

EFFECTIVENESS OF FORMAL AUDITORY TRAINING IN ADULTS WITH AUDITORY PROCESSING DISORDER

A eficácia do treinamento auditivo formal em adultos com distúrbio do processamento auditivo (central)

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ABSTRACT

Purpose: to compare the performance of adults with auditory processing disorder in behavioral tests before and after formal auditory training, in order to verify the effectiveness of this approach. **Methods:** this is a quantitative retrospective study for which we selected 18 individuals with auditory processing disorders evidenced by the behavioral assessment, aged between 16 and 38 years old. All subjects underwent a formal auditory training program conducted in eight sessions of 45 minutes each, twice a week. Sessions were organized in ascending order of complexity of the listening skills such as, auditory closure, figure-ground for sentences, words, syllables and sounds and nonverbal temporal processing of sounds (analysis of the intensity, duration and frequency). For statistical purposes the results of the SSW test SSI (ICM) and Duration and frequency pattern recognition obtained before and after auditory training, considering the ear and sex variables. **Results:** there were no statistically significant differences between the right and left ears. Both men and women when analyzed separately showed better results in post-training. These differences were statistically significant in for duration and frequency pattern tests, for men and women. In SSW improvement in male and SSI R / S –15 females, respectively. In addition, all subjects reported better attention and better communicative performance after auditory training. **Conclusion:** the formal auditory training improves listening skills figure – ground for verbal sounds and temporal processing measured by behavioral tests in adults diagnosed with auditory processing disorders.

KEYWORDS: Hearing; Auditory Perception; Hearing Disorders; Neuronal Plasticity

■ INTRODUCTION

Central auditory processing disorder is characterized by difficulty analyzing acoustic signals even in the presence of preserved hearing sensitivity.¹⁻³ In adulthood, the impact of this disorder is evident in social and professional realms. Conventional language therapy does not generally include the expectations of the patient. Thus, formal auditory

training can be offered as therapy for such individuals.^{4,5}

Auditory training in individuals with altered central auditory skills stimulates hearing in such a way as to maximize the effects of the plasticity of the central nervous system.⁶⁻⁸ The aim is to improve access to auditory information so that the patient can communicate better in an unfavorable environment and improve performance on tasks that place high demands on hearing.^{9,10}

The present study is justified by the complaints of adults regarding auditory processing and the scarcity of investigations involving central auditory processing in the adult population. The aim of this study was to compare the performance of adults with auditory processing disorder on behavioral tests performed prior to and following formal auditory training to determine the efficacy of such training.

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Conflict of interest: non-existent

METHODS

A retrospective study was carried out involving patient charts selected from the Auditory Processing Clinic of the Hearing Disorders Sector of the *Universidade Federal de São Paulo/Escola Paulista de Medicina* (Brazil) between 2001 and 2007.

The following were the inclusion criteria: age 16 years or older; normal peripheral hearing (hearing threshold between 250 and 8000 Hz \leq 25 dB); abnormal result on at least one behavioral test for the assessment of auditory processing; absence of evident syndrome or cognitive disorder; and having completed formal auditory training. Based on these criteria, 18 individuals between 17 and 38 years of age were selected (9 males and nine females).

Patient histories were taken and all subjects underwent a basic hearing evaluation, an auditory processing behavioral evaluation and formal auditory training. Each subject served as his/her own control based on the stability/changes demonstrated on the auditory processing behavioral tests.¹¹ The auditory processing behavioral evaluation tests were administered before and after auditory training.

Auditory training was organized in eight 45-minute sessions held twice a week and involved the training of the following listening skills: temporal ordination, auditory closure, figure-ground for verbal and nonverbal sound on tasks of monotic and dichotic listening. The right and left ears were trained separately.¹² Figure 1 displays the chronogram of the sessions

SESSION	TEST	LISTENING SKILL	S/N RATIO	EAR
1	SSI	Figure-Ground	MCC- 0 / -40 MCI- +10 to -20	Right/Left Left/Right
2	DDT/NVD	Figure-Ground	DDT- +10 to -30 NVD- 0 to -40	Right/Left
3	S+WN	Closure	+15 to 0	Right/Left
4/5/6	DPT/FPT	Temporal Ordination	DPT-Open field and musical tone FPT- Open field, musical tone and pure tone	Right + Left Right/Left
7	DCV	Figure-Ground	+40 to -10	Right/Left
8	Reevaluation			

