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The Effect of Active and Receptive Musical Training on Emotional Memory in Preschoolers

El Efecto del Entrenamiento Musical Activo y Receptivo en la Memoria Emocional de los Preescolares

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Music training has beneficial effects on the development of various skills in children, whether it is receptive (listening to music) or active (producing music). Although it is known that emotional items are better remembered than neutral ones, this phenomenon remains poorly understood in preschoolers. This study aimed to evaluate the effect of music training on the emotional memory of 4- and 5-year-old preschool children. One hundred and forty-eight preschool children from two private kindergartens in Buenos Aires, Argentina, were randomly divided into groups to receive either active or receptive music training. The content was adapted from the educational music curriculum or regular music classes over a period of 4 weeks. Next, they observed 24 neutral and emotional pictures, rated their valence and arousal, and their recall and recognition (immediate and deferred) were assessed. The data was analyzed using a repeated measures analysis of variance (ANOVA). The between factors were conditions (control versus active versus receptive) and age (4 and 5), while picture (neutral, positive, or negative) was the repeated measure. The primary findings indicated that children exposed to music training had better mnemonic performance than the control group and they remembered more emotional than neutral images. These results highlight the relevance of music programs in school curricula.

Keywords: children, emotional-memory, school-based music training, valence, arousal.

El entrenamiento musical tiene efectos beneficiosos en el desarrollo de diversas habilidades en niños, ya sea receptivas (escuchar música) o activas (producir música). Aunque se sabe que los elementos emocionales se recuerdan mejor que los neutrales, este fenómeno sigue siendo poco comprendido en los niños en edad preescolar. Este estudio tuvo como objetivo evaluar el efecto del entrenamiento musical en la memoria emocional de niños preescolares de 4 y 5 años. Ciento cuarenta y ocho niños preescolares de dos jardines de infantes privados en Buenos Aires, Argentina, fueron divididos aleatoriamente en grupos para recibir entrenamiento musical activo o receptivo. El contenido se adaptó del plan de estudios educativo de música o clases regulares de música durante un período de 4 semanas. Luego, observaron 24 imágenes neutrales y emocionales, calificaron su valencia y arousal, y se evaluó su recuerdo y reconocimiento (inmediato y diferido). Los datos se analizaron utilizando un análisis de varianza de medidas repetidas (ANOVA). Los factores entre sujetos fueron las condiciones (control versus entrenamiento activo versus entrenamiento receptivo) y la edad (4 y 5 años), mientras que la imagen (neutral, positiva o negativa) fue la medida repetida. Los principales hallazgos indicaron que los niños expuestos al entrenamiento musical tuvieron un mejor rendimiento mnemónico que el grupo de control y recordaron más imágenes emocionales que neutrales. Estos resultados resaltan la relevancia de los programas de música en los planes de estudio escolares.

Palabras clave: niñas y niños, memoria emocional, entrenamiento musical escolar, valencia, arousal.

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The topic of how musical experiences affect cognitive development has garnered significant attention in recent years. According to Masataka (2009) and Peretz (2008), humans are born with the potential to participate in musical experiences through composing, performing, and listening. However, several studies suggest that explicit music training not only improves knowledge of music itself but also impacts children's behavioral, functional, and anatomical capacities (Flaugnacco et al., 2015; Hallam, 2010; Hannon & Trainor, 2007; Kraus & Chandrasekaran, 2010; Schlaug et al., 2005).

The effect of music training on various domains is commonly referred to as transfer, which can be divided into near and far transfer (Forgeard et al., 2008; Sala & Gobet, 2017; Schellenberg, 2004). Near transfer implies a close resemblance between the musical skill and the domain under evaluation, such as the transfer of music training to motor skills, finger tapping, or motor coordination (Fujioka et al., 2006; Hyde et al., 2009; Schlaug et al., 2005). Research on far transfer suggests that the domains under study are not easily related to music training, such as spatial abilities and language, among other (Cheung et al., 2017; Flaugnacco et al., 2015; Gooding et al., 2014; Moreno & Besson, 2006; Norton et al., 2005). However, far-transfer research is more controversial and scarcer than near-transfer investigation, requiring more caution in interpretation. While the extra-musical benefits of music participation have been widely reported, meta-analyses have indicated the need for more controlled research to enhance the quality of investigations with randomized studies (Dumont et al., 2017; Hogan et al., 2018; Sala & Gobet, 2017).

Although several cognitive functions related to music training have been investigated (Hogan et al., 2018; Sala & Gobet, 2017), the exploration of emotional memory remains limited. Emotional memory refers to the memory for emotional items, which are better remembered than neutral ones (Bradley et al., 1992; Cahill & McGaugh, 1998; McGaugh & Roozendaal, 2009). Furthermore, negative items tend to be better remembered than positive ones (Alexander et al., 2010; Hua et al., 2014; Leventon & Bauer, 2016; Van Bergen et al., 2015). A study conducted by Izumika et al. (2022) investigated the neural mechanisms underlying emotional memory, revealing the crucial role of the amygdala in the encoding and retrieval of emotional memories. They concluded that understanding the neural basis of emotional memory could facilitate the development of more effective interventions for people with emotional difficulties. Additionally, Tahirovic & Jusić (2016) emphasized the significance of considering emotional memories in the context of social development, as emotional experiences can shape social behavior and relationships, both in childhood and beyond. The research on emotional memory in children is a vital area of study with implications for educational and therapeutic interventions, as well as the comprehension of social and emotional development. Although extensive research on this topic exists for adults (McIntyre et al., 2012; Roozendaal & McGaugh, 2011), the influence of emotions on children's memory remains less clear, underscoring the importance of conducting comprehensive examinations of emotion and memory in children (Otgaar et al., 2008; Solomon et al., 2012).

There are various ways to modulate emotional memory, including sleep (Diekelmann & Born, 2010; Rasch & Born, 2013), stress (Borg et al., 2011), and music (Judde & Rickard, 2010). Music is a powerful tool, with a strong connection to emotions and memory, where the emotional states induced by music can influence memory (Jäncke, 2008; Rickard et al., 2012). Therefore, in this process, the role of emotion is twofold: it is involved in the emotional charge of the items to be remembered (the emotional memory effect) and in the emotional characteristics of the activity that modulates memory (perceiving and creating music).

