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# Effect of stimulation of auditory skills of speech-language pathologists to perceptual evaluation of vocal deviation

## Efeito da estimulação das habilidades auditivas de fonoaudiólogos para avaliação perceptiva do desvio vocal

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## ABSTRACT

**Purpose:** To verify if the stimulation of auditory skills of speech therapists with and without difficulty in auditory processing (CAP) interferes in performance of auditory-perceptual assessment (APA) regarding predominant vocal deviation. **Methods:** Prospective, quasi-experimental study, conducted with 26 speech therapists and developed in five stages: Stage1: Pre-intervention - APA, composed of 30 samples of sustained vowel emissions /ɛ/, plus 20% repetition (six repeated samples) in which participants should identify the predominant vocal deviation. Stage2: Screening of CAP skills through nine tests of AudBility web platform. Stage3: Perceptual-auditory training of predominant vocal deviation and, later, second APA, identical to previous one. Stage4: Intervention - Stimulation of auditory skills (EHA) performed by 14 participants, eight of which failed the screening from Stage2 and six who passed th e screening and spontaneously performed EHA (Group G2a ). The other 12 participants did not perform EHA and formed the G2b Group. Stage5: Post-intervention – Third execution of APA, identical to previous, by all participants. Accuracy of analysis and intra-rater reliability were assessed in all APAs. **Results:** The three groups showed similar performances in the three APAs. G1 and G2a showed no improvement in the performance of the analysis of predominant vocal deviation after EHA. Pre-intervention intra-rater reliability in G1 was lower than in G2a and G2b in APA1 and APA2, and similar to them in APA3, post-intervention. **Conclusion:** Proposed EHA had no impact on APA accuracy, but influenced in intra-rater reliability of speech therapists with difficulty in the hearing skills of CAP.

**Keywords:** Auditory perception; Hearing tests; Voice training; Voice screening; Auditory processing

## RESUMO

**Objetivo:** Verificar se a estimulação das habilidades auditivas de fonoaudiólogos com e sem dificuldades no processamento auditivo central (PAC) interfere no desempenho da avaliação perceptivo-auditiva (APA) do desvio vocal predominante. **Métodos:** Estudo prospectivo, quase-experimental, realizado com 26 fonoaudiólogos, desenvolvido em cinco etapas: Etapa1: Pré-intervenção – primeira APA, composta por 30 amostras da vogal sustentada /ɛ/, acrescidas de 20% de repetição (seis amostras repetidas), apresentadas randomicamente, na qual os participantes deveriam identificar o desvio vocal predominante; Etapa 2: Triagem das habilidades do PAC com nove testes da plataforma *AudBility*; Etapa 3: Treinamento perceptivo-auditivo do desvio vocal predominante e segunda APA, idêntica à anterior; Etapa 4: Intervenção - estimulação das habilidades auditivas (EHA), realizada por 14 fonoaudiólogos, sendo oito que não passaram na triagem da Etapa 2 (Grupo1) e seis que passaram na triagem e, espontaneamente, realizaram a EHA (Grupo G2a). Os outros 12 participantes não realizaram EHA e formaram o Grupo G2b; Etapa 5: Pós-intervenção - realização da terceira APA, idêntica às anteriores, por todos os fonoaudiólogos. A acurácia das respostas e confiabilidade intra-avaliadores foram verificadas ao longo das três APAs. **Resultados:** Os três grupos apresentaram desempenhos semelhantes nas três APAs. G1 e G2a não apresentaram melhora no desempenho da análise do desvio vocal predominante pós-EHA. A confiabilidade intra-avaliador pré-intervenção no G1 foi inferior a do G2a e G2b nas APA1 e APA2, e similar a eles na APA3, pós-intervenção. **Conclusão:** EHA proposto não impactou a acurácia da APA, mas influenciou a confiabilidade intra-avaliador dos fonoaudiólogos com dificuldades nas habilidades auditivas do PAC.

**Palavras-chave:** Percepção auditiva; Testes auditivos; Treinamento da voz; Triagem da voz; Processamento auditivo

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## INTRODUCTION

The auditory-perceptual assessment of voice is considered the gold standard procedure for analyzing the type of voice and the degree of voice quality deviation. Despite being widely used, it presents a high level of subjectivity, as the clinical experience and the auditory training level of the evaluating speech therapist influence the evaluation[1-4].

