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The influence of music technology on the academic behavior of preschool children with autism spectrum disorder

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Abstract

This study explored the effects of combining two music technology teaching approaches, holistic music educational approach for young children (HMEAYC) and multisensory musical activities (MSMAs), on children's academic behavior performances. The venue was a nonprofit early intervention organization and private preschool. Purposive sampling was used to select six children with autism spectrum disorder (ASD) and six without ASD around the age of 40-63 months, and the course arrangement was a 40-minute class each week for 14 weeks. This study demonstrated that the MSMAs teaching method could improve children's learning habits and performance without ASD. In addition, the intervention of HMEAYC teaching method can improve the academic behavior of both children with ASD, and without ASD, especially for children with ASD; it has more significant benefits on learning habits. In addition, through HMEAYC's music therapy courses, children's communication, emotional and social performance can also be improved.

Keywords: multisensory musical activities, music technology, holistic music educational approach for young children, academic behavior, preschool children with autism spectrum disorder

INTRODUCTION

On the occasion of the 70th anniversary of the founding of the United Nations in 2015, "Transforming our world: The 2030 agenda for sustainable development" was released and based on the active practice of equality and human rights, announced 17 sustainable development goals (SDGs) expected to be achieved by 2030, among which, goal 4 is "to ensure fair and high-quality education without discrimination and to promote lifelong learning." This study corresponds to "4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples, and children in vulnerable situations." And "4. Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all." These two goals are expected to enable children with special needs to receive a quality education, improve their future life, and improve learning effectiveness.

Human languages and symbols originate from music and performance. Their universal and cross-cultural features can arouse emotions, cause people to recall memories, and provide social experiences through music learning (Molnar-Szakacs & Overy, 2006). Holistic music educational approach for young children (HMEAYC) is a set of music curriculum models designed for preschool children in Taiwan. HMEAYC is a researcher, after learning experience in the United States and Taiwan, out of the structure of children's music Curriculum model, through nearly 20 years of practical teaching research to prove that the local children are positive help. HMEAYC is a curriculum model of activity designed for normal young children and children with special needs that interdisciplinary learning, which the curriculum planning, meets for children of development level and capacity. HMEAYC integrates localized music education and music therapy

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Contribution to the literature

- The combination of technology and music therapy, especially for preschool children, was the most significant contribution of this study.
- Review the past literature; music technology has evolved over the years and continues to improve.
- Mainly applied in popular music and leisure entertainment, there are few related kinds of research on early childhood education.

into a cross-domain integrated curriculum. It can be used to plan courses for children with general and special needs to meet their developmental capabilities, and it can also be applied to individual and group activities (Lee, 2016). Research on HMEAYC has revealed some positive effects on language communications, attention, body movement, and emotions in preschool children and children with special requirements (Lee & Ho, 2017; Lee & Li, 2016). HMEAYC has also been proven to positively affect the language, emotions, and behaviors of children with autism spectrum disorder (ASD) (Lee & McCord, 2012). Researchers have demonstrated that music plays an essential positive role in helping preschool children and children with specific requirements adjust to education but also indicated that widespread application of HMEAYC can upgrade and intensify children's learning capabilities.

The children of the modern era, belonging to generation alpha, which refers to a group of people born between 2010 and 2025, are also the children of the millennial generation, who are the first people born fully in the 21st century and are the youngest generation today. Generation alpha is considered to be the group of people who are most able to integrate into technology. They know how to operate innovative technology. They grew up with iPhones, iPads, and other technology devices. They are highly concerned about how technology can empower and improve human well-being. They do not know and cannot imagine without technology products how to live. According to Webster's (2002) research, the combination of technology and music began as early as Industrial Revolution in the 17th century. Music is such a multisensory learning method. Children's early music experience is far more critical than adults imagine. Music is entertainment or a pastime for young children and a catalyst for learning. The multisensory approach is a systematic teaching that combines multiple senses such as touch, vision, hearing, proprioception, kinesthetic, and vestibular tactile senses. Multisensory stimulation is closer to the real natural environment than a single sense and is more likely to produce effective learning (Shams & Seitz, 2008). Multisensory teaching has gradually received attention in early childhood education, especially the combination of technological equipment to create attractive sounds and vivid colors that can be integrated into real-life teaching environments. This study used the Finnish FigureNotes teaching method and combined technology to develop multisensory music activities (MSMAs).

Based on the above, this study aims to understand the impact of HMEAYC, multisensory musical activities (MSMAs), and music technology teaching methods on the academic behavior of non-ASD and ASD children. In addition, we want to explore the improvement of children with ASD's academic behavior through music technology teaching.

LITERATURE REVIEW

HMEAYC has been proven effective at improving children's academic behavior and special education (Lee & McCord, 2012). When children learn music, FigureNotes is an interactive medium that enhances their body movements and social communication (Poutiainen et al., 2013; Ruokonen et al., 2012). This study incorporated MSMAs into HMEAYC teaching method to explore the impact of music technology teaching on the communication, emotional, and social skills of children with ASD and non-ASD.

