

# Music therapy intervention for memory, attention, and language in children with dyslalia

## *Intervención musicoterapéutica para mejorar la memoria, atención y lenguaje in niños con dislalia*

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### Abstract

Dyslalia is a language disorder that is present in a wide percentage of children. This work proposes an intervention protocol in music therapy to improve attention, memory, and language for children with the dyslalia disorder. A confirmatory mixed-method design composed of two studies was conducted: the first included a quantitative and pre-experimental design with a sample of 20 children aged between 5 and 8 years ( $M_{age}=6.45$ ,  $SD=1.23$ ) diagnosed with dyslalia. The second study used a qualitative confirmatory methodology, where participants' parents and therapists participated. Wepman's and the initial Luria pre- and post-tests measurements were applied. The results of the pre-experiment found statistically significant improvements in verbal regulation  $t_{(19)}=-5.03$ ,  $p<.001$ ,  $d=.76$ , attention  $t_{(19)}=-5.05$ ,  $p<.001$ ,  $d=.76$ , and memory  $t_{(19)}=-2.88$ ,  $p=.009$ ,  $d=.55$ . In the qualitative phase, narratives were found that affirmed the positive results of the pre-experiment. Moreover, data surrounding the benefits of the music therapy intervention protocol in the improvement of cognitive processes and the relationship with previous literature that found positive results with this type of intervention are discussed.

**Keywords:** Dyslalia, Music Therapy, Memory, Attention, Language, Intervention, Treatment.

### Resumen

La dislalia es un trastorno del lenguaje que está presente en un amplio porcentaje de niños. Este trabajo propone un protocolo de intervención en musicoterapia para mejorar la atención, la memoria y el lenguaje de los niños con dislalia. Se realizó un diseño confirmatorio de método mixto compuesto por dos estudios: el primero incluyó un diseño cuantitativo y pre-experimental con una muestra de 20 niños de entre 5 y 8 años ( $M_{edad}=6.45$ ,  $DE=1.23$ ) diagnosticados de dislalia. El segundo estudio utilizó una metodología confirmatoria cualitativa, donde participaron los padres y terapeutas de los participantes. Se aplicaron las mediciones previas y posteriores a las pruebas de Wepman y Luria iniciales. Los resultados del pre-experimento encontraron mejoras estadísticamente significativas en la regulación verbal  $t_{(19)}=-5.03$ ,  $p<.001$ ,  $d=.76$ , atención  $t_{(19)}=-5.05$ ,  $p<.001$ ,  $d=.76$ , y memoria  $t_{(19)}=-2.88$ ,  $p=.009$ ,  $d=.55$ . En la fase cualitativa, se encontraron narrativas que afirmaron los resultados positivos del pre-experimento. Se discuten los datos que rodean los beneficios del protocolo de intervención de musicoterapia en la mejora de los procesos cognitivos y la relación con la literatura previa que encontró resultados positivos con este tipo de intervenciones.

**Palabras clave:** Dislalia, Musicoterapia, Memoria, Atención, Lenguaje, Intervención, Tratamiento.

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### Introduction

The following research presents an analysis of the benefits of music therapy in the processes of language, attention, and memory of children diagnosed with dyslalia. These cognitive functions are the base for succeeding in the variety of activities that must be achieved in educative, personal, social, familiar, and other contexts. Hence, this study provides a description of dyslalia and studies the

benefits of music in terms of cognition performance and the processes of music therapy. Moreover, an empirical study using a mixed confirmatory methodology of two phases is presented: the first is a quantitative pre-experimental phase that analyzes the effect of a protocol based in music therapy, and the second phase is based in qualitative methodology and analyzes the narratives of parents and therapists involved in the intervention process.

