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Effect of music engagement and movement on attentiveness and memory in children with down syndrome: A quasi-experimental research

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ABSTRACT

Children with Down syndrome (DS) could have problems with attentiveness and memory due to innate developmental deficits. Studies have found that music can help improve the attentiveness and memory of children with DS. Orff-Schulwerk, a creative and improvisational music pedagogy, is often used to support the development of children with special needs. However, no study has used Orff-Schulwerk-based music interventions to explore their influence on the attentiveness and memory of children with DS. Therefore, this research aimed to examine the effect of music engagement and movement (MEM) on attentiveness and memory in children with Down syndrome. This quasi-experimental study involved 8-week MEM activities based on Orff-Schulwerk as the music intervention. This study recruited 18 children with DS, aged 7–10 years. MEM was used to teach vocabulary to children with DS and measured their memory and attention in classes. The results demonstrated that the attentiveness and memory of the participants were significantly improved in the MEM classes compared with the control group. The results of the paired t-test also showed statistically significant differences in attentiveness ($t = 9.88$, $p < 0.001$) and memory ($t = -10.92$, $p < 0.001$) before and after the intervention. The results of this study supported that MEM could help improve attentiveness and memory in children with DS. Implications and future directions are also discussed.

Contribution/Originality: This study highlights the potential benefits of Orff-Schulwerk based music interventions for the education of early school-aged DS children and provides new ideas for music teachers. In addition, it provides innovations in memory and attention measurements for DS children.

1. INTRODUCTION

Down syndrome is known to be a chromosomal disorder caused by an abnormality on chromosome 21 and is associated with many deleterious phenotypes, including developmental delays, abnormal balance and coordination, learning and cognitive impairments, and so on (Akyol & Pektas, 2018). Among them, low level of intelligence is one of the typical features of people with DS; therefore, DS is also classified as a branch of intellectual disability (Mohammad, Mansoor, & Majid, 2016). Typically, the majority of patients with DS exhibit mild to moderate degrees of intellectual impairment (Matthews et al., 2018). Children with DS experience difficulty in learning mainly due to deficits in certain learning-related areas such as attentiveness and memory (Grieco, Pulsifer,

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Seligsohn, Skotko, & Schwartz, 2015; Kirk, Gray, Riby, Taffe, & Cornish, 2017; Neece, Baker, Blacher, & Crnic, 2011).

Scholars highlighted attention as a key to learning and developing cognitive skills as well as an important predictor of academic achievement (McClelland, Acock, Piccinin, Rhea, & Stallings, 2013). However, attention deficits are prevalent for children with DS (Aureli et al., 2010; Neece et al., 2011). The reason is that the brain of these children is congenitally underdeveloped and, therefore, the neurological processes of excitation and inhibition are unbalanced, which results in poor self-control. Children with DS are generally characterized by distraction and short attention span. Many children with intellectual disabilities display symptoms of attention deficit hyperactivity disorder (ADHD), typically manifested with inattentiveness and hyperactive behavior, which largely influence learning (Grieco et al., 2015; Kirk et al., 2017; Neece et al., 2011; Van Gameren-Oosterom et al., 2011).

In addition to this, the defective development of the brain in children with DS is also accompanied by poor memory. Conners, Rosenquist, Arnett, Moore, and Hume (2008) note that in terms of learning and remembering new knowledge, people with DS always spent more time than normal, and their cognitive learning was much slower due to poor memory. Therefore, using appropriate teaching strategies is essential to help children with DS improve their attention and memory in order to learn more effectively (Jacob, Pillay, & Oyefeso, 2021).

Studies have found that music can help children with DS learn various skills (Albin, 2016; Clark, 2011; Wylie, 2006). Firstly, children's education typically uses music, because it is considered an effective intervention strategy to improve the attention of children. For example, Iwasaki, Rasinski, Yildirim, and Zimmerman (2013) revealed that integrating songs into teaching greatly attracted the attention of children due to the engaging quality of the rhythmic nature of music. Therefore, using music as a teaching strategy can lead to long-term effects in helping children to improve their performance in other subject areas. In addition, Rawana, Flett, McPhie, Nguyen, and Norwood (2014) suggested that classical music could be introduced into the classroom to improve performance and overall attention. Even classical music can exert a great influence on primary school classrooms, where ADHD problems are most prevalent. Children with ADHD require more stimulation to help them focus; thus, music serves as an auditory stimulus that produces dopamine in the brain. This *reward system* induced by dopamine is strongly associated with cognitive functions such as increased productivity and attention (Rawana et al., 2014).