However, most studies investigating music training have focused on children with musical expertise (Ho et al., 2003; Mandikal Vasuki et al., 2017; Schellenberg, 2006; Swaminathan & Schellenberg, 2020; Zuk et al., 2014) or have implemented musical interventions as intensive training (Janus et al., 2016; Moreno et al., 2011). The first type of study is correlational, which provides valuable insights, but only shows associations between variables and cannot establish causation (Lau, 2017). On the other hand, the second type (musical intervention as intensive training) aims to demonstrate the effects of a specific treatment, but may not be feasible for every child, as it is not easily implemented. Moreover, the literature on learning suggests that spaced or distributed learning is more effective than massed or intensive learning (Domjan, 2010; Sobel et al., 2011; Vlach & Sandhofer, 2012; Vlach et al., 2008).

There is a need for an approach that can be implemented in the everyday lives of children, such as in schools, without additional costs and that can reach a broader population (Jaschke et al., 2018; Linnavalli et al., 2018; Tierney et al., 2013).

In the field of music education, there is a wide range of available music training programs that vary in terms of content, duration, intensity, and quality (Hille & Schupp, 2015). This variability can pose challenges when comparing the effects of different programs and drawing definitive conclusions about the optimal approach to music training. In this study, the focus was on a specific type of training: receptive and active musical training. Receptive training involves individuals acting as recipients of music and its elements (Bellis, 2003; Musiek et al., 2005), while active training includes experiences where individuals actively engage in producing music (Trainor et al., 2009; Young & Glover, 1998).

While research on the effectiveness of active music training has shown promising results, there has been limited investigation in the effectiveness of receptive training or a direct comparison between the two approaches. The act of making music involves the interaction of multiple modalities and higher-order cognitive functions, leading some researchers to hypothesize that active training may be more effective than receptive training (Lappe et al., 2008). However, this remains an unresolved issue and further research is needed to determine the most effective approach to music training.

The primary objective of this study was to assess the impact of spaced music learning, as a form of music training, on a far-transfer cognitive domain in children. Specifically, the aim was to examine the effects of active and receptive music training on neutral and emotional memory in 4- and 5-year-old children. This age range was selected based on research suggesting that music training is most effective when introduced at an early age, before the age of seven (See & Ibbotson, 2018). The training was conducted twice a week for four weeks as part of the regular school curriculum.

In terms of emotional memory, the hypotheses formulated predict that children demonstrate better recall for emotional images compared to neutral images (arousal effect), and that negative images are better remembered than positive images (valence effect). Furthermore, both types of music training were expected to have a differential impact on this recall pattern, with active training showing a more pronounced effect than receptive training. Additionally, it was anticipated that both forms of music training outperform an active control condition involving regular music classes.

Method

Participants

A total of 148 children, aged four and five, attending kindergarten in two private kindergartens subsidized by the state in San Francisco Solano, Quilmes, Buenos Aires, Argentina, participated voluntarily in this study. Among the participants, 37% were boys, and their ages were recorded as *M*age4 = 55 months (*SD* = 5 months) and *M*age5 = 66 months (*SD* = 4 months). Prior to the testing phase, the researchers sought approval from the school administration and conducted a meeting with the parents, obtaining informed consent from each child's parent, mother, or legal guardian. The children's assent was also obtained before their participation in the study. It is worth noting that most of the participating families came from a low to middle socioeconomic background, and Spanish was the primary language spoken at home. The participants were then randomly assigned to different conditions for the study.

Materials

Emotional Memory

A total of 72 child-appropriate images were chosen from the International Affective Picture System (IAPS; Lang et al., 1995) for this study (Table S1 in the Appendix). Out of these, 24 images were classified as pleasant/positive (e.g., ice cream), 24 as unpleasant/negative (e.g., a child crying), and 24 as neutral (e.g., scenes of nature). Among these images, 24 were selected for rating valence and arousal and were considered as the target pictures (eight images for each valence). The remaining 48 images were used for the recognition tests, both immediate and deferred.

To avoid any potential biases in affective processing of stimuli involving humans (Leventon & Bauer, 2016), half of the images within each emotional category included humans, while the other half did not.

The task was administered individually using a PowerPoint presentation, and all stimuli were displayed on a 14-inch monitor. The children were seated at 60 cm from the computer screen.

Instrumental Setting

For the active training, percussion instruments, including drums, maracas, bells, woodblocks, shakers, tambourine, xylophone, and metallophone were employed (see Figure S1 in the Appendix). These instruments were chosen for their user-friendly nature, making them suitable for the children's participation and engagement.

In the receptive training, music stimuli were presented through a sound system and board games featuring images of musical components were utilized for the recognition tasks (se Figure S2 in the Appendix). This approach allowed the children to engage with and recognize various musical elements in a playful and interactive manner.

Sociodemographic Questionnaire

The parents completed a sociodemographic questionnaire that gathered basic information about the child and family, such as age, illnesses or pathologies of the child, and the highest educational level of the parents or legal guardians.

Procedure

During the meeting with the parents, the researchers explained the study, showed sample images, and addressed any concerns or questions raised by them. Parents who agreed to have their children participate in the study provided informed consent by signing a consent form.

The study was conducted in three phases: (1) four weeks of music training (with either receptive or active training) and a control group with regular music classes; (2) rating of valence and arousal by having the children observe pictures, as well as immediate memory free-recall and recognition tests (Session 1); and (3) deferred free-recall and recognition memory tests one week after the immediate test (Session 2). All children followed the same schedule.

Musical Conditions

The music training was conducted within the school setting over a period of four consecutive weeks. Each training group received two half-hour sessions per week. Both the active and receptive training groups followed the same curriculum, but were delivered from different perspectives (see Figures S3 and S4 in the Appendix).

In the active training condition, children engaged in activities that involved musical production, such as singing, moving, and playing percussion instruments. The curriculum covered various elements of music discourse, rhythm, melody, textures, musical forms, tempo, genres, and musical styles, as described by Gerry et al. (2012).

On the other hand, in the receptive training condition, children participated in auditory perceptual activities that focused on listening, identifying, and recognizing different musical components, as described by Musiek et al. (2005).

Both music training conditions were carefully designed by researchers, teachers, and music therapists, to not only facilitate music learning but also enhance cognitive abilities.

