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Relationship between musical training and working memory in adolescent between 12 and 14 years old from the San Vicente district, province of Buenos Aires

Relación entre el entrenamiento musical y la memoria de trabajo en adolescentes entre 12 y 14 años del partido de San Vicente, provincia de Buenos Aires

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ABSTRACT

The objective of this master's thesis was to evaluate the impact of the program of a youth orchestra in the Province of Buenos Aires on the operability of working memory, executive functions and verbal working memory with standardized tests. A transectional study was carried out, where two groups of adolescent participants were compared, with and without musical training. Significant differences were found in favor of the group with musical training in the direct digit tests, reverse digit tests and the verbal comprehension subtests (similarities, vocabulary and comprehension), adding to the studies that affirm that musical training affects working memory verbal. No significant differences were found in the other tests. Finally, it is concluded that the youth orchestra program benefits some aspects of cognitive development in its participants.

Palabras clave:
Entrenamiento musical, memoria de trabajo, transferencia, adolescentes.

RESUMEN

La presente tesis de maestría tuvo por objetivo evaluar el impacto del programa de una orquesta juvenil de la Provincia de Buenos Aires en la operatividad de la memoria de trabajo, las funciones ejecutivas y la memoria de trabajo verbal con pruebas estandarizadas. Se realizó un estudio transeccional, donde se compararon dos grupos de participantes adolescentes, con y sin entrenamiento musical. Se hallaron diferencias significativas a favor del grupo con entrenamiento musical en las pruebas de dígitos directos, dígitos inversos y las sub pruebas de comprensión verbal (semejanzas, vocabulario y comprensión), sumándose a los estudios que afirman que el entrenamiento musical afecta la memoria de trabajo verbal. No se hallaron diferencias significativas en las demás pruebas. Finalmente, se concluye que el programa de orquesta juvenil beneficia algunos aspectos del desarrollo cognitivo en sus participantes.

Introduction

The broad field of studies investigating the brain and music has currently focused on investigating how the active practice of music can bring about lasting changes (Hallam, 2010) in brain organization and plasticity (Kraus & Chandrasekaran, 2010). In comparative type studies between populations with and without music training, it is investigated whether music training would lead to a transfer of skills from music to other music-related or non-music related fields (Miendlarzewska & Trost, 2014). As a consequence, beneficial effects on cognitive functions have been found in musically trained children and adolescents (Ciaroti et al., 2019) in both musical and non-musical skills (Custodio & Cano-Campos, 2017). In the last decade, cortical areas of hearing have been found to be more sensitive to auditory information in adult musicians compared to participants without this type of training (George & Coch, 2011), while, in children and adolescents, music favors brain development and stimulation of intellectual capacities for cognitive development and learning (Arenas, Lázaro, & Sánchez, 2016). In addition, greater brain plasticity has been found in subjects who have undergone musical training since childhood (Benítez, Diaz Abrahan & Justel, 2017; Wan & Schlaug, 2010), depending on the duration and experience of the training (Vaquero, Rousseau, Vozian, Klein & Penhune, 2020).

In studies of brain neuroimaging recordings, it has been found greater connectivity in adults and children with musical training (Arias, 2014), due to a repeated activation in areas of the prefrontal cortex in areas of the prefrontal cortex, where working memory is located (Peretz & Zatorre, 2005; Zuk, Benjamin, Kenyon & Gaab, 2014), cognitive control or control of mechanical automatic responses (Pallesen et al., 2010) and attention (Jurado, 2016). Anatomical modification has been found in this area in adult musicians, due to the ability to reorganize as cognitive demand requires (Hallam, 2010; Soria-Urios, Duque & García-Moreno, 2011).

Within the structural modifications of brains of musically trained children, the most important is the increased activation of the auditory cortex and plasticity throughout the auditory system (Elangovan, Payne, Smurzynski & Fagelson, 2016)due to the need to manage auditory elements over time (Hyde et al., 2009). This could be explained by the fact that children with early musical training demonstrated a more extensive cortical representation (auditory cortex) than untrained children (Wan & Schlaug, 2010). Based on neuroscientific findings, it specifies what musical training consists of and how this complex and demanding training benefits motor, articulatory and cognitive development in children, adolescents and adults.