Secondly, music is considered as one of the most effective methods for helping improve short-term memory skills. Many experts believe that designing text to music enhanced the ability to learn and remember information, and this concept is frequently used for educational purposes, such as the teaching of alphabet through the melody of the song "Twinkle Twinkle Little Star" (Balch & Lewis, 1996; Rainey & Larsen, 2002; Wallace, 1994). Scholars demonstrate that the combination of melody, rhythm, and textual information of music could improve short-term memory, because the close connection between text and music enables the storage of information in a unique state of the brain. Moreover, further studies find that if music was played repeatedly for learning purposes, then long-term memory may be formed. For example, when people hear their country's national anthem a few years later, they can still recall at least a few of the lyrics. The reason is that the constant repetition of the song builds a strong and stable memory. In other words, short-term information stored can be transformed into long-term memory through repeated practice and reinforcement. However, experts also point out that only the use of melodies familiar to the participants could help with memory and that combining text with unfamiliar melodies may yield the opposite result. In addition, if the music contained complex structures and rhythms, then memory for the text may not be helpful (Broadley & MacDonald, 1993; Norris, 2017; Wallace, 1994).

2. LITERATURE REVIEW

2.1. Music and Attention in Children with Down Syndrome

Few studies have been conducted to help improve the attentiveness of children with Down syndrome through music. Akyol and Pektas (2018) used violin music pieces in a waltz rhythm pattern and combined them with

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gymnastic exercises in a randomized controlled trial of children with autism spectrum disorders and DS aged 8-14 years; they found that musical rhythms could help improve participants' balance, flexibility, and coordination in movement by increasing their attention. However, their study focused more on the participants' improvements in the motor level rather than attention, and the participants were a mixed group with autism spectrum disorder and DS, rather than focusing on the DS group. In 2010, the results of a study by Ning in Chinese school-aged children with DS aged 10-16 years showed that Orff music therapy significantly improved the attentional stability of children with DS. However, the attention measurement scales used in their study were developed for the normal healthy elementary and middle school students and are not fully applicable to the group of children with specific disorders. Additionally, the measurement used in the study scored participants primarily by completing a number of instructions, such as finding a target figure within a specified time.

In fact, most measures of attention in children with DS require participants to respond to a variety of stimuli, such as a flashing light or instructions (Brown & Clarke, 1963; Miezejeski, 1974; Zekulin, Gibson, Mosley, & Brown, 1974). Although certain commonalities about attention exist among researchers and classroom teachers, a fundamental difference may exist between them. In classroom, teachers focus on attentional performance and responses to the course content, such as whether they respond positively to musical melodies (Lunzer & Stratford, 1984). The study by Amin et al. (2020) used monophonic beat music therapy in class with middle school students with DS, and then observed their attentional performance in class, such as whether they listened attentively. The results of the study showed that 8-12 Hz monophonic beat music had a significant positive effect on the participants' academic attention performance, as it strongly influenced brain waves and thus the work of the limbic system of the brain. However, although that study did make observations of participants' attentional performance in class, the observations occurred after the end of the music therapy and they focused on the effect after listening to the music rather than the participants' immediate response to the music during the intervention.

