

Cognitive Auditory Training: Comparative Impact of Telerehabilitation and In-person Training

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Doi: <https://doi.org/10.56769/ijpn09303>

Abstract

Background: Cognitive auditory approach has been shown effective in assessment and intervention with children with Central Auditory Processing Disorders (CAPD). **Objective:** To compare the intervention methods: telerehabilitation for synchronous auditory training through an Online Cognitive Auditory Training Program, with the traditional rehabilitation method, called acoustically controlled auditory training, carried out in person in an acoustic booth. **Methods:** The sample included 23 children between the ages of 7 and 9, of both genders, living in the state of São Paulo, Brazil, who were divided into two groups: Group I - 13 children undergoing telerehabilitation and Group II - 10 children undergoing auditory training in an acoustic booth. The instruments used were: i) Pediatric Speech Intelligibility (PSI) test in the ipsilateral competitive messages (ICM condition); ii) Digit Dichotic (DD) in binaural integration and separation skills test in auditory separation and integration skills. **Results:** In this study the following results were: a) there were statistically significant differences in the performance of children who underwent telerehabilitation for CAPD, revealing the reliability of the method, b) there were statistically significant differences both in the effect of auditory training carried out through telerehabilitation and in the effect of auditory training carried out in person, proving that the effectiveness of the two methods is equivalent, c) there were statistically significant differences in the performance of school-age students with CAPD who used the Online Cognitive Auditory Training Program, showing that the cognitive auditory approach is effective in intervention with children with CAPD. **Conclusion:** There is efficacy in cognitive auditory training through the telerehabilitation intervention. Results shown that intervention through the Online Cognitive Auditory Training Program support student learning and communication skills.

Keywords: Auditory Processing, Cognitive Auditory Training, Telerehabilitation, Central Auditory Processing Disorders (CAPD).

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Vendruscolo, V., Cruz-Santos, A., & Morgado, J. (2023). Cognitive Auditory Training: Comparative Impact of Telerehabilitation and In-person Training. *International Journal of Psychology and Neuroscience*, 9(3), 25-38. Doi: <https://doi.org/10.56769/ijpn09303>

Introduction

Telerehabilitation in audiology, more specifically for Central Auditory Processing Disorders (CAPD), is a recent practice in Brazil. Although telerehabilitation gained momentum after the start of the COVID-19 pandemic and is an important relationship tool imposed by social distancing, preliminarily, the study on telerehabilitation was thought of as a way of bridging the gap between patient and specialist in Brazil, considering "its relevant continental dimensions and its uneven distribution of speech-language professionals, which accentuates the heterogeneity of the quality and availability of the services offered", (Spinardi et al., 2009). Furthermore, telerehabilitation can offer an alternative treatment for patients living in large urban centers, even when a personal visit is not practical or feasible (American Speech-Language-Hearing Association [ASHA], 2021).

Prior to the COVID-19 pandemic, trends showed an increased interest in the use of telehealth services by both healthcare professionals and patients (American Medical Association [AMA], 2020). In addition, changes made to policies during the COVID-19 pandemic have reduced barriers to accessing telehealth and promoted the use of telehealth as a way of providing acute, chronic, primary and specialist care (ASHA; 2021; Bashshu et al., 2020). Therefore, this study involving telerehabilitation took place in this evolving scenario and proved to be providential and pertinent in the face of the new care needs established by the circumstances imposed by social distancing.

This study aims to compare the telerehabilitation method in the intervention of students with Central Auditory Processing Disorders with the traditional rehabilitation method, called acoustically controlled auditory training, carried out in person in an acoustic booth, in addition to verifying the effectiveness of

the PAC Online Cognitive Auditory Training Program available on the Online Platform, which will be described and analyzed.