Method

The research design and methodology is transectional or cross-sectional, non-experimental, causal between variables (Hernández Sampieri, Fernández Collado & Baptista Lucio, 2010). The relationship between an independent variable (musical training) and dependent variables (working memory, verbal working memory, executive functions) was investigated without manipulation of variables (non-experimental).

Working Memory Subtests

Participants performed standardized WISC-IVtests (Wechsler, 2010), specifically the working memory index tests (direct digits, reversed digits, letters and numbers), verbal comprehension (similarities, vocabulary and comprehension) and the Corsi cube task (Corsi, 1972) in progression. The direct digit and inverse digit subtest calculates the working memory IQ. The Similarity, Vocabulary and Comprehension subtest calculates the IQ of verbal comprehension.

Digit retention. He required the child to repeat the digits presented, modifying his request into direct (the same order presented) and inverse (the opposite order to the one presented). Digit retention has an oral presentation and is designed to measure short-term auditory memory and the ability to sequence attention and concentration (Wechsler, 2010). Direct digit retention according to Wechsler (2010) involves memory and mechanical repetition learning, attention, encoding and auditory processing, while inverse digit retention involves working memory, information transformation, mental management, imagination, cognitive flexibility and mental alertness.

Letters and numbers. It is a subtest composed of a task of orally repeating a sequence of letters and numbers combined, first the numbers in ascending order and then the letters in alphabetical order. This task involves sequence formation, mental management of information, attention, auditory short-term memory, visuospatial image formation and processing speed (Wechsler, 2010).

Corsi cubes in progression. It consists of presenting visuospatial information by means of nine painted wooden cubes, arranged in a non-exact square. The researcher touched the cubes one by one and the participants observed and repeated what they observed by touching the cubes, respecting the sequence presented. This task is characterized by having the same digit logic (working memory), where each series was expanded and made more complex to the maximum level that the participant could remember (9 combinations of cubes). This study completes the evaluation of working memory by providing information on visuospatial retention.

Verbal Comprehension Subtests

Similarities. It is the main subtest in verbal comprehension, where two words representing common objects were presented and the child had to describe verbally how they were similar. This task is designed to measure verbal reasoning and concept formation, in addition to auditory comprehension, memory, distinction between essential and secondary features, and verbal expression (Wechsler, 2010).

Vocabulary. In this subtest, the presentation has four graphic items and four verbal items, designed to measure word knowledge and verbal concept formation by first seeing and recognizing information and then hearing a word. It measures wealth of knowledge, learning ability, long-term memory and degree of linguistic development (Wechsler, 2010).

Comprehension. This test has a question mode and is designed for the child to respond verbally - based on an understanding of a series of general principles and social situations - what a concept or object is good for or what is good about it. It measures concept formation and verbal reasoning, verbal expression and comprehension, the ability to evaluate and use experience, and the ability to handle practical information (Wechsler, 2010).

Results

The results were analyzed with the *Statistical Package for the Social Sciences* (SPSS), performing the following analyses: i) Shapiro Wilk normality test to define the use of non-parametric statistics; ii) the Chi-square statistic was used to evaluate the sociodemographic variables, specifically the total household income and gender of the participants, in relation to two groups of children, with and without musical training; and iii) the mann Whitney U statistic was used to analyze the quantitative variables, corresponding to the parents' schooling and the individual income of the father and mother; adding the subtests of working memory and verbal comprehension performed by the participants.

Results analysis of sociodemographic data. No significant differences were found between groups in age (U = 169.5, p = 963), father's schooling (U = 133.5, p = 221), mother's schooling (U = 143.5, p = .359), father's income (U = 171, p = 1.0), mother's income (U = 159.5, p .699), or total income(U = 159.5, p = .723). Nor were differences found in relation to children's gender (X^2 = .232, p = .630) or parent-reported work (X^2 = 8.9, p = .254). These data allow us to affirm that both samples were similar.