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### *Benefits of Music*

Music is an essential element of a human life. As such, music has a broad relevance in most cultures worldwide, and it has been used with many different goals throughout time. Its therapeutic characteristics are very important in the use and study of music. The usage of music in a therapeutic setting is known as music therapy and allows the patient to positively change his or her cognitive organization, affective and social; it also contributes to the development of mental health, as it allows the performance of diverse cognitive and emotional processes through the utilization of the principal music elements.<sup>1-2</sup>

There is a wide literature that shows the multiple benefits that music and its elements offer within cognitive and learning processes. For instance, Wilbiks and Hutchins<sup>3</sup> carried out a study where they found that musical training through instruments helped the development of non-verbal memory. Pasioli, LaGasse, and Penn<sup>4</sup> reported that attentional abilities improve with musical stimulation. Lim<sup>5</sup> found that musical training through music therapeutic techniques improves talking production and allows the acquisition of new vocabulary.

In the field of language, which is the central focus of this research, studies have contributed evidence of music therapy as being favorable for human's linguistic abilities. Studies conducted by Herrero and Pérez,<sup>6</sup> Lim,<sup>5</sup> and Epstein, Elefant, and Thompson<sup>7</sup> found that music therapy enables the assimilation of treatment processes and enhances the development of linguistic processes in the first years of life. They have also evidenced gains in pronunciation, emotional and oral expression implicated in specific language impairments through musical stimulation.

Likewise, there have been some music therapeutic protocols within the contexts of learning and language disorders. González<sup>8</sup> used melodic resources and sound improvisation to stimulate expression and motor skills in children diagnosed with SLI (specific language impairment). On the other hand, Guevara<sup>9</sup> showed the utility of group singing and rhythmic patterns in children's social processes, occurring significant improvements in their emotional and communicative abilities from the music therapeutic intervention.

Many investigations<sup>7,10,11</sup> have reported that there are improvements in the cognitive processes during the first years of childhood development, specially if music is implemented into the scholar environment. From the musical stimulation, perceptual processes, motor skills, creativity, linguistic expression, and primary psychological processes involved in language production and comprehension are developed. This explains the relevance of implementing music therapy techniques in the treatment of neurodevelopmental disorders, such as the implicated in language, specifically in the dyslalia disorder.

### *Dyslalia*

Dyslalia is defined by Corona<sup>12</sup> as a language disorder that produces difficulties in the articulation of specific phonemes. This disorder is correlated to different cognitive processes such as attention and memory, in addition to the linguistic ones. The origin of the dyslalia is multi-causal, although most cases present a relationship with a lack of maturity in neurons and implicated processes in speech. It is known that dyslalia is more prevalent in males, as there is larger evidence found in boys aged between five and seven years, in comparison with girls.<sup>13</sup>

In terms of treatment, there is a need to establish an integral proposal that allows the stimulation of the cognitive key processes involved in this disorder, such as attention, memory, and language. Mora<sup>14</sup> affirms that language is directly related to cognitive superior processes, meaning that if speech is improving and developing, related processes will also improve, such as thinking and motor skills.

Silverman and Schwartzberg<sup>15</sup> and Moore<sup>16</sup> state that musical elements such as melody and rhythm contribute positively to emotional responses and superior mental processes. As such, there is valuable evidence of the benefits of music therapy interventions in the treatment of neurodevelopmental disorders.

### *Music Therapy Intervention*

Music therapy is defined by Haase<sup>17</sup> as the usage of musical elements to positively impact individual and group therapy processes. Odell-Miller<sup>18</sup> affirms that music therapy is a clinical discipline that could be applied in a diversity of social and therapeutic contexts, including the communitarian context, where this technique is currently most commonly applied.

Fachner<sup>19</sup> explains the relevance of music therapy within mental health and neuropsychology fields, discussing how it allows different disorders to be addressed with an integral perspective, using music as a language. From music therapy intervention, the neuronal bases implicated in emotional and superior mental processes are activated.<sup>20</sup>

From the bibliographic review and recently published studies, the benefits of music therapy intervention in superior mental functions as memory, attention, and language were identified. However, there are currently no studies that approach the music therapy interventions applied in dyslalia disorder treatment. Consequently, the present work is an important contribution to the research line of clinical psychology, neuropsychology, and music therapy intervention in the treatment of children diagnosed with dyslalia.