2.2. Music and Memory in Children with Down Syndrome

There are also few studies on music helping to improve memory in people with DS. Ptomey et al. (2018) conducted an exercise intervention with adults with DS, where sessions were based on aerobic exercises such as jogging and dancing to music, and the participants' memory was measured before and after the intervention. The results of the study showed that the memory performance of the participants improved after the intervention. However, the study emphasized the effect of exercise on memory rather than the effect of music on it. Mizuno, Osugi, Sakuma, and Shibata (2013) played numbers accompanied by a musical melody in the key of G through a sound synthesizer to adult DS patients and asked them to recite the correct number sequence immediately after listening. The results of the study showed that DS patients with long-term musical training had significantly higher scores than participants without musical training. However, the study results did not show an improvement in the musical melodies on the memory of the DS patients. This may be due to the fact that the study used melodies that were not familiar to the participants and were not repeated. Similarly, Ning (2010) in her study of preadolescent children with Down syndrome, found that participants' verbal memory was effectively improved after receiving music therapy activities. The study measured participants' memory by asking them to recite numbers in sequence.

The current measurement of memory for individuals with DS focus on memory span, such as requiring immediate repetition of words, numbers, or graphic sequences in the correct sequence order (Jarrold, Thorn, & Stephens, 2009; Lanfranchi, Cornoldi, & Vianello, 2004) or matching corresponding items to pictures to memorize vocabulary (Jarrold et al., 2009) and so on. However, as parental expectations increase, parents of children with DS increasingly prioritize literacy (Al Otaiba, Lewis, Whalon, Dyrlund, & McKenzie, 2009). Other studies illustrate that simply matching target words with corresponding pictures only helps to remember a small number of words, and its limitations are evident (Browder, Wakeman, Spooner, Ahlgrim-Delzell, & Algozzinexya, 2006; Lemons &

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Fuchs, 2010). Therefore, for children with DS, understanding the meaning and recognizing the word itself may be of greater help in their future. A few experts believe that approaches that combine literacy instruction with meaningful enrichment activities may be most effective for children with DS (Lemons & Fuchs, 2010).

In fact, Barker (1999) an academic, a music teacher, and the mother of a girl with DS, repeatedly emphasized the importance of music and singing for children with learning difficulties in her articles early on. She believed that music and singing could stimulate auditory discrimination in children with DS and help improve their language development. Songs also introduce new words and concepts to children in an interesting way, helping them master literacy skills through fun. But Barker (1999) emphasized that repetitive singing is the most basic reinforcement of memory. Singing was so much more enjoyable than talking that children may not even realize that they are repeating words or phrases over and over again and that they were acquiring and remembering vocabulary through music. There is only one study that used music-based intervention (singing, rhythm, dance, and musical games) to teach a mixed group of children with special needs that included a child with DS to learn and remember new vocabulary and concepts (Eren, 2014). However, the research procedure was unclear.

As mentioned above, many forms of music such as singing, rhythm, and movement can help children with DS in their attention and memory skills. Orff-Schulwerk is such a creative and improvisational method that includes singing, bodily movement, and Orff instruments in a rich variety of musical forms (Fillips, 2005). It is typically used to support the development of children with special needs, such as cognition, language development, and social or academic skills, among others (Kaikkonen & Kivijärvi, 2013; McCord, 2013). Therefore, Orff-Schulwerk can be considered as a very suitable and effective intervention for children with DS. Furthermore, as can be seen from the studies presented earlier, most of the research on music to help children with DS improve their attention and memory has used music therapy as an intervention. However, music therapy is scarce in China, and there is a shortage of trained music therapists (Hao, 2018). Therefore, music-based interventions may be more feasible and easily replicable for music teachers, who are mostly untrained in music therapy. In fact, in China, Orff-Schulwerk is very popular. When Orff-Schulwerk was introduced from western countries, it created a wave of enthusiasm in Chinese music education to learn this pedagogy. And today, Orff teacher training courses are available in every major city in China (Xia, 2017). There are many forms of Orff-Schulwerk pedagogy, such as singing, gestures (foot stamping, leg tapping, finger twiddling), Orff instruments, graphic scores, bodily movement, musical dance drama, musical games, music appreciation, and so on. In this study, only three forms of singing, Orff instruments and bodily movement were selected, and they were combined to teach. Thus, a program called music engagement and movement (MEM), which is based on Orff-Schulwerk (song singing with Orff instruments and bodily movement) was used in this research.