Statistical analysis sub MO and CV tests

Working memory.

Significant differences were found between groups, with better performance by the music-trained group in direct digits ($U = 38.5$, $p < .0001$), inverse digits ($U = 51.5$, $p < .0001$), not so in letters and numbers ($U = 126.5$, $p = .172$), or Corsi cubes ($U = 170.5$, $p = .985$). The results are shown in Figures 1, 2, 3, and Table 8.

Figure 1. Direct Digits

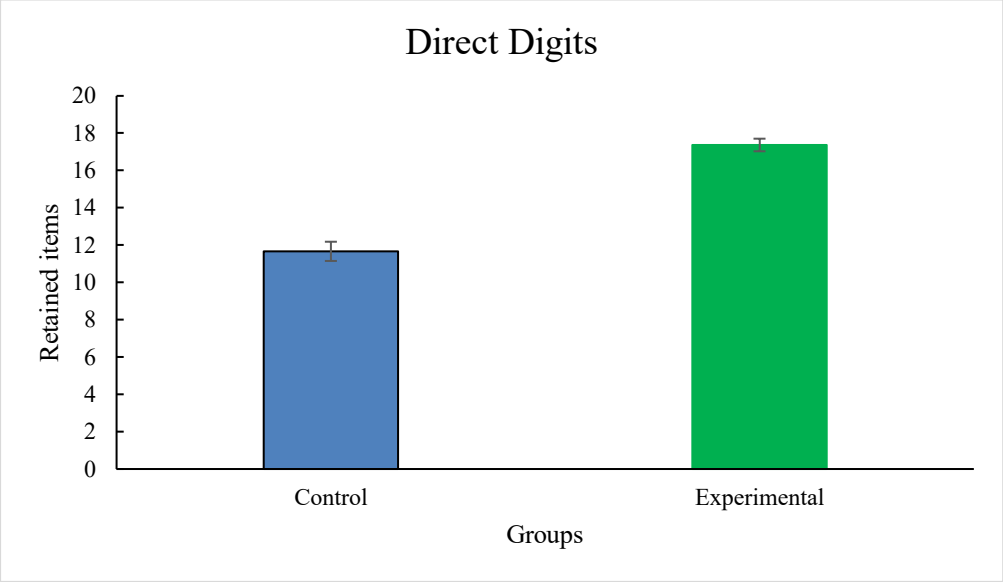


Figure 2. Inverse Digits

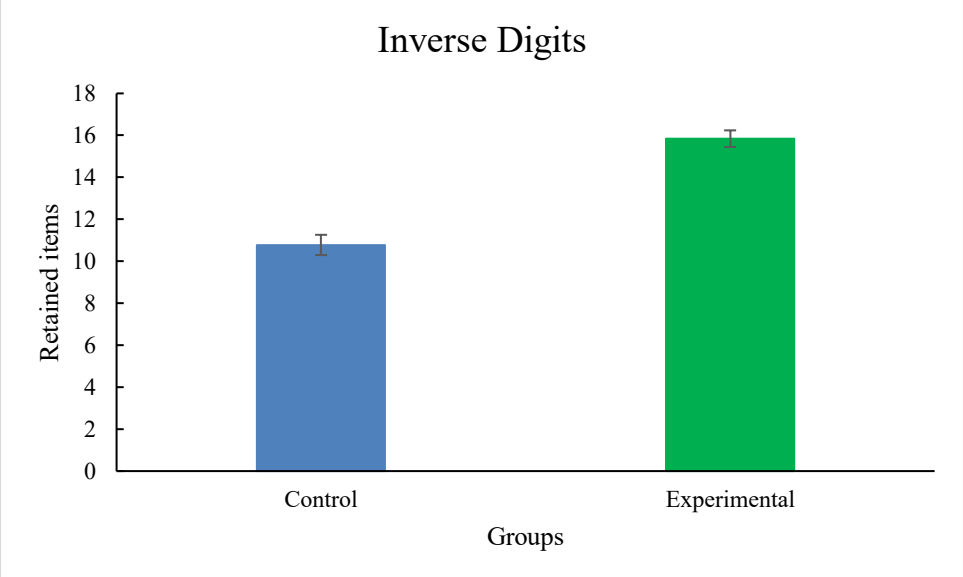