In contrast, the active control condition consisted of regular music lessons based on the curriculum. Children participated in group sessions where they sang accompanied by a guitar played by the music teacher (see Table S2 in the Appendix). These classes were designed solely by the music teacher to achieve learning goals, without a specific focus on cognitive functions, as reported by Bilhartz et al. (1999), Rickard et al. (2010), and Roden et al. (2012).

All three conditions, including the active training, receptive training, and control group, were administered by a professionally trained music therapist/teacher. To account for the different age groups (4- and 5-year-olds) and the different conditions, a total of six groups were formed: 4-year-old children attending regular music classes (CTRL/4), 4-year-old children attending receptive music training (REC/4), 4-year-old children attending active music training (ACT/4), 5-year-old children attending regular music classes (CTRL/5), 5-year-old children attending receptive music training (REC/5), and 5-year-old children attending active music training (ACT/5). Random assignment was used to assign children to each condition, and they participated in the classes as part of groups.

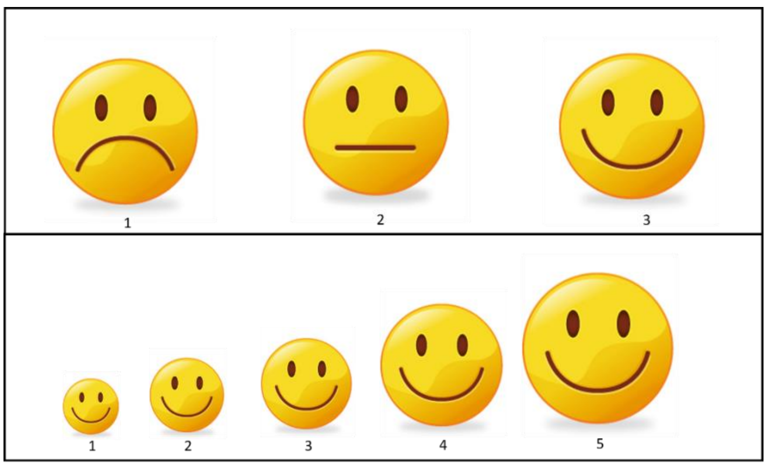
Both the children and parents were blind to the assignment of interventions, and they were not aware of which intervention would be considered more effective. Although the music teacher was not blind to the interventions, the researcher who analyzed the data remained blind to the specific information she was analyzing.

Test Session 1

Each child was individually tested in a quiet room. They were seated in front of a computer monitor and presented with a set of 24 images, displayed in a random order. This set included eight neutral images, eight positive images, and eight negative images.

To simplify the task for the children, it was decided to use sad, neutral, and happy faces instead of the Self-Assessment Manikin (SAM) scale used by Solomon et al. (2012) to assess arousal and valence. The faces (see Figure 1; Ruetti et al., 2019) were utilized to evaluate the valence and arousal associated with each of the 24 images. For the valence assessment, the children were asked to point to the corresponding face (sad, neutral, or happy) that best represented their perception when viewing each image (see Figure 1, top panel).

Figure 1
Set of Faces Used to Evaluate Valence (Top Panel) and Arousal (Bottom Panel)



After selecting one of the emotions, arousal was assessed by showing the children the same face in five different sizes, ranging from small to large, and the children then chose one of the five faces to indicate how happy or sad they felt about the picture (see Figure 1, bottom panel). Once the children had viewed and rated the 24 images, the researcher asked them to recall which images they remembered seeing (immediate free-recall test). Following this, the 24 original images were mixed with 24 new images and the children were asked to identify which images they had seen before (immediate-recognition test). The entire session took between 20 and 30 minutes.

Test Session 2

One week later, each child was individually taken out of the classroom and tested. This session consisted of deferred free-recall and deferred recognition tests, using the same test procedure as in Session 1, with the exception that the 24 new images presented for recognition were different (i.e., not the same as those used in Session 1). The second session lasted between 5 and 10 minutes.

Data Analysis

To examine Valence, the data was transformed into a three-point scale where the sad, neutral, and happy faces were assigned values of |1, 2, and 3, respectively. Similarly, for Arousal, values of 1 to 5 were assigned to the five faces (see Figure 1, bottom panel, for an example of the five happy faces and the arousal evaluation scale).

The data was analyzed using a repeated measures analysis of variance (ANOVA). The between factors were conditions (control versus active versus receptive) and age (4 and 5), while picture (neutral, positive, or negative) was the repeated measure. Significant main effects and interactions were analyzed using post hoc least-significant difference pairwise comparisons. The effect size was estimated using partial Eta squared (η^2_p). Descriptive and inferential statistics were computed using the SPSS software package, with an alpha value set at 0.05.

Results

The final number of children per group was CTRL/4 = 20; REC/4 = 28; ACT/4 = 25; CTRL/5 = 20; REC/5 = 29; ACT 5 = 26.