Legend:

SSI- Synthetic sentence identification

DDT- Dichotic digit test

NVD- Nonverbal dichotic test

S+WN- Speech with white noise

DPT- Duration pattern test

FPT- Frequency pattern test

DCV – Dichotic consonant-vowel test

Figure 1 – Chronogram of formal auditory training sessions

All individuals selected had been submitted to the Duration Pattern Test (DPT), Frequency Pattern Test (FPT), Staggered Spondaic Word (SWW) test and Synthetic Sentence Identification (SSI) test. To determine the effectiveness of auditory training, the results of these tests were compared before and after training.

This study received approval from the Ethics Committee of the university under process number 2123/08.

Statistical analysis involved the nonparametric Wilcoxon test for the comparison of paired data (each subject serving as his/her own control). The confidence interval test was used to determine range of reliability in the mean results. The level of significance was set to 5% ($p < 0.05$).

■ **RESULTS**

No significant differences were found between the right and left ears. Thus, the analysis was

performed considering both ears together. Figures 2 and 3 display the results of the pre-training and post-training hearing behavior tests for the female and male genders, respectively.

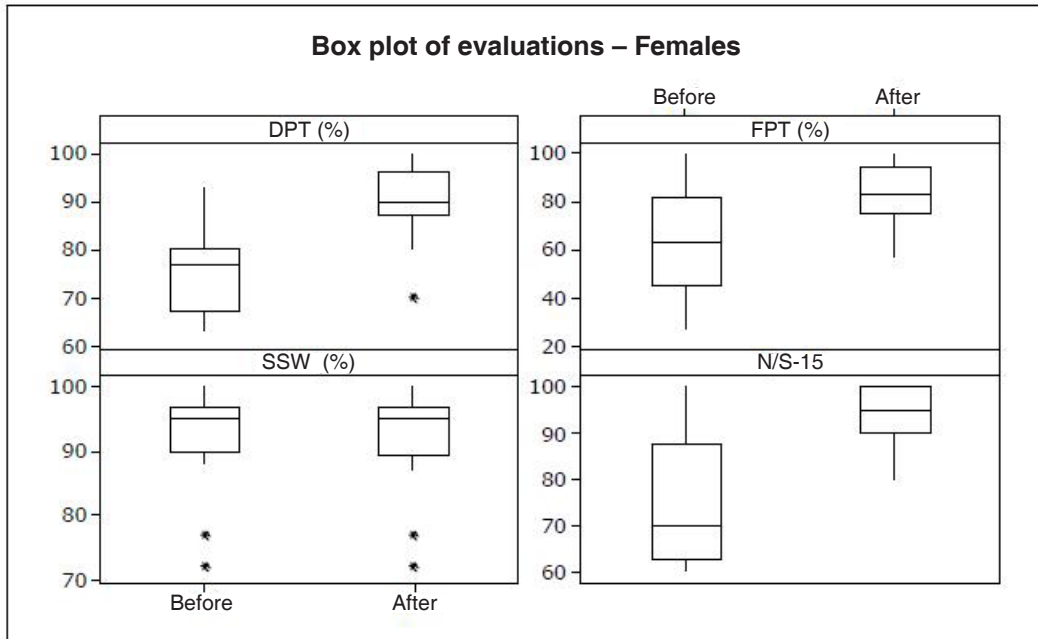


Figure 2 – Results of FPT, DPT, SSW and SSI before and after training among females