History of Multisensory Musical Activities and FigureNotes Music Technology Teaching Method and Its Current Situation

Technology has entered the classroom for many years. Multisensory education is a teaching approach that uses visual, auditory, kinesthetic, and tactile modalities to educate students (Joshi et al., 2002). Technological advances and the increased availability of affordable devices have enabled the rapid adoption of multisensory technologies in many areas (e.g., entertainment, gaming, and education, as well as therapeutic assistive technologies) (Volpe & Gori, 2019). MSMAs refer to using technological equipment to assist cases with special needs to receive external stimuli through the senses. Studies have found that music combined with multisensory stimuli can help children with special needs change their behavior, strengthening learning behavior and other abilities (Katai & Toth, 2010; Matson et al., 2004). Neuroscience and cognitive psychology have also confirmed that teaching or learning with multimedia learning materials combined with multisensory stimulation significantly improves learning effectiveness (Katai et al., 2014; Philpot et al., 2005). Matson et al. (2004) found that multisensory devices can significantly affect visual stimuli. MSMAs provide children with sustained attention and body

movements, and this activity is an essential source of information during the intervention period in the learning process.

FigureNotes is a color-based music teaching method. It is a music teaching method or tool that expresses various high and low sounds through graphics and color matching (Poutiainen et al., 2013). It is also an MSMAs design. Through information, technological equipment is used as a medium to assist teaching. This teaching method is a simple way to learn music intuitively. It has been widely and formally used in numerous music institutions in Finland (Ruokonen et al., 2012). FigureNotes is a simple and controlled teaching method that can help learners build confidence and motivation to continue learning (Poutiainen et al., 2013). Thus, learners can utilize this learning method to improve their learning skills and intuitive social interactions when playing an instrument (Ruokonen et al., 2012). FigureNotes advocates for everyone to have access to music and is highly inclusive of the differences between children with special needs and adults. The teaching method also advocates that the learning content should be adjusted according to the individual with special needs. Many empirical studies of FigureNotes have shown positive effects (Forsblom & Ala-Ruona, 2012; Sanderson et al., 2013). Some studies in the visual analysis have found that graphic symbols positively impact learning in preschool children (Ganz & Simpson, 2004; Ganz et al., 2009; Jurgens et al., 2009). Researchers have discovered a clear difference between same-age children with and without ASD in their treatment of sensory feelings, such as overreactions and under responsiveness (Ben-Sasson et al., 2009). Two primary reasons for learning problems in children with ASD are restricted space and interactions with peers (Solish et al., 2010). Tomchek and Dunn (2007) observed that children aged three-10 years with ASD have significantly different sensory under-responsiveness and sensation seeking compared to children without ASD. One reason may be the desire of children with ASD for multiorgan sensory input because they seek auditory, tactile, vestibular, and proprioceptive input (Tomchek & Dunn, 2007). According to empirical findings, FigureNotes can help children with ASD to communicate and interact with others more smoothly (Sanderson et al., 2013). This music technology integrated teaching method has been proven for many years, and children can quickly learn music and other abilities, such as attention, interpersonal communication, emotional control, etc.

Teaching and Learning Achievements of HMEAYC in Taiwan

Lee (2016) promoted HMEAYC intending to benefit children's mental and physical development during teaching activities. Course arrangements employ traditional musical instruments, state-of-the-art instruments, and multisensory equipment. This theoretical and practical paradigm combination is an innovative mode of music education in Taiwan. HMEAYC enhances the learning experience on four dimensions: one of the dimensions that a few characteristics of "holistic method" have received the frequent application on HMEAYC. Researchers have discovered that HMEAYC positively affects language, communication (Lee & Ho, 2017), attention, body movement, and human interaction (Lee, 2016). HAEAYC courses have other positive outcomes in multisensory environments (Lee & Lin, 2013;), integrations with state-of-the-art instruments (Lee & McCord, 2012). HMEAYC has also been helpful for children with ASD, improving their language, body movement, and attention (Lee, 2016). After the success of HMEAYC and its integration with state-of-the-art instruments, this research attempted to employ MSMAs in HMEAYC course arrangements to help preschool children as a form of curative and alternative education and planning.

Research on Academic Behaviors of Preschool Children

Young children with ASD tend to have atypical sensory processing abilities (Hochhauser & Engel-Yeger, 2010). Sensory obstacles occur when these children deal with emotion, and the incidence of ASD is not dependent on age (Liss et al., 2006; Pfeiffer et al., 2005; Tomchek & Dunn, 2007). The problem of atypical sensory processing abilities may be that the individual does not respond to environmental stimulation, resulting in insufficient input of feelings, frequent low registration, or sensory defensiveness when facing an unexpected situation and intense reaction. Studies have also found that the initial onset of ASD symptoms is closely related to extreme feelings (Ben-Sasson et al., 2007). Baranek et al. (2006) reported that young children with ASD suffer more frequent sensory over-responsiveness than children without ASD. For example, they tend to cover their ears or hide from bright light. They overfocus when they pay special attention to incidental or uncomfortable stimulation (Baranek et al., 2006; Liss et al., 2006) or stereotypical behavior (Lord, 2010; Srinivasan & Bhat, 2013).

Other researchers have found that young children with ASD are much more likely to react slowly than those without ASD (Baranek et al., 2006). This result may be because young children react slowly to insufficient or deficient sensory stimulation. Researchers have found that young children with ASD participate to a limited degree in recreational activities, and their social interactions, movement, and informal activities tend to be closely linked to atypical sensory processing abilities and involve a small degree of participation (Potvin et al., 2013).