Emotionality Measures

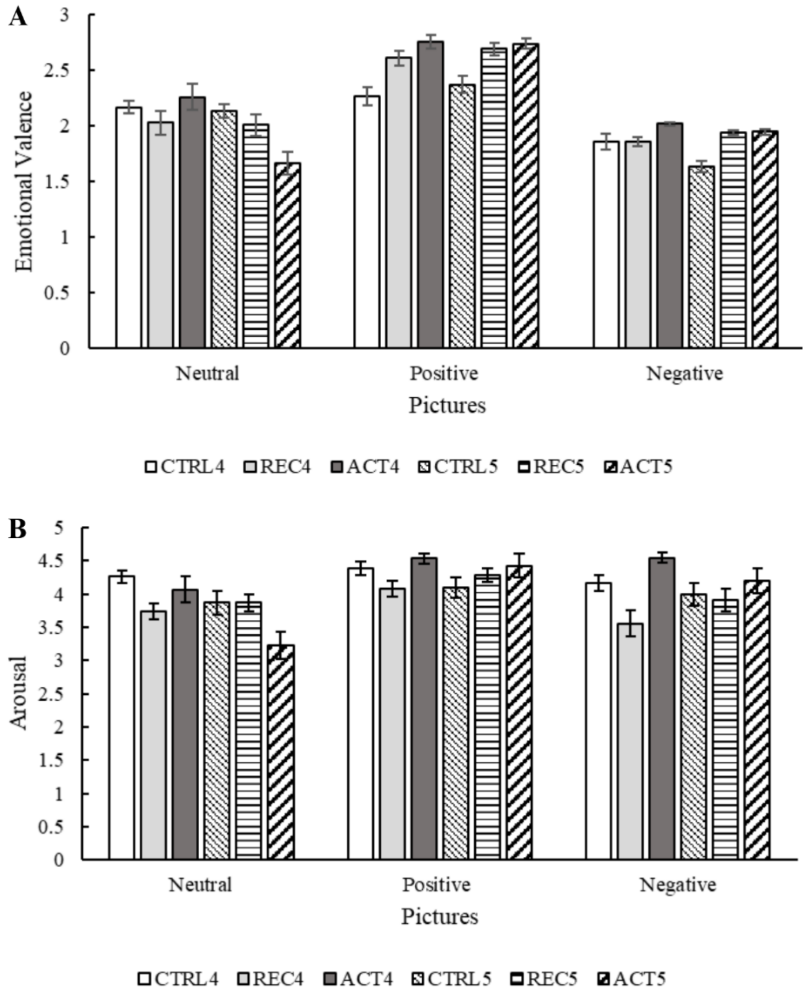
For the first emotionality measure, Valence, the children were individually presented with a set of three faces (Figure 1, top panel) and asked to point to the face that best reflected their emotional response. An ANOVA was conducted and revealed a main effect of Picture, $F(2, 284) = 160.26$, $p < 0.001$, $\eta^2_p = 0.530$, 95% CI [1.84 to 2.62],; Age, $F(1, 142) = 4.64$, $p = 0.033$, $\eta^2_p = 0.032$, 95% CI [2.07 to 2.25]; Condition, $F(2, 142) = 6.42$, $p = 0.002$, $\eta^2_p = 0.083$, 95% CI[2.00 to 2.24]; Picture x Condition, $F(4, 284) = 9.77$, $p < 0.001$, $\eta^2_p = 0.121$, 95% CI [1.68 to 2.83]; Picture x Age, $F(2, 284) = 5.66$, $p = 0.004$, $\eta^2_p = 0.038$, 95% CI [1.79 to 2.62]; Condition x Age, $F(2, 142) = 5.55$, $p = 0.005$, $\eta^2_p = 0.073$, 95% CI [1.95 to 2.43]; and Picture x Condition x Age, $F(4, 284) = 3.79$, $p = 0.005$, $\eta^2_p = 0.051$, 95% CI [1.78 to 2.80] (Figure 2A). Post hoc analysis revealed that the children were able to distinguish between the three types of images. Four-year-old children rated the images higher than five-year-olds, and the active and receptive groups rated the pictures higher than the control group. Further breakdown of the triple interaction showed that for neutral images there were no differences between the groups for 4-year-old children. However, for positive images, the control group rated them lower than the active and receptive groups, and for negative images, the active group rated them higher than the control and receptive groups. For 5-year-old children, the active group rated the neutral images lower than the other two groups, and the control group rated the positive and negative pictures lower than the active and receptive groups.

For the second emotionality measure, Arousal, the children were presented with a scale of five faces ranging in size from small to large (Figure 1, bottom panel) and asked to rate how emotionally or arousing the pictures were for them. The main finding was that emotional pictures were rated as more arousing than neutral ones, and this effect was influenced by the music training the children had received (Figure 2B). The ANOVA yielded a main effect of Condition, $F(2, 142) = 7$, $p < 0.001$, $\eta^2_p = 0.09$; Picture, $F(2, 284) = 17.82$, $p < 0.001$, $\eta^2_p = 0.112$. There was a significant Condition x Age interaction, $F(2, 142) = 5.27$, $p = 0.006$, $\eta^2_p = 0.069$; and Picture x Condition interaction, $F(4, 284) = 6.53$, $p < 0.001$, $\eta^2_p = 0.084$.

Post hoc tests indicated that positive images were rated as more arousing than negative images, and negative images were rated as more arousing than neutral images. The receptive groups rated the pictures as less arousing than the active and control groups, and this effect was observed only in 4-year-old children, not 5-year-olds. For neutral images, the active conditions rated the pictures as less arousing than the control groups, while the receptive groups did not differ from the other groups. For positive images, the receptive and control groups rated the pictures as less arousing than the active conditions. For negative images, the active conditions rated the pictures as more arousing than did the control groups, while the receptive groups did not differ from the other groups. For positive images, the receptive and control groups rated the pictures as less arousing than did the active conditions. In addition, for the negative images, the active conditions rated the pictures as more arousing than did the control groups, and the latter rated them as more arousing than did the receptive conditions (see data file in Supplementary Material).

Figure 2

Emotionality Measures



Note. A. Emotional Valence: children's valence rating of positive, neutral, and negative pictures. B. Arousal: children's arousal rating of neutral, positive, and negative pictures. CTRL4: Four-year-old children attending regular music classes. REC4: Four-year-old children attending the receptive music training. ACT4: Four-year-old children attending the receptive music training. CTRL5: Five-year-old children attending regular music classes. REC5: Five-year-old children attending the receptive music training. ACT5: Five-year-old children attending the receptive music training. Vertical lines represent the standard deviation of the mean.