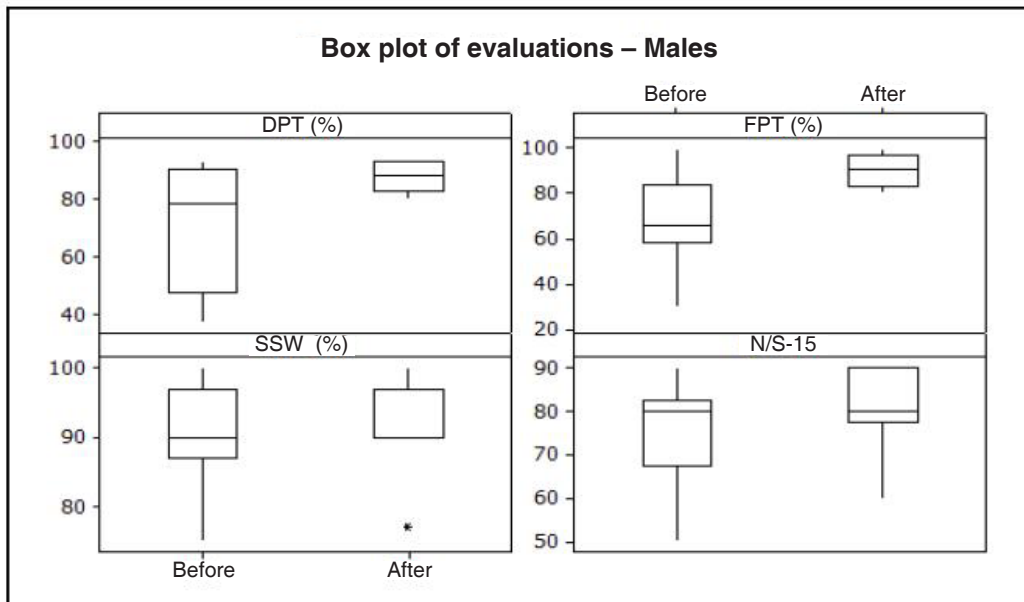


Figure 3 – Results of FPT, DPT, SSW and SSI before and after training among males

Both males and females achieved better results after training, with statistically significant differences on the DPT and FPT. A significant improvement on the SSW only occurred among the males and

a significant improvement on the SSI only occurred among the females. Table 1 displays the performance of the overall sample on the hearing tests at both evaluation times. Significant improvements

occurred on the DPT, FPT and SSI (S/N-15) and a non-significant improvement occurred on the SSW.

Table 2 displays the magnitude of the improvements in performance of the overall sample.

Table 1 – Results of FPT, DPT, SSW and SSI tests before and after training among overall sample

Test	Mean	Median	Standard deviation	Q1	Q3	N	CI	p-value	
DPT(%)	Pré	Pre	72.92	77.0	16.14	63.0	81.8	<0.001*	<0,001*
	Pós	Post	89.36	90.0	6.24	86.8	93.3		
FPT(%)	Pré	Pre	67.00	66.0	20.97	56.0	80.8	<0.001*	<0,001*
	Pós	Post	86.03	87.0	11.74	82.3	97.0		
SSW (%)	Pré	Pre	91.71	93.5	6.97	90.0	97.0	0.208	0,208
	Pós	Post	92.91	95.0	6.63	90.0	97.0		
SSI (N/S -15)	Pré	Pre	74.62	70.0	12.40	70.0	80.0	0.001*	0,001*
	Pós	Post	86.92	90.0	10.50	80.0	90.0	26	

Wilcoxon test

Legend:

DPT- Duration pattern test

FPT- Frequency pattern test

SSW –Staggered spondaic word test

SSI- Synthetic sentence identification

N/S – Noise-to-signal ratio

Q1 – 1st quartile

Q3 – 3rd quartile

N – total number of ears

CI – Confidence interval

* statistically significant difference

Table 2 – Percentage of improvement by test comparing results before and after auditory training

Difference	DPT(%)	FPT(%)	SSW (%)	SSI (N/S -15)
Mean	16.44	19.03	1.21	12.31
Median	15.5	18.5	0.0	10.0
Standard deviation	14.09	16.72	7.74	14.23
CV	86%	88%	642%	116%
Q1	4.8	0.0	0.0	0.0
Q3	24.8	27.0	2.0	20.0
Min	-4.0	-2.0	-25.0	-10.0
Max	56.0	67.0	15.0	40.0
N	36	32	34	26
CI	4.60	5.79	2.60	5.47

Wilcoxon test

Legend:

DPT- Duration pattern test

FPT- Frequency pattern test

SSW –Staggered spondaic word test

SSI- Synthetic sentence identification

N/S – Noise-to-signal ratio

CV – Coefficient of variation

Q1 – 1st quartile

Q3 – 3rd quartile

N – total number of ears

CI – Confidence interval

* statistically significant difference

■ DISCUSSION

The concept of auditory training dates back to the 6th century, but was preferentially indicated for patients with severe to profound hearing impairment and was used in schools for the deaf or in rehabilitation clinics. At the time, this type of training was not used in the clinical practice of hearing and speech therapists due to the lack of scientific research on the subject. Recently, however, new studies have demonstrated promising results in children and individuals who wear hearing aids.^{11,13}

