audience members during a live performance were found to be more synchronized with the musical rhythm than among listeners to a pre-recorded performance, according to Shoda et al. (2016). Furthermore, greater relaxation was detected in the audience when listening to a live performance. Because live performance allows audience members to interact with the artist in person, the social dimension has a positive impact. Regarding children, the studies conducted on preterm infants show that lullabies performed live have a more significant beneficial impact than recorded lullabies (Garunkstiene et al., 2014). These findings should encourage early childhood education teachers to incorporate live music performance on any musical instrument into their regular work with children. They can exploit the transfer value of musical performance

to children regardless of the instrument they play. Early childhood teacher training program providers must make an effort to offer as much content as they can regarding the training of educators in musical performance.

Our study has several strengths. It is one of a few studies investigating the influence of movement-music activity on the rhythmic abilities of preschoolers. The research setting was Montessori kindergartens, where there has also been a need for studies regarding music education. We encourage all researchers and practitioners to contribute to the development of the mentioned field by carrying out research in this area.

However, there are some limitations to the current study. Despite taking great care to ensure the accuracy and reliability of the assessment results, such as using appropriate standards, there is a potential for bias in the assessment due to one of the authors being involved in the rhythm assessment and thus having knowledge of the experiment/control condition of the children. Unfortunately, no suitable alternative was available to resolve this potential bias, as there were no educators in Slovenia with knowledge of both music pedagogy and the Montessori methodology.

In interpreting the results, the reasons for the positive effects can also be attributed to the activity-oriented design of the experimental programs, which enabled children to experience music through their bodies actively. We believe that the choice of music in such activities is crucial, so the use of excerpts with a single emphasized rhythm was an excellent choice for such activities. When discussing the effects of our intervention, however, it is also important that teachers working with young children also consider the cultural and environmental context that young children reside. They must sensibly adapt the content of the music-movement activities to the (musical) environment in which they are located.

When discussing our study's findings, children's natural development, abilities, and skills must be kept in mind. Although our data show significant positive effects of the experimental programs, we cannot conclude with certainty how significant a factor maturation is in developing the rhythmic abilities of preschool children. For future research in this area, we suggest that researchers isolate and examine the maturation factor in the rhythmic development of children even more precisely.

One source of weakness in this study which could have affected the measurements of the rhythmic abilities was also the fact that the teacher who played the piano was an accomplished musician, so that could have effects on the children's performance on the rhythmic tests since the teacher may also, even subconsciously, engage in other musical activities throughout the day. This realization also indicates the importance of continuous professional development of the teachers in the musical field.

Our study has several implications for planning music-movement activities for preschool children. It confirms the importance of synchronous movement in developing musical, especially rhythmic, abilities. It also supports the daily implementation of short undemanding music-movement activities as part of a regular curricular activity. Furthermore, our study offers a concrete strategy for using music and movement to enhance musical abilities, which teachers can use in all contexts regardless of their musical background. Furthermore, integrating music and movement exercises enhances learning transfer, and numerous previous studies have suggested that music-movement programs might help children develop complicated motor abilities (Pollatou & Hatitaki, 2001; Zachopoulou et al., 2004). With this simple and straightforward practice, teachers may be able to not only affect children's rhythmic development but also enhance their motor skills.

From a developmental point of view, children must experience rhythm in their bodies before they can successfully hear the rhythm in their minds (Levinowitz, 1998); the early childhood period is crucial for the body to learn to respond to different kinds of music. Weikart, (1987) suggests that children can gain this experience in realistic situations in early childhood, especially if adults recognize the importance of early motor development and language interaction in rhythm and movement. Research by other theorists of motor skills supports the importance of movement in early childhood, as they found that most basic motor patterns appear before the age of five and only stabilize after that age (Gilbert, 1979). Therefore, to positively influence children's development, teachers must allow children freedom of movement and provide as many activities as possible, including those we recommend.

Conclusion

The research presented here aimed to study the effects of musical-movement activities, as organized according to the concept of Montessori pedagogy, on the development of musical abilities of preschool children from Montessori kindergartens. We found that the interventions had a positive effect on the development of the rhythmic abilities of children included in the study. Both experimental groups made more significant progress in developing rhythmic abilities than the control group. However, children from experimental group 1 made more significant progress in the development of rhythmic abilities than those in experimental group 2. Although previous studies strengthen the idea that this difference between experimental groups could be caused by live music, the limitations of our study design prevent us from drawing any firm conclusions about the causes of this discrepancy.

We can conclude that our research also supports the argument that music-movement programs positively affect the development of the rhythmic abilities of preschool children. In interpreting the results, the positive effects can also be attributed to the activity-oriented design of the experimental programs, which enabled the children to actively experience music through their bodies. We believe that the choice of music in such activities is very important, so the excerpts with a single emphasized rhythm were a good choice for such activities.

Professionals working with children of this age should be aware of the importance of movement in music education and the positive effects of music-movement activities. Based on the results of our research, we can conclude that if professionals are not trained to play the piano, the use of recordings in such musical-movement activities can also be beneficial for the development of children's rhythmic skills. To examine the reasons for our interventions' positive effects, we suggest researching the more precise impact of individual pieces of music from those we used on the musical abilities of preschool children. We also think it makes sense to conduct more detailed research on the impact of various musical activities carried out according to the Montessori concept on the development of musical abilities of preschool and school children.

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