Figure 3. Letters and Numbers

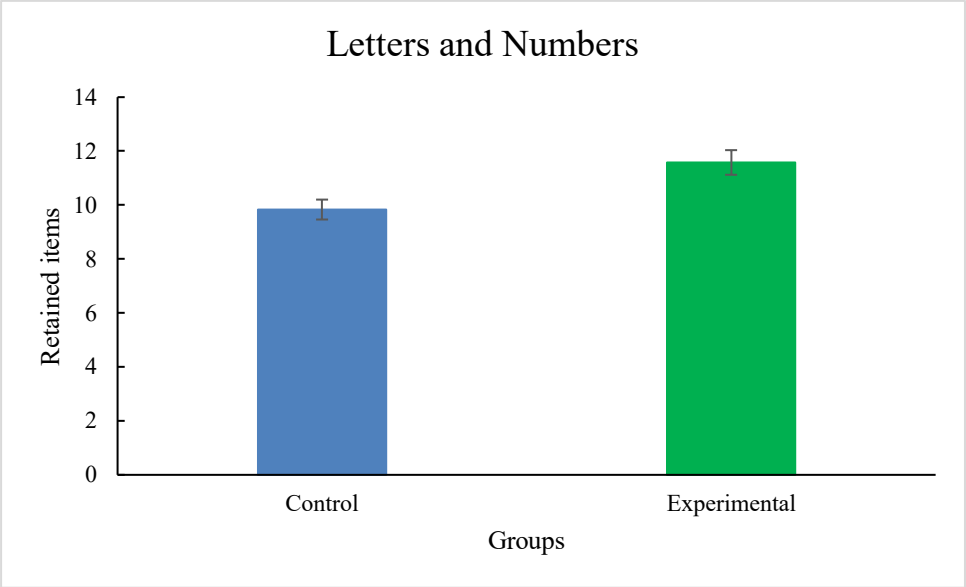


Table 8. Corsi Cubes

Training musical	N	Average range	Sum of ranks
Boys and girls (1)	18	19.03	342.5
Boys and girls (2)	19	18.97	360.5
Total	37		

(1) Without musical training; (2) With musical training

Verbal Comprehension.

In relation to this item, differences were found in similarity ($U = 52$, $p < .0001$), vocabulary ($U = 34.5$, $p < .0001$) as well as comprehension ($U = 43.5$, $p < .0001$) in favor of the group with musical training. The results are shown in Figures 4, 5, and 6.