Based on the previous literature, two hypotheses were proposed in this study:

H_1: Music engagement and movement can help children with DS improve attentiveness.

H_2: Music engagement and movement can help children with DS improve memory.

To test these hypotheses, two research questions were framed:

1. What is the effect of music engagement and movement on the attentiveness of children with DS?
2. What is the effect of music engagement and movement on the memory of children with DS?

3. RESEARCH METHODS

3.1. Participants and Sampling Procedure

The study recruited 18 children with DS (male = 5, female = 13), whose ages ranged from 7 to 10 years (mean age = 8.39 years, SD = 1.06). In addition, the inclusive criteria of participants selection included no hearing or visual impairment, the existence of language ability, all four limbs intact and without physical disability, and an IQ (intelligence quotient) of 35 and above (i.e., moderate mental retardation and above). The participants were recruited using purposive sampling. The recruitment of children with DS was announced within the Down

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Syndrome Association in Hangzhou through WeChat, which is currently the most popular social media platform in China. Eligible children and parents who volunteered to participate in the study could contact the researcher through the contact information in the announcement such as phone, SMS (short message service) and email. The researcher selected 18 children with DS from the applicants. In addition to the 18 participants with DS, two music teachers were also involved in this study (the first teacher taught the participants, and the second is an expert who observed the classes). The selection criteria of the teachers include obtained the relevant qualification certificate for Orff music teaching or received a professional training in Orff music teaching, have worked or be working in a special education school, and possessed extensive experience in special music education. The study determined the recruitment of qualified teacher participants through voluntary enrollment. This study followed the voluntary principle; as such, it provided no rewards.

3.2. Measurements

3.2.1. Vocabulary Memory Test

The 24 Chinese vocabulary words used in the study for memory test were divided into groups of six, for a total of four groups. They were selected from the Living Language Five-Level Literacy List provided in the latest version (2016) of the Chinese Peizhi Curriculum Standards, which is a curriculum standard designed for all children with special needs at the compulsory education level (7–16 years old). The test was a two-step process in which the teacher read the vocabulary for the first session and the participants accurately identified the word in the vocabulary list; at the second session, the teacher pointed out the vocabulary, and the participant was able to read it accurately. Vocabularies that were answered correctly at both sessions were considered to have been memorized and mastered by the participant. The number of vocabularies memorized by each child in each test was counted.

3.2.2. Attention Assessment Scale

Attention Assessment Scale adapted from the SWAN (Strengths and Weaknesses of ADHD-symptoms and Normal-behavior) Rating Scale designed by Swanson et al. (2012). It was developed to measure the attention performance of children with attention deficit disorder in class. A total of 11 items are rated using a seven-point Likert-type scale, (1 = not present, 4 = neutral, and 7 = extremely evident), such as eyes following the movements and instructions of the teacher. They demonstrated good internal consistency in this study with Cronbach's α = 0.97.

3.3. Research Design

In this study, because of the small number of participants, it was not possible to randomize groups or set up parallel control groups due to practical conditions. Therefore, quasi-experimental research was used, which means that no separate control group was set up, but the experimental group itself was used as a control group to compare the situation before and after the intervention. The experiment lasted for eight weeks, with one 30-minute class per week. During weeks 1 to 4 of the experiment, 18 DS children participated in traditional classes, where all Chinese vocabularies were taught only through speech. The teacher taught the children to memorize six Chinese vocabularies through repetition each time. Meanwhile, the participants' attentional responses were observed and scored by the expert and the researcher during the class. After 30 minutes, a test was administered. At weeks 5 to 8, these participants were invited to participate in MEM classes. The same six vocabularies were selected; during this time, however, the MEM program was used to teach them. In the MEM class, the teacher composed songs using familiar musical melodies (such as "Twinkle Twinkle Little Star") for all Chinese vocabulary and taught them with Orff instruments and bodily movement. Similarly, in the MEM classes, the expert and the researcher observed and scored the participants' attentional responses.

Figure 1 flow chart illustrates research design.