### *Research Hypotheses*

H1. Music therapy intervention protocols will increase the scores of memory, attention, and language in

children diagnosed with dyslalia, in comparison with the scores obtained in the pre-intervention test.

H2. The benefits of music therapy intervention protocols will be identified from involved parents and therapists' narratives in the treatment process.

## **Method**

### *Sample*

The sample was composed of 20 children diagnosed with dyslalia aged between 5 and 8 years ( $M_{age} = 6.45$ ,  $SD = 1.23$ ), who attended language therapy at least twice a week. Each participant was a student between first and third grades of basic education and was schooled in the educative system of Quito, Ecuador. 40% belonged to first grade, 30% to second grade, and 30% to third grade. 14 of the participants were males (70%) and 6 were females (30%). It is important to mention that most of the participants were diagnosed with functional dyslalia, and only 10% of participants were diagnosed with dyslalia because of hearing impairments.

### *Research Design*

For the present investigation, a confirmatory mixed-method design composed of two studies was conducted. In the first phase, a quantitative pre-experimental study was carried out, as well as pre- and post-tests measurements were analyzed to obtain the effect of intervention data. The second phase was based in a qualitative study through in-depth interviews with parents, primary caregivers, and therapists; their perception was analyzed through the narratives given. It is important to highlight that participants were not randomly selected.

### *Data collection techniques*

This study used the Wepman test of auditory discrimination adapted to the Spanish. This test allowed us to determine the child's capacity to recognize phonetic differences through word pairs that are similar or equal by mode and articulation point. This instrument must be applied individually and for children aged 4 years and older.<sup>3</sup> Wepman's test is used to assess the development of phonetic-phonematic discrimination in children. It is mostly applied in children presenting learning difficulties to detect developmental problems that could provoke disorders such as dyslalia, dysgraphia, or dyslexia.<sup>3</sup>

The study also employed Luria's subtests from the initial Luria test. This test assesses superior neuropsychological functioning through 14 subtests that approach executive functions such as language, processing, and memory in children from the age of 4. This instrument must be applied individually and takes approximately 60 minutes to complete.<sup>21</sup>

The sub-scales used focused mainly on the linguistic functions, memory, and attention as the language regulator, such as verbal regulation (attention) to name objects and drawings, phonemic hearing, vocabulary in images, similarities and differences, drawings' and colors' denominations, and verbal and visual memory.<sup>21</sup> Finally, in the qualitative phase, in-depth interviews with each participant's parents and therapists were carried out. The goal of this procedure was to obtain a wider and complete perspective of the possible changes in memory, attention, and language demonstrated by participants diagnosed with dyslalia after the music therapy intervention.

### *Music Therapy intervention protocol for language, memory, and attention stimulation*

The following music therapy intervention was implemented during 10 therapy sessions divided into two sessions of 30 minutes per week. The protocol's objective was to stimulate and positively influence children diagnosed with dyslalia in language, memory, and attention processes

The music therapy intervention protocol was realized based on broad theoretical evidence that presents musical elements as therapeutic tools within superior mental processes affected in the dyslalia disorder. Likewise, musical pieces used were chosen to rely on their elements such as melody, harmony, and rhythm; these elements had to be simple to process based on the assessed participants' developmental stage.

During the first two sessions, participants engaged in active listening of classic non-lyrics musical pieces to allow them to activate their attention and phonetic perception through simple sounds. It is important to highlight that these sessions were focused on children's relaxation and establishing rapport with the evaluator. Subsequently, during the 3rd and 4th sessions, nursery rhymes with lyrics were used, which allowed the usage of vocalic techniques through singing to stimulate articulation and adequate breathing when talking. The following sessions (5th and 6th) focused on articulation and the implementation of vocalization techniques in the development of phrases that could be used in conversational language

Finally, during the last sessions (7, 8, 9 and 10), rhythm patterns to stimulate attention, memory, and psychomotricity were used. At first, in order to obtain children's active participation, the patterns only required the use of their bodies (hands, snaps, march, etc.). Afterward, in the last two sessions, musical instruments for stimulating simultaneous processes, such as memory, attention, and language were used. Other processes, such as psychomotricity were also involved.