Thus, to improve the sensory processing abilities of young children with ASD, they should be encouraged to

Table 1. Personal information of the children

Subject	Group	No	AM	Motor	Sensory perception	Social interaction
Children without ASD (n=6)	Experimental	G1	44	Gross & fine motor skills are appropriate for age	Willing to try various tactile experiences & willing to be touched	Willing to interact with others; lacks interactions with peers
		G2	56	Gross & fine motor skills are appropriate for age	Willing to try various tactile experiences & willing to be touched	Willing to interact with others; enjoy helping younger children play games together
		G3	60	Gross & fine motor skills are appropriate for age	Avoids eye contact but is willing to be touched	Shy toward unfamiliar persons; lacks interactions with others
	Control	G4	54	Gross & fine motor skills are appropriate for age	Willing to try various tactile experiences & willing to be touched	Willing to interact with others; lacks interactions with peers
		G5	63	Gross & fine motor skills are appropriate for age	Willing to try various tactile experiences & willing to be touched	Willing to interact with others; enjoy helping younger children play games together
		G6	40	Gross & fine motor skills are appropriate for age	Willing to try various tactile experiences & willing to be touched	Active in talk, communication, & cooperative games
Children with ASD (n=6)	Experimental	S1	60	Insufficient lower limb strength. Weak right-side muscular endurance & balance	Attention deficiency & distraction; avoid physical touch	Avoids eye contact
		S2	60	Insufficient muscular endurance & balance in all limbs	Feels nervous about rocking & speedy movement; prone to screaming when being touched	Refuses eye contact
		S3	50	Poor ability to change position due to the insufficient pelvis & spine movement	Resistant to the auxiliary device & physical touch	Avoids eye contact
	Control	S4	55	Insufficient muscular endurance in lower limbs	Acceptable to be touched by various objects on upper limbs & sole of the foot; refuses to be touched on body	Avoids eye contact
		S5	40	Poor ability to change position & insufficient muscular endurance in lower limbs	Enjoys visual & auditory toys; resistant to being under the weight of others & to physical touch	Refuses eye contact
		S6	48	Able to run & jump; poor balance	Prone to cover the ears in a noisy environment; tendency to move backward when being touched	Refuses eye contact

Note. No: Number; AM: Age-month; & children's age is on pre-test time

participate in self-improvement activities. In addition, they gain a sense of competence when they concentrate on independent learning without cooperation or collaboration with others (Hochhauser & Engel-Yeger, 2010).

METHODOLOGY

This study investigated young children's academic behavior, and the design consisted of experimental and control groups. There were 12 children in this study, six in the experimental group and six in the control group. The experimental group included three children with ASD and three without ASD, and the control group was the same. The details are shown in **Table 1**.

Both groups were instructed under the guidance of HMEAYC. Only the experimental group employed MSMAs, and the study objectives were to determine whether MSMAs substantially affects children's learning behaviors. The learning effect of MSMAs is also discussed.

Table 2. Research design

Subject	Group	Pre-test	Treatment	Post-test
Children without ASD	Experimental group	O1	Acceptance of	O2
	Control group	O3	experiment treatment	O4
Children with ASD	Experimental group	O1	Acceptance of	O2
	Control group	O3	experiment treatment	O4

Note. O1: Experimental group, pre-intervention observation, or measurement; O2: Experimental group, post-intervention observation, or measurement; O3: Control group, pre-intervention observation, or measurement; & O4: Control group, post-intervention observation, or measurement

Research Venue and Subjects

This study enrolled children with ASD children and without ASD, aged between 40 and 63 months, who attended a private kindergarten and a nonprofit early intervention organization, respectively, in Taichung City in Taiwan. The researcher employed purposive sampling to select 12 children to participate in this study; the background of these children is detailed in **Table 1**. The two preschool organizations have similar schedules and classroom atmospheres (both are equipped with learning corners). The six individuals enrolled in the nonprofit early intervention organization received an ASD diagnosis and a diagnosis certificate. Based on the subjects' information, their visual and auditory functions were ordinary, but only difficulties in social interaction (tactile defense) and communication (no eye contact). They had fixed and limited behavior patterns and interests.

Research Design

HMEAYC's teaching philosophy advocates that the Multiple-Method curriculum design is more integrated with multiple teaching methods or technology-assisted instruction. The multisensory approach is systematic teaching and a teaching method that makes learning easy for learners. Since both the experimental and control groups contain ASD and without ASD, the two groups of children were randomly assigned to the experimental group and the control group. Therefore, this study was a quasi-experimental nonequivalent-control-group study in which the independent variable was the use of MSMAs, and the dependent variable was learning behavior. The ultimate goal of the study is not to improve musical performance. To help them learn, because these young children will enter public school in the future, so choose cognition as a research-dependent variable. The observation technique was employed to analyze the entire learning process. The collection of related subject information before the study took two weeks and was performed to understand the situations of the research subjects before designing HMEAYC. HMEAYC teaching process took 40 minutes per week for 14 weeks. The complete experimental teaching process is informed to all parents of young children, and all parents have signed the informed consent form.

It is not easy to find many ASD preschool children for research at one time, and the researchers happened to meet these children while serving in this institution. The institution hoped to assist the children through a professional research team, and the researcher also found preschool children without ASD of the same age to conduct the experimental study. Whether these preschool children were representative or inferential, the research team tried to state the background of the children as clearly as possible so that readers could understand how children with these conditions would improve after participating in these instructions in the experiment.

Two groups of preschool children in the control group only participated in HMEAYC. However, the students in the experimental group employed both HMEAYC and MSMAs to determine whether there was a difference between the experimental and control groups because of the inclusion of MSMAs. HMEAYC includes nine sections: line-walking, welcome songs, roll call songs, singing activities, rhyme games, music stories, rhythm and movement, emotional comfort, and farewell songs. The experimental and control group children need to participate in these activities. In addition, the experimental group had MSMAs, which consisted of four instructional activities: roll call song (marking the beginning of the lesson), music game (using Vision Pursuit Instrument–phonemes have stop and go, fast and slow), emotional soothing (using Starry Sky Instrument) and Farewell Song (to signify the end of class).