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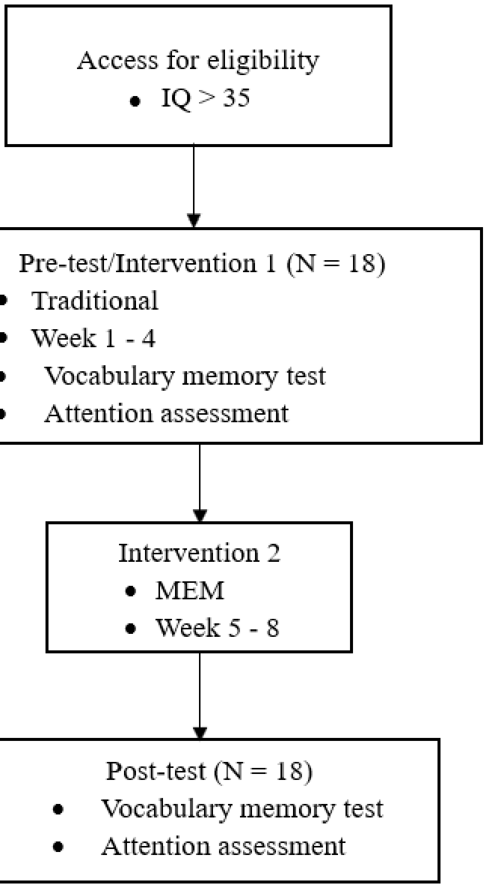

Figure 1. Flow chart of research design.

3.4. Data Analysis

The study first analyzed the descriptive statistics. Additionally, in order to examine whether there was a statistically significant change before and after the intervention, all variables were tested for normal distribution using the Kolmogorov-Smimov test and histogram, and for variables that did not conform to normal distribution firstly used a square rooted transformation to achieve normality in this study. Finally, paired samples t-test was used to compare whether there was a statistically significant difference in attentiveness and memory between the traditional class and MEM class. Since attentiveness and memory violate the normality assumption, the Wilcoxon signed ranks test was used in which to conduct the analysis. All analyses were performed on SPSS 25.

4. RESEARCH RESULTS

4.1. Descriptive Analysis

Table 1 displays the descriptive statistics, including means (M), standard deviations (SD), and mean differences (MD) for the participants' attentional performance scores in both traditional and MEM classes. The lowest mean and standard deviation scored for traditional class (item 5) were 4.31 and 0.16, respectively. The results also showed that "modulate motor activity" (item 10) had the highest mean in traditional class (M = 5.90, SD = 0.05). In addition, "sit still" (item 5) also had the lowest score in MEM class, with M = 5.39 and SD = 0.17 respectively. The results showed that item 10 still had the highest mean in MEM class (M = 6.80, SD = 0.03). Furthermore, the lowest MD score for "keep quiet in class" (item 8) was 0.66, indicating that there was no significant difference of participants' performance between traditional and MEM classes in this regard. However, the highest MD before and after the intervention was 1.58 in "sustain attention on tasks or play activities" (item 3), suggesting that the participants were more successful in maintaining their attention to tasks or play activities in the MEM classes

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compared to the traditional classes. Table 1 clearly illustrates that compared to the traditional classes, participants' performance on each attention item improved to a varying degree in the MEM classes.

Table 1. Means, standard deviations, and mean differences of items for attentiveness to traditional and MEM classes.

Items	Traditional class		MEM class		
	M	**SD**	**M**	**SD**	**MD**
1. Listen when spoke to directly	5.72	0.07	6.79	0.11	1.07
2. Follow through on instructions	5.04	0.13	6.29	0.14	1.25
3. Sustain attention on tasks or play activities	5	0.30	6.58	0.09	1.58
4. Ignore extraneous stimuli	4.35	0.24	5.46	0.23	1.11
5. Sit still	4.31	0.16	5.39	0.17	1.08
6. Stay seated	5.07	0.15	6.19	0.09	1.12
7. Eyes follow the teacher's movement and instructions	5.06	0.12	6.46	0.05	1.40
8. Keep quiet in class	5.62	0.19	6.28	0.17	0.66
9. Answer when asked	5.04	0.12	6.11	0.21	1.07
10. Modulate motor activity	5.90	0.05	6.80	0.03	0.90
11. Do not touch or move that are not related to the current task	4.78	0.17	5.93	0.30	1.15

Note: MD=Mean difference between the score of MEM class and traditional class.