Central Auditory Processing Disorders (CAPD) generally manifest themselves in the classroom and constitute a barrier to learning. These difficulties that are relative to the CAPD condition are readily apparent as: i) children show delayed responses to verbal instructions; ii) they show an inability to separate relevant content and discard irrelevant content; iii) a lack of understanding of spoken language; iv) greater difficulty in using new language; v) difficulty retaining information in short-term memory and manipulating information (i.e. working memory), which affects literacy, math, writing, listening and following instructions (for example, they may remember the last part of the message but forget the first); vi) difficulty taking notes; vii) significant difficulties in acquiring phonetic skills fundamental to reading (and spelling) due to poor representation of basic speech sounds (Chermak et al., 2017). In addition, behavior can take many forms, such as: excessive agitation; the student seems not to listen and at the same time is connected to all the sounds in the environment (e.g., pen falling, car honking); forgetfulness; difficulty understanding orders and rules; confusion when relating facts or stories and difficulty expressing themselves; grammatical errors; difficulty understanding jokes or double entendre words.); forgetfulness; difficulty understanding orders and rules; confusion when relating a fact or story and difficulty expressing themselves; grammatical errors; difficulty understanding jokes and words with double meanings; not being able to understand what they read; inverting letters when writing (b, d, p, q) and dysgraphia; alterations in some speech sounds (mainly R and L); poor school performance (Gielow, 2001).

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The CAPD assessment is a behavioral auditory assessment consisting of a battery of tests using verbal and non-verbal auditory stimuli, standardized and controlled using an audiometer. The aim of this assessment is to identify and categorize hearing impairment or dysfunction (Chermak, 2014). At the time of the assessment, which lasts approximately one hour, the patient with headphones is positioned inside the booth, receives instructions and performs the tests that assess the functions of the brainstem and brain (Alvarez et al., 2000).

Intervention should be implemented as soon as possible after diagnosis to exploit the central nervous system plasticity, maximize successful therapeutic outcomes and minimize residual functional deficits. Considering the frequent comorbidity of CAPD with language and learning disorders, it is crucial that intervention is carried out in a broad and comprehensive manner. Furthermore, it needs to be intensive, exploiting cortical reorganization and plasticity in a broad manner, maximizing generalizations and reducing functional deficits, as well as providing strong reinforcement to promote learning (ASHA, 2017, 2021).

Regardless of comorbidities, in cases of CAPD, the therapeutic indication may be auditory training in which exercises are carried out to stimulate altered hearing abilities (BSA, 2011).

According to several researchers, auditory training therapy improves the function of the central auditory system in transforming acoustic signals (Chermak & Musiek, 2002). This form of therapy is the most suitable for the rehabilitation of CAPD, as proven by various studies and research, because it is a therapy based on the principles of neuroplasticity.

Specific auditory training techniques can positively influence the auditory processing of children with learning and language disorders (Musiek, 1999).

A child diagnosed with CAPD - whether the disorder exists alone or comorbid with another disorder in another domain - should receive deficit-specific hearing interventions (Chermak, 2014) given the potential impact of CAPD on hearing, communication, academic success, work performance and social function, as well as the frequent comorbidity of this disorder with language-related, learning and cognitive disorders (American Academy of Audiology [AAA], 2010).

In order to carry out this study the Online Cognitive Auditory Training Program was designed to build essential cognitive skills for learning, based on studies of auditory neuroscience by Vendruscolo (2021). It is structured in categories, which must be combined in the sense of the proposed objective defined on the basis of the online assessment, with sessions organized in increasing order of complexity, namely activities with: word dichotics, sentence dichotics, frequency, rhythm and duration, auditory discrimination, prosody, phonological awareness, figure-ground, rhyme, alliteration, narrative texts by grade, informative texts, opinion texts, chronicles, think fast (lexical evocation), and varied texts. For this study, the categories used were: word dichotics, sentence dichotics, rhyming, informative texts and narrative texts. The Online Cognitive Auditory Training Program works through an Online Platform created for this study and aims to stimulate auditory pathways as well as memory, language and attention and is based on the accumulated literature of auditory and cognitive neuroscience, which supports comprehensive programming, incorporating *bottom-up* and *top-down* approaches. The Online Cognitive Auditory Training Program is made up of audio tracks and strategies selected on the basis of their clinical applicability, certified by the progress recorded in the platform file assessments and the school performance after rehabilitation.

Bottom-up intervention approaches include auditory skills training to reorganize auditory pathways and environmental modifications (AAA, 2010).

Top-down intervention approaches include core resource training, educational interventions and accommodations in the workplace, at play and at home (AAA, 2010).

According to Chermak (2016), CAPD is not a working memory, metacognition or language disorder, however, she states that the interactions between central auditory processing, cognition, metacognition and language processing offer considerable opportunities to strengthen auditory skills and maximize the efficient allocation of resources for more effective intervention.