Social behavior assessment system for preschool (SBASP) was used to obtain pre- and post-intervention behavior assessments. The pre-intervention scores were covariant, and the differences between the pre-intervention and post-intervention scores served as this study's final result and effect (**Table 2**). The research group consisted of instructors, co-instructors, and observers. The instructor is a qualified music teacher and music therapist for children aged zero-six in the United States. The co-instructors and observers were qualified professionals with kindergarten or special education degrees and at least six months of professional training. Although there was a small group participating in this study, the subjects all had the conditions of homogeneity and high representativeness, which promoted the high inherent validity of this study. In order to avoid type I

and II errors, the method of controlling errors was to use random assignment arrangements to control experimental errors.

Research Instruments

SBASP was implemented to collect quantitative data before and after the intervention to provide the instructors and observers with evaluation data. HMEAYC observation scale was also a crucial qualitative tool used in this study. The research team provided the required musical instruments and teaching materials. The following is a detailed description of the three research tools employed.

Holistic music educational approach for young children

HMEAYC guides young children to improve their mental and physical well-being. Trainees have already been educated on providing the specially designed course alongside primary teachers. The teaching content comprises welcome songs, roll-call songs, singing activities, musical stories, rhythms, relaxation time, and goodbye songs. Multisensory musical apparatus, instruments, and related auxiliary teaching materials are incorporated to meet the goals of music activities.

Multisensory musical activities

MSMAs referred to in this study are teaching combined with technological equipment, allowing children to learn through visual, tactile, auditory, and kinesthetic stimulation so that their learning performance can be improved due to the intervention of stimulation. The multisensory technological instruments include "Vision Pursuit Instrument" and "Starry Sky Instrument." The former is designed for fast-slow and stop-and-go music activities, while the latter is a sizeable liftable platform for children to use when participating in relaxing music activities.

This study also converted the video data of MSMAs into research-related information. Scoring criteria include posture, movement, and use of arm and hand muscles, such as grasping or moving. Quantitative data is scored based on sustained attention and body movements, and each time a single data of "roll call, visual pursuit (stop and go), visual pursuit (speed and slow) and starry sky instrument (soothing)" will be obtained. Qualitative data record the specific learning performance of each case in MSMAs by observers. Multisensory instruments included the "visual pursuit instrument": the device presented visual stimulation patterns, integrated with fast-slow and stop-and-go music activities; the "starry sky instrument" projected graphic stimulation patterns imitating starry sky on the ceiling and incorporated relaxing music activities. The content of MSMAs includes roll call songs (reminder to start), music games (visual tracking instrument phonemes with contrastive music of stop and go, fast and slow), soothing emotions (starry sky instrument), and a goodbye song (end reminder).

Social behavior assessment system for preschool

The SBASP is a multidimensional standardized scale designed by Tsai and Wu (2016). It was specially designed for use with children aged four-six years. There are two editions: teacher-rating scale and parent-rating scale. Two aspects of children's behavior are assessed: social capability and problem behaviors. The social capability part evaluates a child's self-control, social interactions, and learning behaviors. The problem behaviors part gauges a child's tendency toward distraction, hyperactivity, anti-violation, and anxious withdrawal. The reliability of the social capability dimension of the scale is .57-.89, and that of the problem behaviors dimension is .38-.90 (Tsai & Wu, 2016; Tsai et al., 2014). This study employed the Teacher-Rating scale and focused on learning habits (eight items) and learning performance (eight items). Learning habits refer to the relevant skills, attitudes, and habits that young children can contribute to learning, such as high motivation to learn and willingness to try after failing an activity. Learning performance refers to children's learning achievements and performance in school, as indicated by, for example, language comprehension ability above the middle level (including intermediate level) of children of the same age and the completion of consistent homework or works with their ability.

Observation record sheet of children's target ability

A 5-point Likert scale was used to indicate preschool children's participation in musical activities with scores of 1 (never), 2 (rarely), 3 (sometimes), 4 (often), and 5 (always). Observers enter the teaching site after the training and record the children's performance in the classroom from an objective perspective through cross-observation. The researchers designed the observation form, and the observation items were divided into three categories: communication, emotion, and social.

Data Analysis

The data collection included pre-intervention and post-intervention quantitative data regarding academic behavior, comprising learning habits and learning performance, and 14 weeks' worth of observation records in the form of video recordings. Because the sample was small, including six children, each with ASD and without ASD, and the sample was divided into the experimental and control groups, the nonparametric statistics method was employed for data analysis. Nonparametric statistics are used, a rigorous approach for small sample research and analysis. The statistical software was IBM SPSS statistics 24.0. This study uses video recording throughout the entire process, hoping to view the actual academic behaviors of preschool ASD

Table 3. Descriptive statistical analysis of academic behavior for children (n=3)

Variables		Young children without ASD				Young children with ASD			
		Experimental group		Control group		Experimental group		Control group	
		M	SD	M	SD	M	SD	M	SD
Learning habits	Pre-test	17.00	1.00	15.33	2.66	12.33	2.08	8.67	1.15
	Post-test	22.33	1.53	15.67	6.35	19.67	2.89	10.67	1.52
Learning performance	Pre-test	18.67	3.21	20.00	4.36	9.00	1.00	8.00	1.00
	Post-test	22.67	1.15	20.00	4.36	14.67	3.21	8.33	1.53

children through video recording, to improve ecological validity. Besides, in addition to the quantitative data analysis of each group, this study also analyzed the trend changes of individual children.