Table 2 displays the results of the study on the effects of MEM on the vocabulary memory of children with DS, specifically in vocabulary accuracy and accuracy difference. The table highlights that the correctness of all vocabulary words improved to a certain extent following the MEM classes compared to traditional classes. However, three words rain (5.6%), left (5.6%), and right (5.5%) displayed low levels of difference in accuracy.

Table 2. Accuracy of vocabularies and accuracy differences in traditional and MEM classes.

Vocabularies	Accuracy of traditional class	Accuracy of MEM class	Accuracy difference
Down	38.9%	66.7%	27.8%
Up	44.4%	55.6%	11.2%
Sun	27.8%	61.1%	33.3%
Four	50%	77.8%	27.8%
Head	44.4%	77.8%	33.4%
Long	50%	66.7%	16.7%
Many	22.2%	50%	27.8%
Little	50%	72.2%	22.2%
Rain	22.2%	27.8%	5.6%
Five	61.1%	83.3%	22.2%
Hand	44.4%	77.8%	33.4%
Door	44.4%	88.9%	44.5%
Big	55.6%	83.3%	27.7%
Small	50%	77.8%	27.8%
Seven	66.7%	88.9%	22.2%
Wind	27.8%	66.7%	38.9%
Eye	33.3%	61.1%	27.8%
Towel	27.8%	50%	22.2%
Left	33.3%	38.9%	5.6%
Right	38.9%	44.4%	5.5%
Nine	55.6%	100%	44.4%
Tooth	44.4%	83.3%	38.9%
Fire	50%	94.4%	44.4%
Car	50%	88.9%	38.9%
Total	40.5%	70.1%	29.6%

4.2. T-Test Analysis

Paired sample t-test was utilized in the study to determine whether the effects of MEM on the attentiveness and memory of children with DS were statistically significant. Table 3 presents clearly that the differences before and after the intervention were indeed statistically significant for attentiveness ($t = 9.88$, $p < .001$), with the MEM

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class (M = 6.21, SD = 0.55) demonstrating higher levels than the traditional class (M = 5.08, SD = 1.18). Therefore, hypothesis 1 was accepted. In other words, children with DS in the MEM classes displayed an upward trend in attention levels, indicating better performance and concentration in MEM compared to traditional classes. Additionally, the MEM classes (M = 4.21, SD = 1.28) demonstrated higher levels of memory than the traditional class (M = 2.58, SD = 1.32) with t = -10.92 ($p < .001$). Thus, hypothesis 2 was also supported. These results suggest that the use of MEM can effectively improve attentiveness and memory levels in children with DS.

Table 3. Paired T-test results of attentiveness, memory in traditional and MEM classes.

Variables	Class type	Mean	SD	t	p
Attentiveness	Traditional class	5.08	1.18	9.88	0.000
	MEM class	6.21	0.55		
Memory	Traditional class	2.58	1.32	-10.92	0.000
	MEM class	4.21	1.28		

5. DISCUSSION

5.1. Discussion of Descriptive Analysis

Before going to the intervention effect, several descriptive results were noteworthy. Children had the lowest average score in keeping still no matter when they were receiving the traditional or MEM classes. In other words, they had the most difficulty in sitting still, controlling the movement of hands or feet, or controlling squirming. The participants did not perform as well on this item compared with the other items. In fact, the inability to sit completely still may not have much of an impact on the attention levels of children with DS. Traditionally, constancy and stillness have been viewed by educators as essential elements of attention, and thus changes in perspective and movement when students are unable to sit still are often cited as undesirable factors that impede concentration (Langer, 1997). However, studies have found that rather than requiring students (including those with inattention and ADHD) to sit still in the classroom, allowing them to observe learning materials through multiple perspectives or even move around the classroom not only does not affect their concentration, but rather activates the orienting reflex in the brain due to the increased novelty of the situation, thus helping students to focus on the stimuli and facilitating information processing. Therefore, students may benefit from the novelty of multiple perspectives on learning materials resulting from occasional movement in the classroom as opposed to sitting completely still (Carson, Shih, & Langer, 2001).