Methods

To process the data collected, the results were statistically analyzed using descriptive and inferential statistical models, entering and analyzing all the variables in the Statistical Package for the Social Sciences (SPSS) software, version 28. This study took place between 2019 and 2020 in the state of São Paulo, Brazil, and followed the rules of the Code of the Ethics Committee of the University of Minho and the authorization of the Scientific Council of the University of Minho (dated 24.02.2020), after all aspects of confidentiality and anonymity of the data resulting from the procedures adopted by the University of Minho were ensured.

In order to take part in the research, the parents signed a consent form for the performance and/or use of test data (audiometry, impedanciometry and central auditory processing tests), treatment (carried out in 10 sessions via the web or in person, in a booth), and re-evaluation of the tests. The consent form provides clarification on voluntary participation, with confidential information being collected for research purposes.

Participants

Our sample consisted of 23 children living in the city of São Paulo, Brazil aged between 7 and 9, with a history of learning and language difficulties. Children diagnosed with sleep disorders, conductive hearing loss, sensorineural hearing loss or other neurological diseases and a family history of hereditary diseases, assessed by physical examination and health history, were ineligible for this study.

The children were divided into two groups: Group I - 13 children were allocated for telerehabilitation and a specific auditory training program.

Group II - 10 children were allocated for acoustically controlled hearing rehabilitation (in an acoustic booth) and a specific hearing training program.

The assessment, diagnosis and auditory training process took place in three distinct stages, described below:

First stage: the children in groups I and II underwent inspection of the external auditory canal, audiometry, impedanciometry, Pediatric Speech Intelligibility (PSI) tests with ipsilateral competitive messages (ICM condition) in the -15 ratio, and Digit Dichotic (DD), in binaural integration and separation skills.

Second stage: the children in group I underwent auditory training through telerehabilitation, while the children in group II underwent face-to-face training, in a booth, with the same exercise program.

In the third stage, the children in groups I and II were assessed with the PSI tests in the ICM condition in the -15 ratio, and DD, in the binaural integration and separation skills.

In Group I, telerehabilitation method was carried out online using an Online Platform, which was developed for this study. For this study, we used the PSI and Digit Dictode (DD) tests in both the auditory integration stage (AIS) and the auditory separation stage (ASS).

Different types of dichotic tests are presented in the international literature, but in this study we opted to use the Digits Dichotic test (Musiek, 1983), adapted for Brazilian Portuguese (Pereira & Schochat, 1997), as it showed a specificity of 100% and a sensitivity of 66% in research carried out in Brazil (Pereira, 2005). A comparison of behavioral tests (test and retest) for assessing the central auditory processing of primary school children showed that the test with the greatest sensitivity for detecting changes in auditory skills was the Digits Dichotic and proved to be the most suitable for screening children who should be referred for a full assessment (Sartori et al., 2020).

A study carried out by the Laboratory of Speech and Hearing Research in Auditory Processing at the Faculty of Medicine of the University of São Paulo concluded that the PSI and DD behavioral tests were reliable among the tests investigated, as they showed no statistically significant difference between their presentations in the test and retest situations (Frasca et al., 2011).

Procedures to collect data

All the recorded material included in the Program was developed for this study. The audio tracks were recorded and treated by the examiner to eliminate background noise and optimize the quality of the voice, using the tools in the Audacity system itself, and then sent to a professional studio to check the quality.

The material used during the different intervention sessions was developed and adapted to meet the specific objectives outlined for each session. In addition, the material was carefully designed, selected and adapted by the therapist for the age group for which it was intended.

The material consists of:

- tasks with dichotic words (words presented simultaneously in the right and

left ear) with presentation levels between them: 0, -15 and -20;

- tasks with dichotic sentences (sentences presented simultaneously in the right and left ear) with presentation levels between them: 0, -15 and -20

- stories with interferers in the same or opposite ear.

The content of the Cognitive Auditory Program (used for both face-to-face and online intervention) mentioned above is based on the accumulated literature of auditory and cognitive neuroscience, which supports comprehensive programming, incorporating bottom-up (auditory training) and top-down (cognitive, metacognitive and language strategies) approaches (21-22).

In certain tasks, recordings were used at ratios of 0, -10, -15, -20 and -25, contra and ipsilateral sound/interference (in the opposite ear or in the same ear), allowing the volume of the ear in lag to be increased, with the aim of improving selective attention, defined as the ability to direct attention to a particular auditory stimulus while ignoring the others, in the presence of dichotic listening.