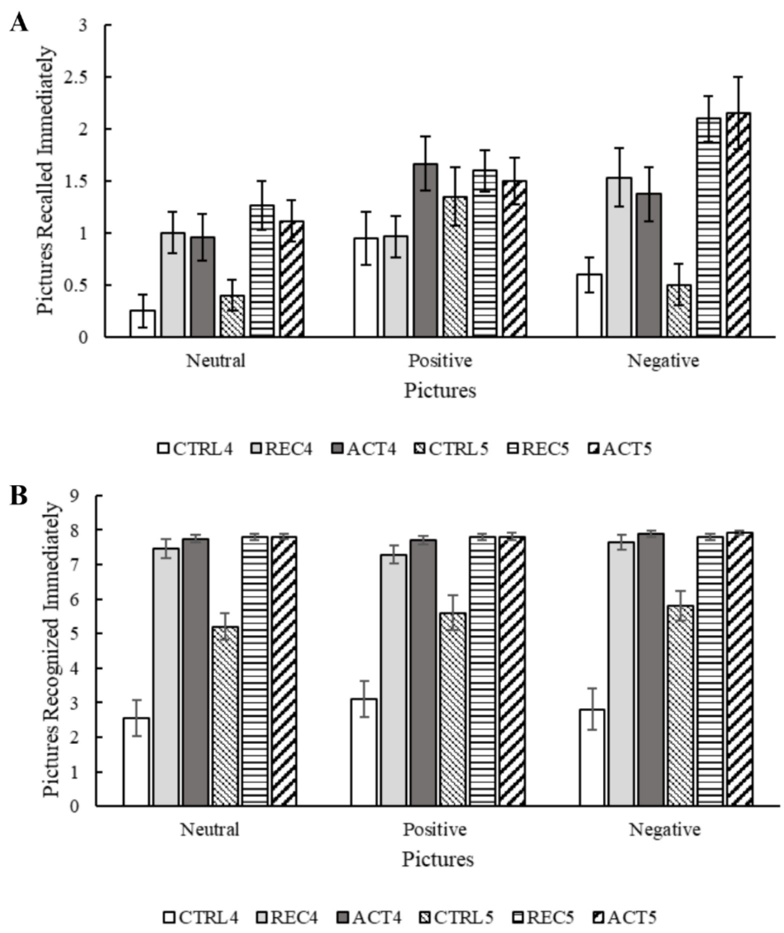
Immediate Measures

To assess immediate free recall, the researcher asked the children which images they remembered immediately after rating their valence and arousal. The results are presented in Figure 3A. The ANOVA revealed a main effect of Picture, $F(2, 284) = 11.38$, $p < 0.001$, $\eta^2_p = 0.074$; where emotional pictures were remembered better than neutral ones. It also showed a main effect of Age, $F(1, 142) = 5.53$, $p = 0.002$, $\eta^2_p = 0.037$; where 5-year-old children remembered more pictures than 4-year-old children. Additionally, a main effect of Condition was found, $F(2, 142) = 14.52$, $p < 0.001$, $\eta^2_p = 0.176$; where the control groups remembered fewer pictures than both musical conditions, and the ANOVA yielded a significant interaction of Picture x Condition, $F(4, 284) = 3.47$, $p = 0.009$, $\eta^2_p = 0.047$.The post hoc analysis revealed that the differences between the musical conditions and the control were for the neutral and negative images, but not for the positive ones.

To evaluate recognition, the 24 target pictures were mixed with 24 new pictures and the children were asked to indicate if the images were new or old. False recognitions were subtracted from the total recognition score. The results are depicted in Figure 3B. The statistical analyses showed a main effect of Condition, $F(2, 142) = 134.057$, $p < 0.001$, $\eta^2_p = 0.654$; Age, $F(1, 142) = 28.58$, $p < 0.001$, $\eta^2_p = 0.168$; and Age x Condition, $F(2, 142) = 16.91$, $p < 0.001$, $\eta^2_p = 0.192$. The post hoc analysis indicated that the control condition recognized fewer images than the musical conditions, and this was true for both ages being evaluated. Furthermore, 5-year-olds recognized more pictures than 4-year-old children (see data file in Supplementary Material).

Figure 3

Memory Performance



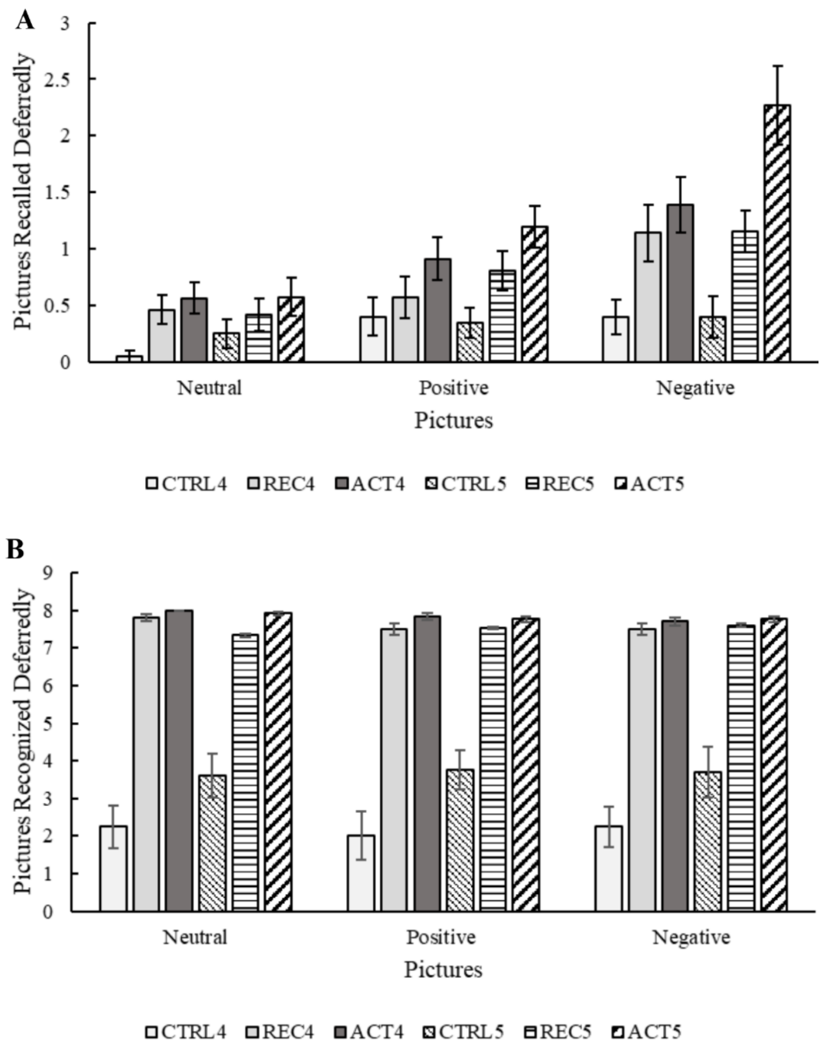
Note. A. Immediate free recall: number of neutral, positive, and negative pictures that each group could remember after the treatment. B- Immediate recognition: number of neutral, positive, and negative pictures that each group could recognize as previously seen. CTRL4: Four-year-old children attending regular music classes. REC4: Four-year-old children attending the receptive music training. ACT4: Four-year-old children attending the receptive music training. CTRL5: Five-year-old children attending regular music classes. REC5: Five-year-old children attending the receptive music training. ACT5: Five-year-old children attending the receptive music training. Vertical lines represent the standard deviation of the mean.