**Tabla 1:** Music therapy program.

| # Session | ACTIVITY  | OBJECTIVE   | TIME       | MATERIALS   |
|-----------|---|---|------------|---|
| 1         | Active listening to music pieces.   | To activate attention, and to stimulate phonetic perception.<br>Work in relaxation. | 30 minutes | -Audio concert for piano No. 21 Wolfgang Amadeus Mozart, to stimulate attention and perception of melody, harmony and rhythm.<br>-Speakers.   |
| 2         | Active listening to music pieces.   | To activate attention, and to stimulate phonetic perception.<br>Work in relaxation. | 30 minutes | -Sonata audio for piano No. 8 Wolfgang Amadeus Mozart, to stimulate attention and perception of melody, harmony and rhythm<br>-Speakers   |
| 3         | Syllables' repetition from a musical piece with lyrics.   | To stimulate articulation and work on breathing.                                    | 30 minutes | -2 Nursery rhymes based on farm animals' stories (example: Lola the cow), to stimulate perception, language articulation, and breathing.<br>-Speakers   |
| 4         | Syllables' repetition from a musical piece with lyrics.   | To stimulate articulation and work on breathing.                                    | 30 minutes | - 2 Nursery rhymes based on vowels to stimulate attention, language articulation, an adequate vocalization, breathing and memory.<br>- Speakers   |
| 5         | Word/ sentences repetition from a musical piece with lyrics.  | To stimulate articulation and language by imitation.                                | 30 minutes | - 2 Nursery rhymes based on animals' stories (example: little elephants) to stimulate perception, attention, articulation, language imitation, and memory.<br>- Speakers  |
| 6         | Word/ sentences repetition from a musical piece with lyrics.  | To stimulate articulation and language by imitation.                                | 30 minutes | - 2 Nursery rhymes based on animals' stories (example: Lil Butterfly) to stimulate perception, attention, articulation, language imitation, and memory<br>- Speakers  |
| 7         | Imitation of rhythm patterns with body usage.   | To stimulate attention and psychomotor skills.                                      | 30 minutes | -2 Nursery rhymes based on animals' or objects' stories (example: Twinkle, Twinkle Little Star) to stimulate attention, vocalization, articulation, memory and motor skills.<br>- Speakers<br>-Clapping   |
| 8         | Imitation of rhythm patterns with body usage.   | To stimulate attention and psychomotor skills.                                      | 30 minutes | -2 Nursery rhymes based on animals and children stories (example: Let's play in the forest) to stimulate attention, vocalization, memory and motor skills.<br>- Speakers<br>-Clapping   |
| 9         | Usage of music instruments that allow patterns' repetition, and integration of singing with lyrics. | To stimulate attention, articulation, memory and psychomotor skills.                | 30 minutes | - 3 Nursery rhymes based on animals' stories, as well as following directions' songs (example: if you are happy and you know it, clap your hands) to improve language articulation, vocalization, breathing, attention, memory and motor skills.<br>- Rhythm instruments.<br>-Speakers. |
| 10        | Usage of music instruments that allow patterns' repetition, and integration of singing with lyrics. | To stimulate attention, articulation, memory and psychomotor skills.                | 30 minutes | -3 Nursery rhymes based on animals' stories, as well as following directions' songs (example: if you are happy and you know it, clap your hands) to improve language articulation, vocalization, breathing, attention, memory and motor skills<br>-Rhythm instruments.<br>-Speakers.    |

### Procedure

Once the theoretical research was conducted, it was necessary to obtain the parental and therapists' permission to apply the instruments and execute the music therapy intervention protocol, and to conduct the in-depth interviews with them. Further, participants were invited to collaborate with the study, and it was necessary to obtain their signature in a written document as a proof of consent. The researchers explained to the participants their rights as voluntary and anonymous participants, the objectives of the research, characteristics, and instruments to be applied. Further, every applied procedure was made in conjunction with Helsinki's standards for research with human beings. Throughout this research, the physical and psychological health of every participant was protected.