To ensure the reliability of this study, the instructors and co-instructors discussed whether and how to adjust the content of the activities. Two observers paid attention to everything concerning the entire process and discussed the final results to achieve consensus. The observers had been strictly trained and had acquired data entry and log-in technique skills before the study began to ensure a consistent coding standard (consistency of observers was 71%-96%). During the intervention, the active performance was recorded to provide the observers with multiple perspectives and photographs. This authentic representation of reality could increase the validity of the research (Lee et al., 2017; Rosenstein, 2002). Additionally, high internal validity was ensured by collecting 14 weeks' worth of quantitative data.

RESEARCH RESULTS AND DISCUSSION

The purpose of this study was to explore the impact of the MSMAs teaching method combined with HMEAYC concept in children with and without ASD.

Descriptive Statistical Analysis Results for Academic Behavior

The results of descriptive statistical analysis of academic behavior in children with and without ASD are displayed in **Table 3**. The academic behavior discussed in this study are learning habits and learning performance. The mean scores after HMEAYC intervention were slightly improved in the experimental group or control group. The two experimental groups, who underwent HMEAYC and MSMAs instruction, also had slightly improved scores after the intervention. The significance of the difference in the children's performance is explained later.

Differences Between Pre-Intervention and Post-Intervention Academic Behavior in Two Groups

The difference between pre- and post-intervention learning habits and learning performance scores were also explored. The Wilcoxon signed-rank test revealed that in the children with ASD (n=6), the Z=-1.826 (p=.034<.05, one-tailed, Cohen's d=1.12) for learning habits and the Z=-1.604 (p=.055>.05, one-tailed) for learning performance. The mean post-intervention score was higher than the mean pre-intervention score, and the difference in learning habits between the two tests was significant. In the without ASD (n=6), the Z=-2.201 (p=.014<.05, one-tailed, Cohen's d=0.6) for learning habit and the Z =-1.826 (p=.034<.05, one-tailed, Cohen's d=0.6) for learning performance. The mean post-intervention performance score for learning habits and learning performance was significantly higher than the mean pre-intervention score. According to the above statistical analysis results, MSMAs and HMEAYC teaching methods affect the learning habits of children with ASD. Besides, MSMAs and HMEAYC teaching methods also significantly impact the learning performance and learning habits of children without ASD.

Differences in Learning Behavior Between Experimental and Control Groups

The difference between the experimental and control groups was determined among the children with and without ASD. In Mann–Whitney U test, no differences were discovered in pre-intervention learning habit and learning performance scores between the experimental and control groups, regardless of whether the children had ASD (children without ASD: p=.072, p=.261; children with ASD: p=.513, p=.376). Therefore, the behavior of the experimental and control groups for the two ASD-related groups was the same before the intervention.

The experimental and control groups' mean post-intervention scores were compared for learning habits and performance. According to Mann–Whitney U test, in terms of learning habits and learning performance, a difference existed after the intervention between the experimental and control groups for the children without ASD (learning habits: p=.023<.05, Cohen's d=1.44; learning performance p=.025<.05, Cohen's d=0.84). These results show that after the MSMAs teaching method intervention, the children without ASD had made significant progress in their learning habits (mean score increased from 17.00 to 22.33) and learning performance (mean score increased from 18.67 to 22.67). In the group of children with ASD, the difference was nonsignificant (learning habits: p=.134>.05, learning performance p=.244>.05), and the mean learning habits and performance scores were higher in the experimental

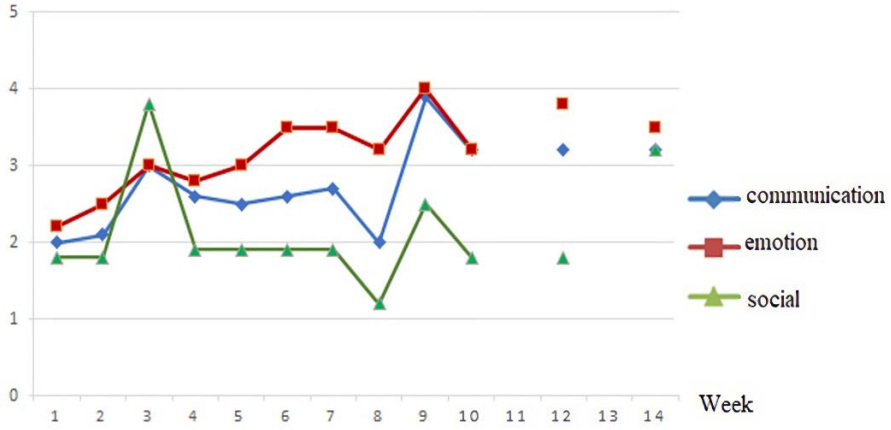

Figure 1. Comprehensive performance of S1 in MSMAs (no data was collected in 11th & 13th weeks) (Source: Authors' own elaboration)

group. But, difference was nonsignificant, so we cannot assume they made significant progress. The success rate difference (SRD) (Cliff, 1993) is an effect size commonly used in nonparametric statistics, also known as Cliff's delta. Kraemer and Kupfer (2006) tried to convert SRD and Cohen's d. According to the standard of Cohen's d effect size (>0.8 is high; 0.5-0.8 is medium; 0.2-0.5 is low), it is suggested that the SRD value more than 0.43 represents a significant change; 0.28-0.43 is moderate; 0.11-0.27 is small. According to this criterion, the results tested in this study all have a medium to high effect size.

Case Discussion and Analysis

Due to the small sample size in this study, the observation records of two ASD children, the oldest and the youngest, are selected for illustration. Observation records contain three dimensions: communication, emotion, and social.