The material used during the different intervention sessions was developed and adapted taking into account the specific objectives outlined for each session. In addition, the material was carefully designed, selected and adapted by the therapist for the age group for which it was intended.

The content of this material aims to improve sensory perception of the acoustic signal and stimulate cognitive and linguistic skills, such as memory, attention, lexical access, listening comprehension and interpretation, so that they can be incorporated into everyday communication.

To this end, it employs *bottom-up* and *top-down* strategies focused on developing the auditory skills of vigilance, auditory localization, localization, discrimination, association, temporal processing and auditory integration through strategies of directed listening, figure-

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ground, analysis and synthesis of information, auditory closure, binaural separation, attention, inter-hemispheric integration, association, comprehension and auditory memorization.

For each child, the complexity of the material increased over the course of the auditory training respecting each child's predisposition and ability, in order to provide better auditory/cognitive conditions for favoring and improving communication skills.

Results

As shown in Table 1, children who underwent neurocognitive stimulation through telerehabilitation, through the Online Platform initially showed an average performance of 60.77 (± 21.00) on the Pediatric Speech Intelligibility in relation to the right ear in the first assessment, while in relation to the left ear the average performance was 41.54

(± 18.64). When assessed after the intervention period, it can be seen that there was a significant increase of $\pm 24\%$ ($p < 0.05$) in the average performance in relation to the right ear, while in relation to the left ear there was also a significant increase of $\pm 83\%$ ($p < 0.01$).

Children who underwent acoustically controlled auditory training in the traditional way, in an audiological booth, initially showed an average performance of 66.00 (± 16.47) on the Pediatric Speech Intelligibility in relation to the right ear in the first assessment, while in relation to the left ear the average performance was 64.0 (± 15.06). When assessed after the intervention period, it can be seen that there was a significant increase of $\pm 33\%$ in average performance ($p < 0.05$) in relation to the right ear, and in relation to the left ear there was also an increase of $\pm 31\%$, which also proved to be significant ($p < 0.05$).

Table 1

Descriptive Presentation of PSI Test Results in the S/N -15 Ratio (ipsilateral competitive messages (ICM condition) in Children Undergoing Telerehabilitation and Acoustically Controlled Auditory Training

Telerehabilitation	RE - 1ST AV	RE - 2ND AV	LE - 1ST AV	LE - 2ND AV
Minimum	0,0	30,00	0,0	30,00
Maximum	90,00	100,0	80,00	100,0
Average	60,77	75,38*	41,54	76,15**
Standard Deviation	21,00	18,08	18,64	22,93
Acoustically controlled auditory training	RE - 1ST AV	RE - 2ND AV	LE - 1ST AV	LE - 2ND AV
Minimum	40,00	70,00	40,00	60,00
Maximum	90,00	100,00	90,00	100,00
Average	66,00	88,00*	64,00	84,00*
Standard Deviation	16,47	10,33	15,06	15,06

Note. Telerehabilitation: AV - Assessment; RE - Right ear; LE- Left ear; $n = 13$ * $p < 0.05$ for comparisons between 2nd AV X 1st AV ** $p < 0.01$ for comparisons between 2nd AV X 1st AV Acoustically controlled auditory training: AV X 1st AV - Assessment; RE - Right ear; LE- Left ear; $n = 10$ * $p < 0.05$ for comparisons between 2nd AV X 1st AV.

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Looking at the results (see Table 2) obtained by the children who underwent neurocognitive stimulation through telerehabilitation, they initially obtained an average performance of 78.38 (± 15.25) in Dichotic Listening: Digit Dichotic (DDI) for the right ear (RE) (see Table 1). When assessed after the intervention developed in this study, a significant increase ($p < .05$) of $\pm 15\%$ in performance on the DDI can be seen. With regard to the left ear (LE), the children's initial average performance in the DDI was 59.62 (± 20.94). When looking at the performance after the intervention, it can be seen that the children's average performance showed a significant increase ($p < 0.01$) of $\pm 40\%$.

Looking at the results obtained by the children who underwent neurocognitive stimulation through the booth (Table 2), they initially obtained an average performance of 82.60 (± 13.18) in Dichotic Listening: Digits Dichotic (DDI) for the right ear (RE). When assessed after the intervention developed in this study, a significant increase ($p < .05$) of $\pm 11\%$ in DDI performance can be seen. In relation to the left ear (LE), the children's initial average performance in the DDI was 79.80 (± 9.98). When looking at the performance in the DDI in relation to the LE, it can be seen that the children's average performance showed a significant increase ($p < 0.05$) of $\pm 14\%$.