Subsequently, the application of instruments took place. To complete this procedure, the Wepman<sup>3</sup> test of auditory discrimination and the initial Luria test<sup>21</sup> were applied to every participant to assess their memory, attention, and language before the application of the intervention protocol. Further, the protocol of music therapy intervention was applied and realized during children's assistance to their language therapy along 10 therapeutic sessions through active and passive participation. Its objective was to stimulate auditory discrimination, activate memory, and attention, and to improve verbal articulation.

In addition to the application of the music therapy intervention protocol, Wepman's test of auditory discrimination and the initial Luria test were applied once again. The obtained results allow identifying changes in participant's memory, attention, and language from the music therapeutic stimulation. In-depth interviews with participant's parents and therapists were also carried-out with the intention of obtaining a wider perspective about the research results and the efficacy of the music therapy intervention protocol. Finally, the statistical analysis was conducted using the SPSS software version.<sup>23</sup> Qualitative

data from parents and therapists' narratives plus clinical observation were analyzed throughout the investigation.

## Results

### Study 1. Quantitative Research I: Pre-Experiment

In this first study, an intervention with a pre-experimental design was executed, since a control group was not available. Table 2 presents the descriptive statistical data obtained from the pre- and post-tests, the comparison between these two measurements, its significance, and effect size.

Once the statistical data analysis was completed, statistically significant differences were found in auditory discrimination differences, auditory discrimination alike, verbal regulation, objects and drawings, phonemic audition, vocabulary in images, similarities and differences, drawing and colors' denomination, and visual memory. Meanwhile, statistically significant changes were not found in the verbal memory variable.

Figure 1 presents, graphically, the comparison of pre and post-tests results obtained.

### Study 2: Qualitative Investigation

In this section, qualitative data obtained from participants' parents, primary caregivers, and therapists' narratives are presented. The information obtained from the clinical observation made during the application of the music therapy intervention protocol is also discussed. These narratives' analyses were based on an open codification procedure to identify each narrative that arose from the conducted in-depth interviews.

### Benefits of Music

In their narratives, the children's parents and caregivers indicated that they considered music as a key factor in their children's learning process. They expressed enthusiasm about the investigation since these types of inter-

**Table 2:** Descriptive Statistics

|                                     | Pre -Test |           | Post -Test |           | <i>t</i> (sig) | <i>d</i> |
|-------------------------------------|-----------|-----------|------------|-----------|----------------|----------|
|                                     | <i>M</i>  | <i>SD</i> | <i>M</i>   | <i>SD</i> |                |          |
| Cognitive Functions                 |           |           |            |           |                |          |
| Auditory Discrimination Differences | 18.10     | 5.42      | 14.35      | 6.94      | -6.37 (< .001) | .83      |
| Auditory Discrimination Alike       | 6.70      | 2.15      | 4.60       | 3.74      | -4.47 (< .001) | .72      |
| Verbal Regulation                   | 9.55      | 2.23      | 7.55       | 3.18      | -5.03 (< .001) | .76      |
| Objects and Drawings                | 17.15     | 1.69      | 16.30      | 2.40      | -3.48 (< .001) | .62      |
| Phonemic Audition                   | 11.50     | 1.96      | 9.75       | 2.89      | -4.27 (< .001) | .70      |
| Vocabulary in images                | 17.00     | 2.00      | 15.75      | 2.71      | -5.00 (< .001) | .75      |
| Similarities and Differences        | 4.95      | 2.43      | 4.10       | 2.71      | -4.07 (< .001) | .68      |
| Drawing' Denomination               | 65.95     | 6.20      | 60.85      | 6.38      | -5.59 (< .001) | .79      |
| Colors' Denomination                | 72.60     | 6.66      | 67.70      | 6.85      | -5.05 (< .001) | .76      |
| Verbal Memory                       | 21.90     | 7.01      | 21.15      | 7.05      | -1.92 (.07)    | .40      |
| Visual Memory                       | 5.85      | 2.43      | 5.05       | 3.17      | -2.88 (.009)   | .55      |