In the present study, four hearing behavior tests were selected to study the effectiveness of formal auditory training on adults with normal hearing but with abnormal results on at least one of these hearing behavior tests (DPT, FPT, SSW and SSI N/S-15).¹⁴ Both genders demonstrated improvements following auditory training (Figures 2 and 3). Statistically significant differences were found on the DPT and FPT in both genders, whereas a significant improvement on the SSW only occurred among the males and a significant improvement on the SSI only occurred among the females. Previous studies also report improved performances following auditory training, but these studies did not involve an adult population.^{11,13,15-22}

Neural plasticity is the key factor involved in this improvement. The stimulation of listening skills "activates" neural plasticity and enhances the odds of successful treatment.¹⁵⁻²⁶ Greater improvements are achieved in younger patients. However, a certain degree of plasticity remains throughout a person's lifetime, which justifies auditory training in adults as well.^{7-9,27,28} Moreover, the improvement is not limited to statistical analyses, as demonstrated by the reports of patients and family members regarding academic, professional and social performance.²⁶

In the analysis of the overall sample, an improvement was found on the SSW following auditory training. However, as the pre-training scores were within the range of normality, this improvement did not achieve statistical significance. Similar findings are described in the literature consulted.⁸ In contrast, the scores on the other tests (DPT, FPT and SSI) were not within the range of normality on the pre-training evaluation and statistically significant improvements on all three tests were found following auditory training, with the participants achieving normal quantitative results for the age group.^{13-15,19,21,22,24} These findings demonstrate the effectiveness of auditory training. Previous studies report the stability of auditory processing behavior tests.^{11,21,24,25}

Questions remain regarding who patients will use the skills learned in formal auditory training in activities of daily living and whether such skills will be maintained in the long term. However, studies have demonstrated that the demands of the environment itself lead to the maintenance of learned listening skills.³

■ CONCLUSION

The findings of the present study demonstrate that the auditory training program was effective with regard to the hearing rehabilitation of adults with auditory processing disorder. Improvements were found in the listening skills of figure-ground for verbal sounds (sentences and words) and the temporal ordination of sounds (duration and frequency). Following training, the participants reported no longer having difficulties conversing in unfavorable environments. Thus, such short-term training is a viable option for these patients, offering improved access to auditory information.

RESUMO

Objetivo: comparar o desempenho de adultos com distúrbio do processamento auditivo em testes comportamentais pré e pós-treinamento auditivo formal, visando verificar a eficácia desse treinamento. **Métodos:** trata-se de um estudo retrospectivo quantitativo com 18 indivíduos com distúrbio do processamento auditivo comprovado pela avaliação comportamental, idade entre 16 e 38 anos. Todos os indivíduos foram submetidos a um programa de treinamento auditivo formal realizado em oito sessões de 45 minutos cada, duas vezes por semana, cujas sessões foram organizadas em ordem crescente de complexidade visando o treinamento das habilidades auditivas de fechamento auditivo, figura-fundo para frases, palavras, sílabas e sons não verbais e de processamento temporal dos sons (análise da intensidade, duração e frequência dos sons). Foram comparados os resultados dos testes SSW em Português, SSI (MCI) e Reconhecimento de Padrão de Duração e de Frequência obtidos no pré e pós – treinamento auditivo, envolvendo as variáveis: orelha e sexo. **Resultados:** não foram observadas diferenças estatisticamente significantes entre as orelhas. Tanto homens quanto mulheres quando analisados separadamente demonstraram resultados melhores no pós-treinamento. Estas diferenças foram estatisticamente significantes nos testes de padrão de duração e frequência, para homens e mulheres. No SSW melhora no sexo masculino e no SSI R/S –15 no sexo feminino, respectivamente. Além disso, todos os indivíduos relataram melhor desempenho comunicativo e de atenção no pós-treinamento. **Conclusão:** o treinamento auditivo formal melhora as habilidades auditivas de figura – fundo para sons verbais e de processamento temporal medidas por testes comportamentais em adultos diagnosticados com distúrbio de processamento auditivo.

DESCRIPTORIOS: Audição; Percepção Auditiva; Transtornos da Audição; Plasticidade Neuronal

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