Table 2

Descriptive Presentation of the Results of the DDI Test (dichotic digit test of auditory integration skills) for the Group of Children Who Underwent Telerehabilitation and Acoustically Controlled Auditory Training

Telerehabilitation	RE - 1ST AV	RE - 2ND AV	LE - 1ST AV	LE - 2ND AV
Minimum	40,00	57,00	35,00	42,00
Maximum	95,00	100,0	90,00	100,0
Average	78,38	90,69*	59,62	83,62**
Standard Deviation	15,25	11,54	20,94	14,59
Acoustically controlled auditory training	RE - 1ST AV	RE - 2ND AV	LE - 1ST AV	LE - 2ND AV
Minimum	57,00	63,00	62,00	77,00
Maximum	98,00	100,00	95,00	100,00
Average	82,60	91,80*	79,80	91,40*
Standard Deviation	13,18	11,45	9,98	8,15

Note. Telerehabilitation: AV - Assessment; RE - Right ear; LE - Left ear; $n = 10$ * $p < 0.05$ for comparisons between 2nd AV X 1st AV** $p < 0.01$ for comparisons between 2nd AV X 1st AV / Acoustically controlled auditory training: AV - Assessment; RE - Right ear; LE - Left ear; $n = 10$ * $p < 0.05$ for comparisons between 2nd AV X 1st AV.

An analysis of table 3 shows that initially the children who underwent neurocognitive stimulation through telerehabilitation had an average

performance of 76.15 (± 17.22), in the first assessment in relation to Dichotic Listening: DDS for the right ear (RE), while when assessed after the intervention period

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it is possible to see a significant increase ($p<.05$) of $\pm 13\%$ in DDS performance. In relation to the left ear, the initial average performance in the DDS was 53.46 (± 24.44), and it can also be seen that in the second evaluation there was a significant increase ($p<0.01$) of $\pm 20\%$.

An analysis of table 3 shows that initially the children who underwent neurocognitive stimulation in the booth had an average performance of 71.00 (± 25.03) in Dichotic Listening: DDS for the right ear (RE) in the first assessment, while when assessed after the intervention period there was a significant increase ($p<0.05$) of $\pm 12\%$ in DDS performance.

Table 3

Descriptive Presentation of the Results of the DDS Test (dichotic digit test of auditory separation ability) in Children Undergoing Telerehabilitation and Acoustically Controlled Auditory Training

Telerehabilitation	RE - 1ST AV	RE - 2ND AV	LE - 1ST AV	LE - 2ND AV
Minimum	35.00	42.00	20.00	48.00
Maximum	90.00	100.0	90.00	100.0
Average	76.15	86.31*	53.46	74.08**
Standard Deviation	17.22	18.32	24.44	20.40
Acoustically controlled auditory training	RE - 1ST AV	RE - 2ND AV	LE - 1ST AV	LE - 2ND AV
Minimum	20,00	35,00	40,00	50,00
Maximum	100,00	100,00	90,00	100,00
Average	71,00	80,20*	70,50	84,50*
Standard Deviation	25,03	22,32	19,50	8,15

Note. Telerehabilitation: AV - Assessment; RE - Right ear; LE- Left ear; $n= 10$ * $p<0.05$ for comparisons between 2nd AV X 1st AV ** $p<0.01$ for comparisons between 2nd AV X 1st AV Acoustically controlled auditory training: AV X 1st AV - Assessment; RE - Right ear; LE- Left ear; $n= 10$ * $p<0.05$ for comparisons between 2nd AV X 1st AV.

With regard to the left ear, the initial average performance on the DDS was 70.50 (± 19.50), and it can also be seen that in the second evaluation there was a significant increase ($p<0.05$) of $\pm 12\%$.

Results from this exploratory study show that the Online Cognitive Auditory Training Program is effective (telerehabilitation method) and validates the specialized auditory training program implemented in this study.

Discussion

The data from this study show that intervention through the Online Cognitive Auditory Program proposed in this study, applied on school age children, contributes to developing and improving auditory figure-ground skills through selective attention, figure-ground skills for verbal sounds in the process of sustained attention and selective attention and binaural integration in that it exploits cortical reorganization and plasticity, maximizes

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generalization and reduces functional deficits, as well as providing strong reinforcement to promote learning (ASHA, 2017, 2021).