S1 is the oldest child with ASD in this study, 60 months old, about five years old. His emotional performance will affect the course participation and communication expression indirectly. During the whole process of participating in music learning activities, in the social part, in addition to interacting with the instructor and facilitators, the number of interactions with peers also increased, and he could say good morning or goodbye to peers. Secondly, he is susceptible to music and can tell in advance that the music should be prepared to change in the high-contrast music elements. For example, tempo and stop-and-go in musical elements. In addition, his high sensitivity to music is also reflected in "attendance song" in the activity. However, in the second half of the early stage, he began to reject participating in "attendance song," he resisted participating in the activity until the end of the teaching manipulation. From this, we also saw the fixation behavior of children with autism. Looking at the performance of S1 in various aspects through music therapy courses, it is found that he tends to improve in communication, emotion, and social development. Through music, this child can develop better emotional regulation and stability. Music can indeed bring positive effects on children with autism. The overall performance of the S1 child in communication, emotion, and social was shown in **Figure 1**.

S5 was the youngest child in this study, 40 months old. In the first week of the music therapy course, he hardly followed the instructions of the instructor to carry out activities. It is speculated that he may be full of strangeness to the environment and people, but he behaved differently from the second week. By the end of the course, the frequency of active expression has increased significantly. For example, when an elephant's voice appears in musical storytelling, he asks actively: "What is this sound?"

Overall, the comprehension and expressive language performance in the later courses are above the benchmark, and the ability is stable. In addition, we found that S5 often frowned, shook its head, screamed, or reacted with anger when it encountered instructions that it did not want to do. When the music beat fast, he laughed. After the third week of music activities, more positive emotions began to appear, such as: smiling, laughing, and frowning decreased. In the social part, there was no social behavior with other children, and there was a solid unwillingness to interact with other children. The overall performance of child S5 in communication, emotion, and social was shown in **Figure 2**.

The strong effect on the acoustic treatment and learning habits of children without ASD may be that after auditory sound stimulation through colors, shapes, and corresponding musical notes, the children's self-confidence and learning motivation are significantly increased (Poutiainen et al., 2013). MSMAs emphasized flexibility in course arrangements to meet the needs of learners. FigureNotes aims to benefit every learner (Kaikkonen & Kivijärvi, 2013; Kivijärvi, 2012; Laes & Westerlund, 2017; Ruokonen et al., 2012).

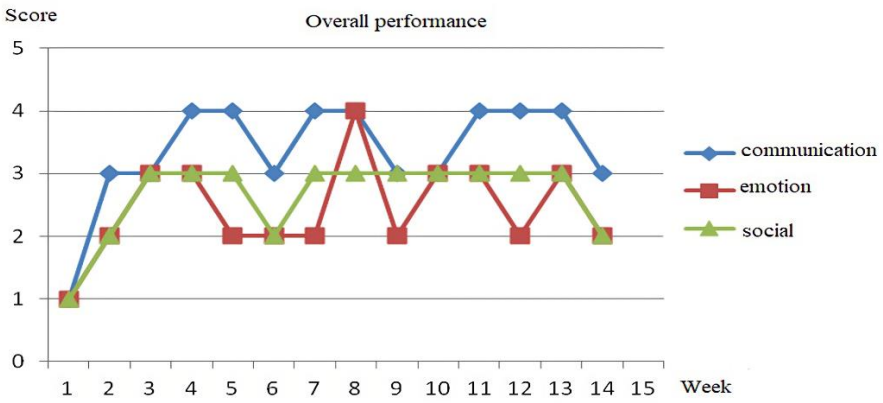

Figure 2. Comprehensive performance of S5 in MSMAs (Source: Authors' own elaboration)

The course design in HMEAYC focuses on flexible adjustment by young children's mental and physical development (Lee, 2016). Thus, similarities in teaching philosophy and activity designs between MSMAs and HMEAYC are beneficial because the music course arrangement aids the holistic development of young children.

MSMAs method creates opportunities to participate in music activities for people with special needs. We initially expected MSMAs method to lead children with ASD to make significant progress in their learning behavior, but the experimental results revealed no apparent improvement in the quantitative data. Although the intervention comprised 40 minutes per week and was 14 weeks long, for children with ASD, this duration may not have been sufficient for the children to achieve considerable growth, and the qualitative data supplemented this aspect. From observation records, we could observe growth trajectory of children with ASD.

CONCLUSIONS

This study discovered that in an analysis of the learning habits of children without ASD, their mean post-intervention scores were significantly higher than their mean pre-intervention scores. This result revealed that MSMAs intervention made a significant difference. A further discovery was that the postintervention scores of the children without ASD in the experimental group (MSMAs intervention) were higher than those of the children without ASD in the control group, indicating a significant difference in their learning habits and performance. This study incorporated HMEAYC and MSMAs methods to help preschool children improve their learning behavior. The final results show the positive effects of the intervention on the learning habits of young children without ASD.

Using HMEAYC incorporated with MSMAs revealed positive effects on preschool children's academic behaviors. Future studies can further analyze preschool children of various ages and special needs to provide points of comparison between different data collections to improve understanding of the effects of holistic learning on preschool children. Furthermore, the inclusion of body movement and social behaviors in MSMAs can offer some reference to related studies. Because of the few study subjects and control criteria in this study, it is also suggested that future studies can recruit more subjects and use interdisciplinary themes to probe the effects of MSMAs. Finally, although this study is an experimental study with a small sample, it is hoped that such results can provide a reference for future researchers when conducting larger samples and a reference for preschool teachers and parents to assist children with ASD. The results of this study hope to correspond to SDGs, expecting that children with special needs can also enjoy high-quality education so that their learning can be treated fairly and justly.