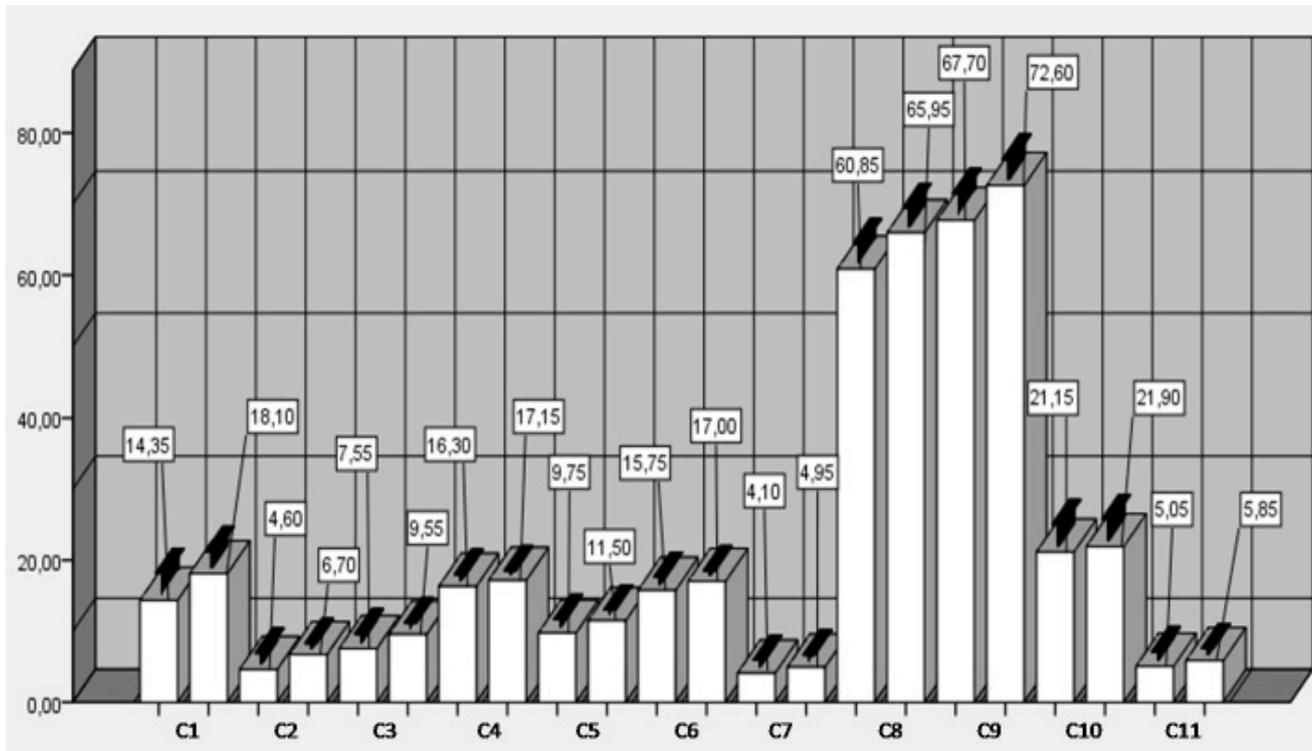


Figure 1: Comparisons: pre and post test

Note. Differences between pre and post-tests are presented. C1: Auditory discrimination differences, C2: Auditory discrimination alike, C3: Verbal regulation, C4: Objects and drawings, C5: Phonemic audition, C6: Vocabulary in images, C7: Similarities and differences, C8: Drawing's denomination, C9: Colors' denomination, C10: Verbal memory, C11: Visual Memory.