Deferred Measures

The deferred tests were conducted one week after the immediate tests. Results are shown in Figure 4. The ANOVA for free recall indicated a main effect of Picture, $F(2, 284) = 28.37$, $p < 0.001$, $\eta^2_p = 0.167$. The negative pictures were the most memorable, followed by the positive pictures and then the neutral ones. The ANOVA also revealed a main effect of Age, $F(1, 142) = 8.82$, $p = 0.004$, $\eta^2_p = 0.058$; with 5-year-old children remembering more images than 4-year-old children. Additionally, the main effect of Condition was significant, $F(2, 142) = 21.59$, $p < 0.001$, $\eta^2_p = 0.233$; with better performance in the musical conditions than in the control conditions. The Picture x Condition interaction was also significant, $F(4, 284) = 3.87$, $p = 0.004$, $\eta^2_p = 0.052$; and the post hoc analysis indicated that the Condition effect was observed for all three types of images.

Figure 4

Deferred Memory Measures



Note. A. Deferred free recall: number of neutral, positive, and negative pictures that each group could remember a week after the treatment. B. Deferred recognition: number of neutral, positive, and negative pictures that each group could recognize a week after treatment. CTRL4: Four-year-old children attending regular music classes. REC4: Four-year-old children attending the receptive music training. ACT4: Four-year-old children attending the receptive music training. CTRL5: Five-year-old children attending regular musical classes. REC5: Five-year-old children attending the receptive music training. ACT5: Five-year-old children attending the receptive music training. Vertical lines represent the standard deviation of the mean.

Figure 4B presents the results of the delayed recognition test. The ANOVA revealed a main effect of Condition, $F(2, 142) = 212.36$, $p < 0.001$, $\eta^2p = 0.749$; with better performance in the musical conditions than in the control conditions. The analysis also indicated a main effect of Age, $F(1, 142) = 4.84$, $p = 0.029$, $\eta^2p = 0.033$; and the post hoc analysis showed that 5-year-old children recognized more images than 4-year-old children. Furthermore, the Condition x Age interaction was significant, $F(2, 142) = 5.95$, $p = 0.003$, $\eta^2p = 0.077$; and the post hoc analysis indicated that the Condition effect was observed for both age groups. Please refer to the data file in the Supplementary Material for more information).

Discussion

The aim of this study was to examine the effect of two types of music training, receptive and active, on the emotional memory of children aged 4 and 5, as measured by free-recall and recognition tests. Results showed that both types of music training were effective in modulating emotional memory. Emotional pictures were found to be more arousing and better remembered than neutral pictures. Although positive images were rated as more arousing than negative images, they were not better remembered in either the immediate or deferred measures. Finally, 5-year-old children performed better than 4-year-olds.

It has been documented that young children find it difficult to evaluate the emotional valence and arousal of pictures using the tool employed with adults (SAM; Bradley et al., 1992). Therefore, a face system was used, which was a more suitable approach for children (Ruetti et al., 2019). With the face system for valence, the children were able to differentiate between the three types of images. Using the face system for arousal, emotional images were found to be more activating than neutral ones. Specifically, positive images were more activating than negative ones, and negative images more activating than neutral ones, with a stepped score. The face protocol was a reliable tool for assessing valence and arousal in young children.

In both the immediate and deferred free-recall measures, emotional pictures were better remembered than neutral ones, and five-year-old children performed better than younger children. However, there were differences in the pattern of results between the immediate and deferred tests. In the immediate measure, positive and negative images were better remembered than neutral ones, while in the deferred test, negative images were better remembered than positive ones and positive images were better remembered than neutral ones, in a stepped manner. Importantly, in both free-recall measures children receiving receptive and active music training remembered more pictures than the control group. This mnemonic advantage was for neutral and negative images in the immediate measure, and for all three types of images in the deferred free recall.

If arousal were the main factor explaining the results, positive pictures would be better remembered than negative ones and negative ones would be better remembered than neutral ones. However, this was not the case, because both positive and negative images were better remembered than neutral ones in the immediate measure and negative images were better remembered than positive ones in the deferred measure, with all emotional images better remembered than neutral ones. On the other hand, if valence were the main factor, emotional images would be better remembered than neutral ones. This was supported by the fact that positive and negative images were better remembered than neutral ones in the immediate measure and negative images were better remembered than positive ones in the deferred free-recall measure, with emotional images better remembered than neutral ones. Overall, the free-recall results indicated that both arousal and valence were modulators of memory, but valence had a slight advantage over arousal (Adelman & Estes, 2013).

In the deferred free recall, the results indicated that negative pictures were better remembered than positive ones, which is consistent with previous research suggesting a negativity bias (Alexander et al., 2010; Leventon et al., 2014; Van Bergen et al., 2015). Negative information elicits stronger physiological, cognitive, and behavioral responses (Taylor, 1991). Negative stimuli require more cognitive effort and attention, are more salient and complex (Bowen et al., 2018; Cordon et al., 2013), and have a more enduring emotional impact than positive ones (Sheldon et al., 1996). Moreover, there are more words to describe negative emotions than positive ones (Cordon et al., 2013) and negative events are evolutionarily important to remember to avoid future danger (Vaish et al., 2008).

Regarding recognition, both types of music training resulted in better recognition scores than the control groups, in both the immediate and deferred measures. Furthermore, 5-year-old children recognized more images than the younger group. The emotionality of the images did not have an effect on recognition, as all images were better recognized than the neutral ones by children in both types of music training.

In the literature on far-transfer, the majority of studies have focused on the verbal domain, with little research on the visual domain (Ho et al., 2003; Rickard et al., 2010). Most authors attribute the benefits of music to the verbal domain, due to the shared neural areas of language and music (Cohrdes et al., 2019; Moreno et al., 2011). However, this study found evidence of a visual transfer effect, which could be due to the emotional nature of the task, as opposed to neutral tasks used in other studies.

The literature on hemispheric specialization suggests that language processing is mainly responsible for the left hemisphere, while music and visual processing are mainly responsible for the right hemisphere in the general population (Ho et al., 2003). However, for musicians, both hemispheres are responsible for music processing, with a greater engagement of the left hemisphere, since musicians perceive music in a more analytical way (Soria-Urios et al., 2011; Zatorre et al., 2007). Since the sample used consisted of non-musical background children, they may have engaged the right hemisphere to process music training, and this engagement of the right hemisphere could have been responsible for the enhanced visual memory results obtained since visual processing is carried out by the right hemisphere. If verbal memory and older children with musical backgrounds or musicians were to be assessed, musicians would probably differ from non-musicians in this type of memory since the left hemisphere is necessary for verbal information and musicians engage the left hemisphere to analyze music (Chan et al., 1998; Ho et al., 2003). It would be interesting to study this topic in future works to further analyze these issues.