The best performance of the participants in both the traditional and MEM class was noted for the tenth item (modulate motor activity). The specific criteria for the tenth item were modulating motor activity and inhibiting inappropriate walking, running, or climbing. One possible reason for this is that because individuals with DS are affected by developmental delays, so they commonly have underdeveloped postural control, inadequate muscle tone, and poor balance. The difficulties associated with developmental delay lead to inactive body movements in most children with DS (Mégarbané et al., 2009; Sherman, Allen, Bean, & Freeman, 2007). Another reason may be that all schools in China, whether regular or special handicapped schools, pose basic classroom rules one of which is inhibiting inappropriate walking, running, or climbing in the classroom. Teachers and parents advise Chinese students to follow classroom norms and discipline since their entry into kindergarten. Therefore, this item may have been a habit for the majority of the participants and could be achieved with a little reminder from the teacher. This rationale may be a reason for the high average performance of the participants for this item (Wang, 2019; Zhou, 2020).

For the eighth item (keep quiet in class), it only yielded a mean difference of 0.66. Based on the performance of the participants in the four-week traditional and four-week MEM classes, it is speculated that the ability to remain quiet in class may be related to individual personality. Children who are expressive do not opt to remain quiet just because it is a traditional or MEM class, while quiet children may not choose to express themselves just because their learning environment has changed. Students may choose to be expressive or silent due to personality traits or

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situational factors. For example, students with quiet personalities are usually very engaged in the learning process but remain habitually silent (Medaille & Usinger, 2019). Thus, the presence or absence of musical elements in the class may not affect the students' performance in the "keep quiet in class" item. This reason may explain the small difference in the results for the eighth item before and after the intervention. For the third item (sustain attention to tasks or play activities), which exhibited a large gap before and after the intervention, this result is consistent with other expert studies (Iwasaki et al., 2013; Rawana et al., 2014). Researchers tend to agree that incorporating songs into teaching is very engaging for children because of the rhythmic qualities of music. Because the melody, rhythm and simplicity of the lyrics make the task easy to learn and remember, it likewise helps children to be more willing to engage in the task at hand, allowing them to have fun with music while learning. Using music as a teaching strategy can go a long way in helping children improve their performance in various subject areas. Therefore, musical activities can help children to focus their attention on the task at hand, and this finding is also valid for children with DS.

The results of the vocabulary memory test showed that with the help of MEM, the participants' correctness was all improved to some extent, with the difference in correctness ranging from 5.5% to 44.5%. However, the accuracy differences of rain (5.6%), left (5.6%) and right (5.5%) meant that only one more participant remembered the word (rain/left/right) after the intervention. The low accuracy difference for rain may be due to the fact that for some participants it has a more complex Chinese spelling compared to other words, which have more strokes. Perhaps Chinese characters with complex strokes are to some extent more difficult for children with DS to remember. This finding is consistent with the results of Huang (2022) study. She concluded that Chinese elementary school students are most likely to make errors for vocabulary with complex strokes or word structures. For left and right, the low accuracy difference is likely due to the fact that their strokes are very similar. This is a conjecture based on the participants' performance on the vocabulary test. During the test on left and right, some participants answered incorrectly not because they did not remember them at all, but because they misidentified left as right, or right as left. Thus, teaching two similar characters in the same lesson may cause confusion among some participants. This result is also consistent with previous research (Huang, 2022) in which Huang argued that vocabulary with formal similarity is often misidentified even by most average Chinese elementary school students with normal intelligence.