ventions encourage their children to be highly motivated. They also affirmed that they have observed changes in their children's behavior since the beginning of the application of the music therapy intervention protocol. They reported that their children were more flexible and receptive to orders or directions given to them. One participant's mother, age 39, affirms: "I see him more peaceful since the intervention began, I think he is more well-behaved now."

An important characteristic that most of the participants' parents and caregivers' narratives present is motivation. They consider their children to be more motivated to assist in the therapy and to realize the activities presented during the music therapy intervention protocol. One participant's mother, aged 34 years, stated that her son "talks a lot about music at home and is happy when he has to go to therapy to listen to music. When we got out home, he is singing the elephant's and Lola the cow songs."

Likewise, from the clinic observation, it was possible to see behavioral positive changes and an easy assimilation of the therapeutic process. Participants demonstrated enthusiasm when waiting for the moment of the protocol intervention, repeating by singing the learned songs and making phrases, exercising like this their articulation, and activating different areas of their brain.

#### Linguistics changes

In relation to changes in linguistics presented by the participants, the group of language therapists affirmed that a significant positive change occurred. Therapists assure that the rehabilitation process of children that participated in the intervention has been assimilated with higher speed and efficacy. "When children come to therapy always improve, although, I think that music has helped them to assimilate in a better way to the process," stated the language therapist, aged 53 years.

Additionally, parents pointed out that there have been changes in their children's language and pronunciation, affirming that their language is more spontaneous, conversational, precise, and clear; as 27 years old mother of a participant mentioned, "now it is possible to understand what my child is saying, before, just myself was able to understand." In the clinical observation, a significant improvement in the participants' verbal language was identified. Their articulation and vocabulary benefited from the implementation of the music therapy intervention protocol; they used musical pieces with lyrics that assisted with the repetition of words and phrases, allowing them to use their conversational language fluidly.

### *Changes in memory and attention*

Referring to memory and attention in participants' processes, therapists' work-team consider there is an observable change in these neuropsychological processes, since children are seen as more attentive, concentrated, and less avoidant to realize specific tasks. For instance, one participant's therapist, aged 45 years, stated, "*sustained attention and memory processes have improved, before the intervention, they could evoke 6 cards, now, they can retain.*"<sup>10</sup> *These processes always improve after a time of rehabilitation, but, in these participants, specifically, have improved pretty fast.*"

On the other hand, parents' responses were less precise. Those who did not consider a significant change in these processes, perhaps, had little knowledge about mild signs of cerebral functioning and neuropsychology. One participant's father, age 39, stated "*I see him alike the same, he stills not listening to my directions when I ask him to make his homework, and forgets to copy in his diary the homework asked in class.*"

In the clinical observation, a significant change from the application of the music therapy intervention, mainly in sustained attention and visual memory, was evidenced. Participants showed higher enthusiasm and concentration when realizing the tasks within the therapeutic process and along with the application of the post-tests. Finally, parents, primary caregivers, and therapists involved conceived the music therapy intervention as a necessary element to keep stimulating and developing children's cognitive processes and as a complement to their usual therapeutic process.

### **Discussion**

This investigation elaborated on a music therapy intervention protocol applied in the therapeutic process of 20 children diagnosed with dyslalia. The music therapy intervention was executed throughout five weeks divided into two sessions of language therapy per week. This generated significant positive changes in attention, memory, and language processes that are involved in dyslalia. To explain these changes, results of the two conducted studies are analyzed. The first one was a quantitative pre-experimental study that took into account the punctuation obtained from the psychometric tests applied (Wepman's and Initial Luria tests) before and after the intervention. On the other hand, the second study was a qualitative one, and the improvements were evidenced by parents' and therapists' narratives, given in the in-depth interviews. According to the obtained results, we consider it is important to implement musical stimulation and the music therapy intervention protocol to treat dyslalia as a complementary or primary treatment.