It is worth mentioning that the evaluations showed differences in test performance based on age, due to the neurotypical development of infants. There is evidence that with age storage intervals increase and memory errors decrease (Bauer et al., 2003).

Two types of musical training were implemented: receptive and active. Both were effective in modulating emotional memory. Although active training was predicted to be more effective than receptive training (Lappe et al., 2008), this prediction was not confirmed. A possible explanation for this discrepancy may be related to the low-to-middle socioeconomic status of the sample. It has been documented that this type of population is most receptive to environmental interventions (Barbaroux et al., 2019; Hanscombe et al., 2012; Kraus et al., 2014; Lipina & Evers, 2017). Therefore, both types of music training enhanced the cognitive function of the children, irrespective of the musical specificity of the intervention. Future research could study another socioeconomic status to compare results. Such an approach could contribute to the preventive potential of musical experiences in different contexts, a topic that has not been sufficiently explored in the literature on music training.

It is noteworthy that in the design used children were randomly assigned to the interventions, children and parents were blinded to the effectiveness of each intervention, and an active control group was used. All these factors enhanced the quality of the investigation, reinforcing the results obtained (Dumont et al., 2017).

One of the main interests was to apply music training to a broader population, since the vast majority of studies have used massed/intensive music learning or investigated children who are musicians, limiting the children to whom the training can be given (Tierney et al., 2013; Zuk et al., 2014). Intensive training is difficult to implement and not all parents can afford the cost of extracurricular activities (Linnavalli et al., 2018). The music training was part of the school curriculum that the children attended every day, making the training affordable and promoting social equality. This musical approach could be implemented in educational settings without additional costs by replacing regular teaching with a more specific musical approach and using the available resources of the educational institution. The findings from such music training provide educators, music therapists, and education policymakers with crucial information to maximize the benefits of music programs for children.

This research has highlighted the potential of music training to promote changes in brain function, particularly in areas associated with memory (Hyde et al., 2009). Knowledge about the effects of music training and its effect on emotions in the brain makes significant contributions to knowledge in different fields. In the field of psychology of music, this research contributes to understanding the complex relationship between music and human behavior and how music affects emotions and cognition (Juslin & Sloboda, 2011).

In terms of health, music can be used in rehabilitation programs as a tool to enhance memory (Särkämö & Soto, 2012). In the field of education, this study has shown how the integration of music into the curriculum can improve emotional memory (Schellenberg, 2006). These findings highlight the importance of art, in general, and musical learning, in particular, within the educational system for emotional and cognitive development in early childhood. The experience-induced cognitive improvement has the potential to stimulate further investigation into possible ways to enhance human brain functioning and develop a project for cognitive rehabilitation, such as using music training to enhance memory (Chanda & Levitin, 2013; Fancourt et al., 2014; Ho et al., 2003).

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Supplementary materials

See here the supplentary material: Data File_The Effect of Active and Receptive Musical Training on Emotional Memory.xlsx

Appendix

Table S1
Set of Child-Appropriate Images Selected From the International Affective Picture System

International Affective Picture Sistem														
Encoding phase					Immediate recognition					Deferred recognition				
Type	N°	Valence	Arousal	Description	Type	N°	Valence	Arousal	Description	Type	N°	Valence	Arousal	Description
Unpleasant	2900	2.45	5.09	Baby crying	Unpleasant	9320	2.65	4.93	Toilet	Unpleasant	2830	4.73	3.64	National geographic
Unpleasant	9041	2.98	4.64	Scared child	Unpleasant	9390	3.67	4.14	Dirty plates	Unpleasant	7380	2.46	5.88	Cockroach on food
Unpleasant	9050	2.43	6.36	Crashed plane	Unpleasant	9400	2.5	5.99	Soldier	Unpleasant	9430	2.63	5.26	Burial
Unpleasant	9250	2.57	6.6	Bloody child and docs	Unpleasant	9402	4.48	5.07	Man being pulled	Unpleasant	9440	3.67	4.55	Skulls
Unpleasant	9300	2.26	6	Toilet	Unpleasant	9480	3.51	5.57	Skulls	Unpleasant	9520	2.46	5.41	Boys
Unpleasant	9421	2.21	5.04	Crying soldier	Unpleasant	9490	3.6	5.57	Burned man	Unpleasant	9594	3.76	5.17	Blood draw
Unpleasant	9470	3.05	5.05	Collapsed building	Unpleasant	9530	2.93	5.2	Boys	Unpleasant	9600	2.48	6.46	Sinking ship
Unpleasant	9582	4.18	5.29	Dentist	Unpleasant	9611	2.71	5.75	Crashed plane	Unpleasant	9622	3.1	6.26	Crashed plane 3
Neutral	7175	4.87	1.71	Pedestal table	Neutral	7004	5.04	2	Spoon	Neutral	7031	4.52	2.03	Shoes
Neutral	7080	5.27	2.32	Fork	Neutral	7006	4.88	2.33	Bowl	Neutral	2190	4.83	2.41	Gandalf
Neutral	7090	5.19	2.61	Book	Neutral	7705	4.77	2.65	Drawers	Neutral	7025	4.63	2.71	Sidewalk
Neutral	7050	4.93	2.75	Dryer	Neutral	7224	4.45	2.81	Cabinets	Neutral	7100	5.24	2.89	Water mouth
Neutral	7140	5.5	2.92	Collective	Neutral	5500	5.42	3	Mushrooms	Neutral	7009	4.93	3.01	Cup
Neutral	7034	4.95	3.06	Hammer	Neutral	7160	5.02	3.07	Abstract image	Neutral	5534	4.84	3.14	Mushrooms
Neutral	7002	4.97	3.16	Towel	Neutral	7170	5.14	3.21	Lamp	Neutral	9401	4.53	3.88	Knives
Neutral	5991	6.65	4.01	Heaven	Neutral	7211	4.81	4.2	Clock	Neutral	7095	5.99	4.21	Auto headlight
Pleasant	1460	8.21	4.31	Little cat	Pleasant	1463	7.45	4.79	Little cat	Pleasant	1722	7.04	5.22	Little jaguars
Pleasant	1710	8.34	5.41	Puppy dogs	Pleasant	1610	7.82	3.08	Rabbit	Pleasant	8031	6.76	5.58	X games
Pleasant	1750	8.28	4.1	Little bunny	Pleasant	2070	8.17	4.51	Baby	Pleasant	8490	7.2	6.68	Roller coaster
Pleasant	1999	7.43	4.77	Mickey	Pleasant	8380	7.56	5.74	Athletes	Pleasant	1601	6.86	3.92	Giraffes
Pleasant	2040	8.17	4.64	Baby	Pleasant	1620	7.37	3.54	Deer	Pleasant	2340	8.03	4.9	Family
Pleasant	2655	6.88	4.57	Child	Pleasant	2165	7.63	4.55	Dad	Pleasant	7410	6.91	4.55	M&M
Pleasant	7325	7.06	3.55	Watermelon	Pleasant	2345	7.41	5.42	Child	Pleasant	1920	7.9	4.27	Dolphins
Pleasant	7330	7.69	5.14	Ice cream	Pleasant	2311	7.54	4.42	Mom and child	Pleasant	5831	7.63	4.43	Beach with father