Limitations of the Study

In this study, six preschool children with autism and six preschool children without autism were compared after participating in different musical activities. In the research field of special education, it is challenging to collect a large number of samples for quantitative analysis. In this study, the parents' consent to allow the preschool children to participate must be obtained, the music therapy activities must be maintained for at least 14 weeks, and manipulation of the experimental design must be considered as comprehensively as possible. The researchers tried our best to collect quantitative and qualitative data for comparison and discussion. It is hoped that the results of this study will provide readers with another way of thinking about effects of music therapy on preschool children with autism.

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REFERENCES

Baranek, G. T., David, F. J., Poe, M. D., Stone, W. L., & Watson, L. R. (2006). Sensory experiences questionnaire: Discriminating sensory features in young children with autism, developmental delays, and typical development. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 47*(6), 591-601. https://doi.org/10.1111/j.1469-7610.2005.01546.x

Ben-Sasson, A., Cermak, S. A., Orsmond, G. I., Tager-flusberg, H., Carter, A. S., Kadlec, M. B., & Dunn, W. (2007). Extreme sensory modulation behaviors in extreme sensory modulation behaviors in toddlers with autism spectrum disorders. *American Journal of Occupational Therapy, 61*(5), 584-592. https://doi.org/10.5014/ajot.61.5.584

Ben-Sasson, A., Hen, L., Fluss, R., Cermak, S. A., Engel-Yeger, B., & Gal, E. (2009). A meta-analysis of sensory modulation symptoms in individuals with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 39*(1), 1-11. https://doi.org/10.1007/s10803-008-0593-3

Cliff, N. (1993). Dominance statistics: Ordinal analyses to answer ordinal questions. *Psychological Bulletin, 114*(3), 494-509. https://doi.org/10.1037/0033-2909.114.3.494

Forsblom, A., & Ala-Ruona, E. (2012). Professional competences of music therapists working in post-stroke rehabilitation. *Voices: A World Forum for Music Therapy, 12*(3), 1-25. https://doi.org/10.15845/voices.v12i3.647

Ganz, J. B., & Simpson, R. L. (2004). Effects on communicative requesting and speech development of the picture exchange communication system in children with characteristics of autism. *Journal of Autism and Developmental Disorders, 34*(4), 395-409. https://doi.org/10.1023/B:JADD.0000037416.59095.d7

Ganz, J. B., Parker, R., & Benson, J. (2009). Impact of the picture exchange communication system: Effects on communication and collateral effects on maladaptive behaviors picture exchange communication and maladaptive behaviors. *Augmentative and Alternative Communication, 25*(4), 250-261. https://doi.org/10.3109/07434610903381111

Hochhauser, M., & Engel-Yeger, B. (2010). Sensory processing abilities and their relation to participation in leisure activities among children with high-functioning autism spectrum disorder (HFASD). *Research in Autism Spectrum Disorders, 4*(4), 746-754. https://doi.org/10.1016/j.rasd.2010.01.015

Joshi, R. M., Dahlgren, M., & Boulware-Gooden, R. (2002). Teaching reading in an inner-city school through a multisensory teaching approach. *Annals of Dyslexia, 52*, 229-242. https://doi.org/10.1007/s11881-002-0014-9

Jurgens, A., Anderson, A., & Moore, D. W. (2009). The effect of teaching PECS to a child with autism on verbal behavior, play, and social functioning. *Behavior Change, 26*(1), 66-81. https://doi.org/10.1375/bech.26.1.66

Kaikkonen, M., & Kivijärvi, S. (2013). Interaction creates learning: Engaging learners with special educational needs through Orff-Schulwerk. *Approaches: Music Therapy & Special Music Education, 5*(2), 132-137.

Katai, Z., & Toth, L. (2010). Technologically and artistically enhanced multisensory computer-programming education. *Teaching and Teacher Education, 26*(2), 244-251. https://doi.org/10.1016/j.tate.2009.04.012

Katai, Z., Toth, L., & Adorjani, A. K. (2014). Multisensory informatics education. *Informatics in Education, 13*(2), 225-240. https://doi.org/10.15388/infedu.2014.04

Kivijärvi, S. (2012). Project disabled people as musicians: A systemic approach. *Procedia-Social and Behavioral Sciences, 45*, 416-427. https://doi.org/10.1016/j.sbspro.2012.06.578

Kraemer, H. C., & Kupfer, D. J. (2006). Size of treatment effects and their importance to clinical research and practice. *Biological Psychiatry, 59*, 990-996. https://doi.org/10.1016/j.biopsych.2005.09.014

Laes, T., & Westerlund, H. (2017). Performing disability in music teacher education: Moving beyond inclusion through expanded professionalism. *International Journal of Music Education, 36*(1), 34-46. https://doi.org/10.1177/0255761417703782

Lee, D., Arthur, I. T., & Morrone, A. S. (2017). Using video surveillance footage to support validity of self-reported classroom data. *International Journal of Research & Method in Education, 40*(2), 154-180. https://doi.org/10.1080/1743727X.2015.1075496

Lee, L. (2016). Music activities for children with disabilities: an example from Taiwan. In D. Vblair, & K. A. McCord (Eds.), *Exceptional music pedagogy for children with exceptionalities: International perspectives* (pp. 131-153). Oxford University Press. https://doi.org/10.1093/acprof:oso/9780190234560.003.0007

Lee, L., & Ho, H. J. (2017). The exploration of music educational therapy approach on developing the emotional stability and communication skills for young children with severe disabilities: A case study. In I. Vale, & J. Portela (Eds.), *Proceedings of the 27th European Teacher Education Network Conference*.