This research is important within clinical psychology, neuropsychology, and language disorders. From the appli-

cation of the music therapy intervention protocol, there was evidenced an improvement in language and memory and attention processes, which are affected in the dyslalia disorder and other learning disorders. Likewise, musical stimulation is considered an important factor that facilitates the assimilation of therapeutic processes; in the case of dyslalia, it is mainly focused on linguistics development.

From the obtained results of the comparison between the pre- and post-tests, statistically significant changes were identified in the language process related to the analyzed scales: auditory discrimination, objects and drawings' denomination, phonemic audition, vocabulary in images, similarities and differences, drawings' denomination, and colors' denomination. This indicates that children benefited from this intervention and experienced improvements in phonetic discrimination, articulation, and oral expression that are involved in the linguistics process.

Also, attention and memory processes revealed significant changes from the analysis of the pre- and post-tests measurement concerning the verbal regulation and visual memory scales; there is evidence that attentional, behavioral, and retention processes involved in linguistics development were benefited by the music stimulation. The verbal memory scale did not show any significant change; consequently, it is important to add more time for the application of the intervention protocol and to continue with the research related to music therapy and the development of verbal memory.

Results obtained are according to several studies that propose music therapy as a clinical innovator tool that facilitates cognitive development. There is an interest in studying the positive influence of music in children's brains and cognitive processes. For example, an investigation presented by Krauss and Galloway<sup>23</sup> concluded that elements such as melody and singing intonation allow improvements in vocabulary, verbal imitation, and pronunciation of children with linguistic difficulties.

Other studies, including those conducted by Jeong and Lesiuk<sup>23</sup> and Moore,<sup>16</sup> also coincide with the results found in our investigation. They stated that music therapy intervention and musical stimulation allow the activation of different brain structures involved in superior mental processes, such as the memory, attention, language, and motor skills. At the same time, elements of music used in a therapeutic context allow the neuronal activation that intervenes into the emotional regulation, which, in turn, is related to human beings' cognitive development.

Recently published investigations, at the same time, report that musical stimulation is beneficial within neuropsychology and childhood disorders. For example, Brancatisano, Baird, and Forde<sup>24</sup> affirm that music has a great therapeutic impact on several disorders and diseases such as Alzheimer, Parkinson, Autism, and Stroke. This is because, through its elements, the music encompasses

every human plane: the cognitive, individual and social. Likewise, Dvir, Lotan, Videman, and Elefant<sup>25</sup> attribute to music therapy the capacity to create rhythmic patterns that help with the formation of new social links, new manners of communication, and the potentiation of motor skills' development.

Besides previous postulates that support the results presented, we would like to provide an additional explanation taking into account the neuroplasticity concept. This refers to the brain's capacity to form new neuronal connections to adapt itself to the diverse environments' changes. Neuroplasticity is presented highly in early childhood. Music enables raising neuronal plasticity, which permits higher improvement of social, emotional, and cognitive structures<sup>26,27</sup>. Thus, the differences found in the pre- and post-tests of this research would be explained by the musical intervention plus neuroplasticity that allowed improvements in participants' attention, language, and memory performance.

One limitation of our research is the size of the sample, because the number of participants is small and the participants are located in one specific Latin American city. This must be taken into consideration during the results' interpretation and generalization. However, this fact motivates us to continue generating research with an increased number of participants and in many other cities. In doing so, we aim to contribute to the research line of music therapy.

The present investigation intends to open the door for future studies related to the benefits of music stimulation and the music therapy intervention on several learning and language disorders. Moreover, we hope this can also incorporate other psychological disorders involving cognitive, language, memory, and attention processes.

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