Analysis of each child's individual performance in the PSI test, which assesses the auditory system's ability to process complex sounds in the presence of background noise, shows variable performance after treatment, with a percentage of children ranging from 15.38% with no improvement in this skill to 7.69% of children with 80% improvement in the right ear, and a range from 7.69% of children with no improvement to 39.46% of children with 100% improvement in the left ear.

This variability of findings in individual performance was also seen in the other tests applied, DDI (dichotic digit test for auditory integration skills) and DDS (dichotic digit test for auditory separation skills). These data reinforce the idea that the complexity of the material should follow increasing degrees of difficulty, according to each individual's abilities, predisposition and capacity; and the capacity for development is variable and individual.

The audio and video system of the Online Platform was of appropriate quality for the type of clinical procedure carried out, and enabled the auditory training of the children in this study, through the implementation of the Online Cognitive Auditory Training Program.

ASHA (2017) emphasizes the importance of monitoring the individual's level of attention and effort in order to take measures to maintain motivation throughout the tests. We believe that these measures should be maintained during auditory training, because the possibility of viewing the patient in real time throughout the exercises allowed us to observe their behavior during the activities, minimized environmental interference, and promoted focused behavior to perform the exercises

through positive reinforcement and constant feedback from the evaluator.

Data of this study showed that all the children in the group (100%) who underwent telerehabilitation completed the full training program (10 sessions a week) without interruption. This rate corroborates the fact that technology can facilitate intervention in various phases (including follow-up of intervention), and furthermore increases patient adherence and engagement, improves the efficiency of services, including for individuals who are geographically close to the professional, and for whom remote care makes it possible to overcome, for example, common urban problems such as the difficulty of getting around due to traffic jams (Davoine, 2018).

According to the results, the Online Cognitive Auditory Training Program meets the main guidelines of the Brazilian resolution CFFA No. 580, of August 2020, which provides for the regulation of Speech Therapy, and states that "Speech Therapy should complement and improve existing service delivery models, strengthen integrated and person-centered services and contribute to improving population health and health equity".

Evidence was shown from this exploratory study that the Online Cognitive Auditory Training Program is effective and validates the objectives for specialized auditory training, for the exclusive use of the speech therapist with their patient, synchronously for CAPD.

As telerehabilitation is a recent practice in Brazil, there is no scientific research available to compare the data obtained in this study. However, there is evidence that teleaudiology has proven to be very successful in various healthcare practices (Ballachanda, 2019, Sabine et al., 2022), and growing evidence shows that telerehabilitation leads to similar, or better, clinical outcomes when compared to conventional interventions (Kairy et al., 2009; Sabine et al., 2022), showing

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evidence that its introduction in Brazil will also be relevant and pertinent.

This study shows that the children who underwent telerehabilitation had an increase in the percentage of correct answers in the PSI test of 24% in the right ear ($p<0.05$) and 83% in the left ear ($p<0.01$); while the children who underwent acoustically controlled cognitive auditory training in a booth had an increase in the percentage of correct answers in this same test of 33% in the right ear ($p<0.05$) and 31% in the left ear ($p<0.05$).

In everyday listening situations, accurate speech perception depends on the auditory system's ability to process complex sounds in the presence of background noise (Song et al., 2012).

There was a statistically significant increase in the DDI test in the children who underwent telerehabilitation, with an average increase in the percentage of correct answers of 15% in the right ear ($p<0.05$) and 40% in the left ear ($p<0.01$), while the children who underwent acoustically controlled cognitive auditory training in a booth had an average increase in the percentage of correct answers in this same test of 11% in the right ear ($p<0.05$) and 14% in the left ear ($p<0.05$). The percentage results of the DDS test showed a significant improvement in both groups, with children who underwent telerehabilitation showing an average increase in the percentage of correct answers of 13% in the right ear ($p<0.05$) and 20% in the left ear ($p<0.01$), while the children who underwent acoustically controlled cognitive auditory training in a booth had an average increase in the percentage of correct answers in this same test of 12% in the right ear ($p<0.05$) and 12% in the left ear ($p<0.05$).