Lee, L., & Li, T. Y. (2016). The impact of music activities in a multisensory room for children with multiple disabilities on developing positive emotions: A case study. *Journal of the European Teacher Education Network, 11*, 1-12.

Lee, L., & Lin, S. C. (2013). Evaluating the use of music with teaching aids in a multisensory environment on developing children with disabilities positive emotions and communication skills. In J. Portela, I. Vale, F. Huckaby, & G. Bieger (Eds.), *Proceedings of the 23rd Annual Conference of the European Teacher Education Network* (pp. 143-162). European Teacher Education Network.

Lee, L., & McCord, K. (2012). Using music technology with young children with autism: two case studies. In L. Williams (Ed.), *Proceedings of the 30th ISME World Conference on Music Education* (pp. 177). International Society for Music Education.

Liss, M., Saulnier, C., Fein, D., & Kinsbourne, M. (2006). Sensory and attention abnormalities in autistic spectrum disorders. *Autism, 10*(2), 155-172. https://doi.org/10.1177/1362361306062021

Lord, C. E. (2010). Autism: From research to practice. *American Psychologist, 65*(8), 815-826. https://doi.org/10.1037/0003-066X.65.8.815

Matson, J. L., Bamburg, J. W., & Smalls, Y. (2004). An analysis of Snoezelen equipment to reinforce persons with severe or profound mental retardation. *Research in Developmental Disabilities, 25*(1), 89-95. https://doi.org/10.1016/j.ridd.2003.10.001

Molnar-Szakacs, I., & Overy, K. (2006). Music and mirror neurons: From motion to 'e'motion. *Social Cognitive and Affective Neuroscience, 1*(3), 235-241. https://doi.org/10.1093/scan/nsl029

Pfeiffer, B., Kinnealey, M., Reed, C., & Herzberg, G. (2005). Sensory modulation and affective disorders in children and adolescents with Asperger's disorder. *American Journal of Occupational Therapy, 59*(3), 335-345. https://doi.org/10.5014/ajot.59.3.335

Philpot, T. A., Hall, R. H., Hubing, N., & Flori, R. E. (2005). Using games to teach statics calculation procedures: Application and assessment. *Computer Applications in Engineering Education, 13*(3), 222-232. https://doi.org/10.1002/cae.20043

Potvin, M.-C., Snider, L., Prelock, P., Kehayia, E., & Wood-Dauphinee, S. (2013). Recreational participation of children with high functioning autism. *Journal of Autism and Developmental Disorders, 43*(2), 445-457. https://doi.org/10.1007/s10803-012-1589-6

Poutiainen, A., Kivijärvi, S., & Kaikkonen, M. (2013). Music for all for music. In K. Tirri, & E. Kuusisto (Eds.), *Interaction in educational domains* (pp. 171-181). Sense Publishers. https://doi.org/10.1007/978-94-6209-395-9_14

Rosenstein, B. (2002). Video use in social science research and program evaluation. *International Journal of Qualitative Methods, 1*(3), 22-43. https://doi.org/10.1177/160940690200100302

Ruokonen, I., Pollari, S., Kaikkonen, M., & Ruismäki, H. (2012). The Resonaari special music center as the developer of special music education between 1995-2010. *Procedia-Social and Behavioral Sciences, 45*, 401-406. https://doi.org/10.1016/j.sbspro.2012.06.576

Sanderson, T., Sparkes, P., & Murray, R. (2013). MusicSPACE at home: A music tuition model for people on the autism spectrum. *Good Autism Practice, 14*(2), 94-98.

Shams, L., & Seitz, A. R. (2008). Benefits of multisensory learning. *Trends in Cognitive Sciences, 12*(11), 411-417. https://doi.org/10.1016/j.tics.2008.07.006

Solish, A., Perry, A., & Minnes, P. (2010). Participation of children with and without disabilities in social, recreational and leisure activities. *Journal of Applied Research in Intellectual Disabilities, 23*(3), 226-236. https://doi.org/10.1111/j.1468-3148.2009.00525.x

Srinivasan, S. M., & Bhat, A. N. (2013). A review of "music and movement" therapies for children with autism: Embodied interventions for multisystem development. *Frontiers in Integrative Neuroscience, 7*, 1-21. https://doi.org/10.3389/fnint.2013.00022

Tomchek, S. D., & Dunn, W. (2007). Sensory processing in children with and without autism: A comparative study using the short sensory profile. *American Journal of Occupational Therapy, 61*(2), 190-200. https://doi.org/10.5014/ajot.61.2.190

Tsai, M. F., & Wu, Y. Y. (2016). *Social behavior assessment system for preschool*. Nation Taiwan Normal University Special Education Center.

Tsai, M. F., Wu, Y. Y., & Chuang, H. H. (2014). The construction of a social behavior assessment system for preschoolers. *Bulletin of Special Education, 39*(2), 1-31. https://doi.org/10.6172/BSE.201407.3902001

Volpe, G., & Gori, M. (2019). Multisensory interactive technologies for primary education: From science to technology. *Frontiers in Psychology, 10*, 1076. https://doi.org/10.3389/fpsyg.2019.01076

Webster, P. (2002). Historical perspectives on technology and music. *Music Education Journal, 89*(1), 38-43. https://doi.org/10.2307/3399883