Figure 4. Similarities

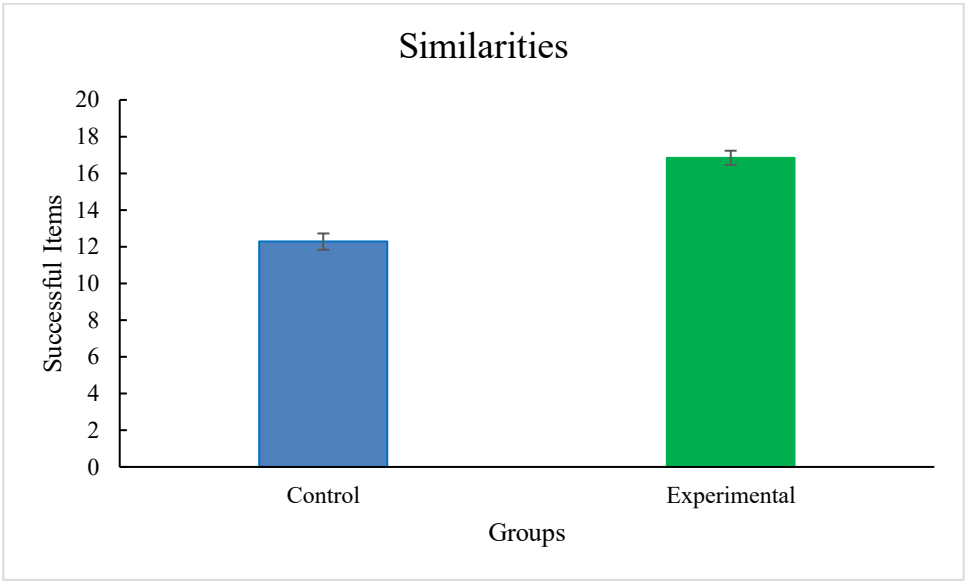


Figure 5. Vocabulary

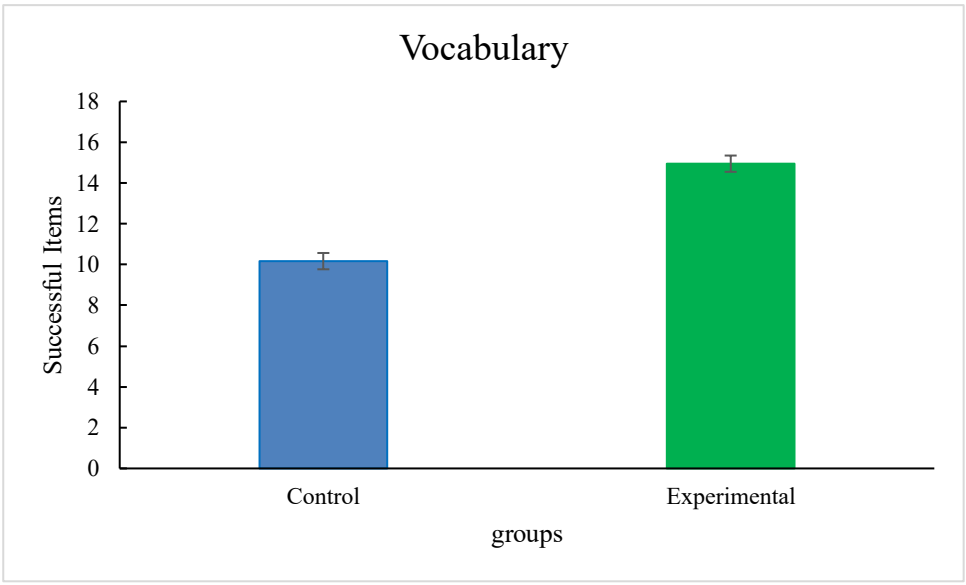
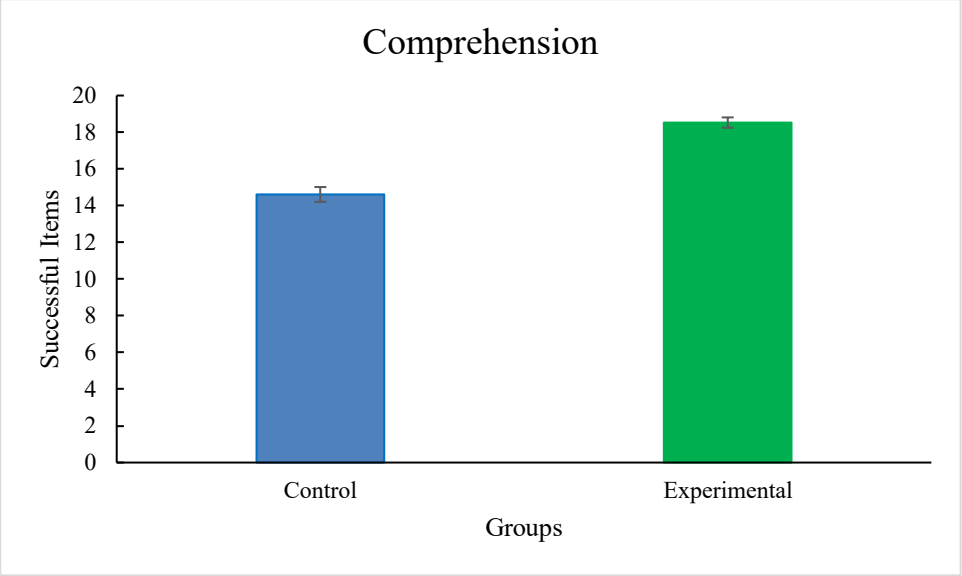