Therefore, a comparison of the re-evaluation findings between children who underwent acoustically controlled auditory training and telerehabilitation showed that

there was a significant, statistically proven improvement in auditory figure-ground skills through selective attention, figure-ground skills for verbal sounds in the process of sustained attention and selective attention and binaural integration assessed in both groups, and that the effectiveness of acoustically controlled cognitive auditory training and telerehabilitation is equivalent. In view of this, this study is in line with Art. 7 of the regulation of teleaudiology in Brazil, which supposes the guarantee of equivalence in relation to services provided in person. Thus, through telerehabilitation, patients can improve their access to care with quality (ASHA; 2021; Gladden, 2018).

Conclusions

The results of this study show the effectiveness of cognitive auditory training through the use of telerehabilitation, which has been shown to be a highly proficient way of treating patients who live in regions lacking specialist professionals, for people who have difficulty getting around, or who live in large cities, with difficulties in incorporating treatment into their routines, and in the face of events such as the pandemic resulting from the new Coronavirus (SARS-CoV-2). In addition, telerehabilitation showed a high approval rating from 100% of the parents of the children treated for this study, through the Online Cognitive Auditory Training Program.

The analyses also show that there are statistically significant differences between the effect of auditory training carried out through telerehabilitation and the effect of acoustically controlled cognitive auditory training carried out in person, proving that the effectiveness of acoustically controlled cognitive auditory training and telerehabilitation is equivalent. Based on this finding, we can affirm that the telerehabilitation carried out through the Online Cognitive Auditory Training Program guarantees equivalence in relation

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to services provided in person, and is in accordance with Resolution CFFA No. 580, of August 2020, Art. 7, which regulates the practice of teleaudiology in Brazil.

We can conclude from this study that there are statistically significant differences in the performance of school-age children with CAPD who underwent auditory training with the Online Cognitive Auditory Training Program available for this study, proving the effectiveness of the cognitive auditory training approach used in this study. These results are in line with the literature found on the subject, which states that broad and comprehensive cognitive auditory training is effective in treating children with CAPD.

This study allowed us to verify that cognitive auditory training through telerehabilitation provides engagement and favors the frequency of auditory training. Intervention through the Online Cognitive Auditory Training Program, in the school learning phase, contributes to developing and improving auditory figure-ground skills through selective attention, figure-ground skills for verbal sounds in the process of sustained attention and selective attention and binaural integration, supporting students' learning and communication skills.

As this is an emerging line of research, not only nationally but also internationally, there are several recommendations to be made, demonstrating the extreme importance of continuing research in this area: future studies should collect data from more states in the country; extension of age groups in future studies, and longitudinal studies should be carried out with the through the Online Cognitive Auditory Training Program.

Limitations

Carrying out any research always involves limitations that may have conditioned the study in some way. In

addition to the time and financial constraints, it is important to reflect on the constraints inherent in the data collection tasks and procedures themselves and the procedures adopted throughout the study. It was our intention to turn the emergence of the pandemic into an opportunity to obtain data showing the effects of telerehabilitation in Brazil in this period. One of the limitations of this study is that data was only collected in one state of Brazil. It is recommended that future studies collect data from more states in the country.

Acknowledgments: The authors want to thank all participants for their contribution to the present study.

Funding: This work was funded by National Funds through FCT - Foundation for Science and Technology under the CIEC (Research Centre in Child Studies from the University of Minho) projects with the references UIDB/00317/2020 and UIDP/00317/2020, and funded by CIEd – Research Centre on Education, from the University of Minho, projects UIDB/01661/2020 and UIDP/01661/2020.

Declaration ethical approval: This study took place between 2019 and 2020 in the state of São Paulo, Brazil, and followed the rules of the Code of the Ethics Committee of the University of Minho and the authorization of the Scientific Council of the University of Minho (dated 24.02.2020),

Competing interests: The authors declare no conflict of interest .

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How to cite this Article:

Vendruscolo, V., Cruz-Santos, A., & Morgado, J. (2023). Cognitive Auditory Training: Comparative Impact of Telerehabilitation and In-person Training. *International Journal of Psychology and Neuroscience*, 9(3), 25-38. Doi: <https://doi.org/10.56769/ijpn09303>

Received: 16/12/2023

Revised: 23/12/2023

Accepted: 29/12/2023

Published online: 31/12/2023

ISSN: 2183-5829

ORIGINAL

Vendruscolo, V., Cruz-Santos, A., & Morgado, J. (2023). Cognitive Auditory Training: Comparative Impact of Telerehabilitation and In-person Training. *International Journal of Psychology and Neuroscience*, 9(3), 25-38. Doi: <https://doi.org/10.56769/ijpn09303>