Table S2
Musical Conditions

Day	Exposure time	Receptive music training	Active music training	Regular music classes
1	30 min	Auditory perception, discrimination, and recognition of object sounds (e.g., keys, pencils, newspapers) and body sounds (e.g., clap, stomp) through a board game. The children had to listen to a sound (see Music Sounds Examples in https://www.dropbox.com/sh/7mjjhi2splw0k2m/AABVjauSjALEg-OYb-oAXBaja?dl=0) and mark on the board game the object or the part of the body which corresponded to that sound.	Auditory perception and sound production through everyday objects (e.g., keys, pencils, newspapers) and the body (body percussion). The children had to listen, recognize, and perform sounds with everyday objects and parts of the body.	Joint singing. The children had to sing in groups a nursery rhyme with the accompaniment of the guitar, performed by the music teacher.
2	30 min	Auditory perception, discrimination, and recognition of different voices (e.g., woman, man, child, baby) and musical instruments (e.g., guitar, drums, violin) through a board game. The children had to listen to a sound and mark on the board game the voice or the musical instrument which corresponded to that sound.	Auditory perception and sound production through the voice and musical instruments. The children had to listen, recognize, and perform sounds with their voices and musical instruments (See musical instruments example).	Joint singing. The children had to sing in groups a nursery rhyme with the accompaniment of the guitar, performed by the music teacher.
3	30 min	Auditory perception, discrimination and recognition of different musical instrument actions (e.g., plucked, strummed, bowed) though a board game, and then listen to a sound story. The children had to listen to a sound and mark on the board game the musical instrument action which corresponded to that sound and listen to the sound story "Don Fresquete" from María Elena Walsh. .	Auditory perception and sound production through different instrument actions (e.g., plucked, strummed, bowed) and listen to a sound story. The children had to listen and perform sounds with different musical instrument actions and listen to a sound story, "Don Fresquete" from María Elena Walsh.	Joint singing. The children had to sing in groups a nursery rhyme with the accompaniment of the guitar, performed by the music teacher.
4	30 min	Auditory perception, discrimination, and recognition of different *timbres* (tone color or tone quality, e.g., an oboe and a clarinet), duration (e.g., long or short sound), pitch (e.g., higher or lower sound), sound intensity and perceived loudness (e.g., week, medium, strong sound). The children had to listen to a sound and mark on the board game the *timbre*, duration, pitch, or intensity of sound, which corresponded to that sound.	Auditory perception and sound production using different *timbres* (tone color or tone quality, e.g., an oboe and a clarinet), duration (e.g., long or short sound), pitch (e.g., higher or lower sound), sound intensity, and perceived loudness (e.g., week, medium, strong sound). The children had to listen and perform sounds with different *timbres*, sounds durations, pitch and intensities through musical instruments.	Joint singing. The children had to sing in groups a nursery rhyme with the accompaniment of the guitar, performed by the music teacher.
5	30 min	Perception, discrimination, and recognition of different *tempo* (e.g., fast or slow). The children had to listen to music and mark on the board game the *tempo* which corresponded to that music.	Auditory perception and sound production using different *tempo* (e.g., fast or slow) through musical instruments. The children had to produce and accompany the music with music instruments, songs with different *tempos*.	Joint singing. The children had to sing in groups a nursery rhyme with the accompaniment of the guitar, performed by the music teacher.

6	30 min	Perception, discrimination, and recognition of different musical textures (e.g., monophonic, polyphonic music) and character (e.g., serene, energetic music). The children had to listen to music and mark on the board game the texture and musical character which corresponded to that music.	Auditory perception and sound production of different musical textures (e.g., monophonic, polyphonic music) and musical character (e.g., serene, energetic music). The children had to listen and perform sounds with different textures and characters, through musical instruments.	Joint singing. The children had to sing in groups a nursery rhyme with the accompaniment of the guitar, performed by the music teacher.
7	30 min	Perception, discrimination, and recognition of different musical styles (e.g., classical music, rock music). The children had to listen to music and mark on the board game the music style which corresponded to that music.	Auditory perception and sound production with different musical styles (e.g., classical music and rock music). The children had to accompany with musical instruments the music of songs with different musical styles.	Joint singing. The children had to sing in groups a nursery rhyme with the accompaniment of the guitar, performed by the music teacher.
8	30 min	Perception and recognition of different music functions (e.g., entertainment, communication, ceremonies) and conventional and unconventional harmonies of Argentine culture. The children had to listen to music and mark on the board game the musical function of music, conventional and unconventional harmonies which corresponded to that music.	Perception and sound production with different music functions (e.g., entertainment, communication, ceremonies), conventional and unconventional harmonies of Argentine culture. The children had to accompany the music with musical instruments, songs with different functions, conventional and unconventional harmonies.	Joint singing. The children had to sing in groups a nursery rhyme with the accompaniment of the guitar, performed by the music teacher.

Figure S1
Musical Instruments Used in the Active Music Training

Figure S2
Board Game Used in the Receptive Music Training

Figure S3
Children Participating in Active Music Training

Figure S4
Children Participating in Receptive Music Training

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