Figure 6. Comprehension



Discussion and Conclusions

In the specific objectives of this cross-sectional research, the performance of working memory was measured, analyzed and compared, specifically in auditory information retention tasks (digit retention task) and visuospatial information retention tasks (Corsi Cubes test). Verbal comprehension was added specifically in similarity, vocabulary and comprehension tasks. The results obtained in the data analysis showed that the adolescents with musical training had a better handling of direct and inverse digits compared to those without musical training, with no results in the Corsi cubes, so that musical training possibly does not affect visuospatial skills.

Transfer of Skills

Within the theoretical framework, the most important finding is the effects of musical learning and training on the transfer of knowledge to non-musical skills. Mainly, musical training has been associated with an increase in operative skills, verbal working memory and executive functions, due to the inhibition and cognitive control required by the skill of a musical instrument (Medina & Barraza, 2019; Moreno & Farfán, 2015); in addition, it also adds to the development of working memory in auditory information (verbal and auditory; Roden et al, 2012; Taylor & Dewhurst, 2017).

For example, in previously presented antecedents in preschool populations, music lessons and music practice, whether vocal or instrumental, have been found to positively affect verbal working memory skills in vocabulary growth and melody learning (Kim et al, 2018), while, in children and adolescents, greater general and domain-specific cognitive development, such as IQ (Roden et al., 2014) and verbal working memory (Alonso, 2017), has been seen. In addition, music is a training that enhances and flexes executive functions in the operative development of these non-musical skills, allowing the positive effects to extend across a wide range of intelligence skills (Vaquero et al., 2020).

Working Memory and Executive Functions

In working memory and executive functions, beneficial effects of musical learning and training on knowledge transfer to non-musical skills have been reported in several domains of general and specific intelligence (Miendlarzewska & Trost, 2014). In a working memory analysis, studies that measured visuospatial and verbal skills selected Wechsler tests for this type of assessment (Alonso, 2017; Francoise et al., 2012; Linnavalli et al., 2018; Moreno et al., 2012; Roden et al., 2012; Schlaug et al., 2005) with only one evidence of a distinct selection of batteries, also with findings of greater working memory in children with musical training (Cohrdes et al., 2018). Those who evaluated working memory and verbal comprehension, used vocabulary and comprehension tests, finding favorable results and associated with auditory and operative effects of musical training (Alonso, 2017; Degé et al., 2011; Francois et al., 2012, Roden et al., 2012).

Phonological Ability

Phonological ability and in general learning that depends on auditory is related to the development of multimodal skills of working memory (Alonso, 2017), considering that it is not possible to develop phonological ability and operational type skills without cognitive or inhibitory control of executive functions, since it is an essential function in working memory performance (Diamond, 2013). Therefore, musical training operates auditory information as auditory training, achieving higher performance and sub-vocal, vocal and phonological production in auditory tasks. As a transfer of knowledge, phonological skill is considered a close transfer, because it is in the same domain as musical, articulatory and auditory learning. The development of short auditory elements, such as auditory discrimination or recognition, is highlighted (Miendlarzewska & Trost, 2014).

Attention

On the other hand, in the attention, both Barbaroux et al. (2019), Bugos and DeMarie (2017), Degé et al. (2011), Francois et al. (2012), Jurado (2016) Linavalli et al. 2018 as Sportsman (2011), selected the NEPSY test for evaluation, without finding any favorable results that can be associated with musical learning or training in these tests. Generally, attention has been related to the cognitive development of the child's growth, since the older the child is, the more likely it is to find favorable performance in the participants, so it was not a skill that was presented as important in the theoretical or methodological background of this research.

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