5.2. Discussion of T-Test Analysis

Paired sample *t*-tests indicated that children with DS displayed significantly higher levels of attentiveness in MEM classes compared with those in traditional classes. Similar to previous studies, MEM helped to improve the attention of children, proved to be an effective teaching strategy to help improve their attention (Iwasaki et al., 2013; Rawana et al., 2014). Participants' good attention in the MEM class may also be due to the fact that the Orff elements are fun, in line with children's nature and instincts to learn, explore, and perceive while "playing music" (Calvin-Campbell, 1998; Cary, 2012; Fillips, 2005) which allowed participants to enjoy and appreciate the MEM curriculum. Consistent with previous research, musical activities produce happy emotions in individuals with intellectual disabilities, thereby engaging their attention (Atterbury, 1998). Emotions largely modulate and influence the selectivity of attention and motivate behavior and action. This attention is closely related to the learning process because of the ability to help learners focus their limited attention on the material being learned (Tyng, Amin, Saad, & Malik, 2017). This study also found that this teaching strategy was equally applicable to children with DS. However, the current result contradicts some of previous studies. A few scholars argued that the majority of attentional intervention strategies are ineffective for children with intellectual disability due to their greater impairments and difficulties in cognitive skills (Carnahan, Hume, Clarke, & Borders, 2009; Deutsch, Dube, & McIlvane, 2008). However, the results of the current study implied that music is an effective intervention for children with DS and can, indeed, help to improve attention.

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The t-test also revealed a statistically significant difference in memory. This suggests that the use of MEM helped children with DS to remember more vocabulary and, to a certain extent, improved their memory levels. This result is also consistent with some previous research findings (Balch & Lewis, 1996; Broadley & MacDonald, 1993; Norris, 2017; Rainey & Larsen, 2002; Wallace, 1994). In this study, the close combination of the participants' familiar musical melodies, simple structured rhythms and textual information allowed the lesson content to be stored by the brain in a unique state, while the constant repetition of the music lessons helped build a strong and stable memory that really helped the participants to remember the vocabulary better. The data also showed that this method was more effective than traditional teaching methods through boring repetition. Not only that, but as mentioned earlier, the pleasurable experience that MEM gave participants may have also helped their memory. Some scholars have found that memory depends to some extent on emotions. They found that emotions help encode and retrieve information efficiently, which has an impact on memory retention and recall. This is because emotions affect the formation of a hippocampus-dependent memory system in the brain. The hippocampus, located in the medial temporal lobe, is thought to be responsible for the potentiation and consolidation of declarative memory before newly formed memories are distributed and stored in cortical areas, which can have long-term effects on learning and memory (Pessoa, 2008; Squire, 1992).

6. CONCLUSION

The result indicates that teaching through song singing with Orff instruments and bodily movement in MEM classes can help to improve the attentiveness and memory of children with DS. Therefore, the study argues that the rich teaching model for MEM classes can help children with DS to participate more actively in activities and to focus their limited attention on the materials being learned. Moreover, the close combination of textual information and familiar melodies with bodily movements and Orff instruments helped children with DS to better remember what they were taught.

7. LIMITATIONS AND RECOMMENDATION FOR FUTURE RESEARCH

This study has shortcomings that require further improvement. First, the sample size was too small. The constraints of time and location coordination issues and the difficulty of recruiting participants resulted in a small number of participants. Therefore, the results cannot be considered generalizable, and the small sample size reduced the persuasiveness of data analysis. Second, these participants were not divided into experimental and control groups due to their small size. Instead, the study used quasi-experimental research, where all participants attended traditional and MEM classes, and the results of the two were then compared. According to the Ebbinghaus forgetting curve, normal people forget 79% of new knowledge and 21% of memory after 31 days of learning new knowledge (Averell & Heathcote, 2011; Murre & Dros, 2015). In the current study, the time interval between traditional and MEM classes was only one month; thus, the study cannot rule out that the children with DS may still possess a residual memory of the content learned in traditional classes, which may influence the results of the MEM classes. In terms of future study design, additional variables could be used to determine whether or not a relationship exists between the learning of memory, attentiveness of children with DS to their level of intelligence, age, and cognitive ability. Moreover, this study was conducted only in Hangzhou, China. Future studies on other cities with varying levels and resources may also reveal other impacts on the development of children with DS. Thus, we suggest that future studies should explore changes and differences due to MEM programs on local children with DS across cities with different levels.

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