The auditory-perceptual assessment allows the inference of important anatomophysiological data, which are difficult to perceive in other types of isolated assessment. Acoustic assessment using computer programs, for example, offers the extraction of significant acoustic measures for voice assessment. However, when analyzed in isolation, without relation to the auditory-perceptual assessment and analysis of vocal behavior, they do not allow identification of the vocal type[5].

Therefore, it is important that speech-language pathologists specializing in voice are able to perform the auditory-perceptual assessment accurately and reliably, not only knowing how to correctly assess the voice, but also maintaining intra-rater reliability. Studies have shown that speech-language pathologists with clinical experience who underwent perceptual-auditory voice training during their education present better performance and reliability in the assessments[1,6]. Thus, training by repetition with recurrent listening to voices considered anchors, that is, specific to a type of voice, helps in the learning process and is an ally for professional training[7].

The auditory-perceptual assessment of the voice allows the description of vocal characteristics, such as the degree of alteration and the type of vocal deviation. Among the types of voices with deviation, the most frequent are rough, breathy, and tense voices. The rough voice has as its pathophysiological correlate the irregular vibration of the vocal fold mucosa; breathy is associated with transglottic air leakage and tense voices with phonatory effort[5]. Vocal deviations may be present alone or in combination. When present in a combined form, it is common for one of the vocal components to predominate. Due to the multidimensionality inherent to the voice and the complexity of the analysis, the auditory-perceptual assessment may be susceptible to sources of systematic and random errors[5,8].

One of the factors that can lead to error is the difficulty in the auditory processing of the evaluator, which can directly influence the result of the perceptual-auditory evaluation of voices. This processing is complex and involves a set of mechanisms that occur within the auditory system, starting in cochlear neurons and ending in the cerebral auditory cortex. It is through this process that it is possible to analyze, classify, organize and interpret the most diverse sound stimuli around us. An alteration in this processing can cause difficulties in the interpretation and distinction of sounds[9,10].

The assessment of central auditory processing (CAP) can be performed using a set of standardized behavioral tests that assess the different physiological mechanisms and auditory abilities[11]. There are several instruments and questionnaires that can help in the screening of central auditory processing disorder[12-15], which can be performed in a soundproof booth, or online[16].

Thus, the auditory-perceptual assessment of voices is a challenge for speech-language pathologists specializing in voice. Perceiving when a voice is altered or not, identifying the predominant vocal deviation and the degree of deviation, involves training, experience, and preserved auditory skills.

Considering the auditory-perceptual assessment of voices as a benchmark instrument of analysis of the vocal type and knowing that alterations in auditory processing can cause difficulties in the interpretation and distinction of sounds, it is important to know if the training of auditory skills is relevant and helps the speech therapists to develop their skills for a good performance in the auditory-perceptual analysis of voices.

The hypothesis is that the training of auditory skills increases the accuracy and intra-evaluator reliability in the assessment of the predominant vocal deviation of all speech-language pathologists, with or without CAP alteration.

Based on the above, this study aimed to verify if the stimulation of the auditory abilities of speech therapists, with and without CAP failures, interferes with the auditory-perceptual assessment (APA) of the predominant vocal deviation, considering the accuracy of the analysis and intra-evaluator reliability.

## METHODS

### Ethical precautions

This study was carried out at the *Centro de Estudos da Voz* – CEV and was previously approved by the Research Ethics Committee of the *Associação Congregação Santa Catarina*, under the number 3.386.485. All study participants signed the Free and Informed Consent Form (FICF).

### Participants

Twenty-six speech-language pathologists participated voluntarily in this study. They were students of a specialization course in voice (including recent graduates and professionals who were already working in the professional voice field). 21 women and 5 men, aged between 22 and 56 years old, with a mean age of 31 years old.

The inclusion criteria were: adult individuals, both genders, who were taking a specialization course in voice. Exclusion criteria were: neurological/psychiatric disease, presence of self-reported hearing complaint, and failure to perform the proposed procedures.

### Procedures

Longitudinal, quasi-experimental study, divided into five stages (Figure 1), as follows:

- Stage 1: Pre-intervention - auditory-perceptual assessment of the predominant vocal deviation (rough, breathy, or tense) (APA1, initial)
- Stage 2: Screening of Auditory Skills
- Stage 3: Auditory-perceptual training of predominant vocal deviation and APA2, intermediate
- Stage 4: Intervention - stimulation of auditory skills (EHA)

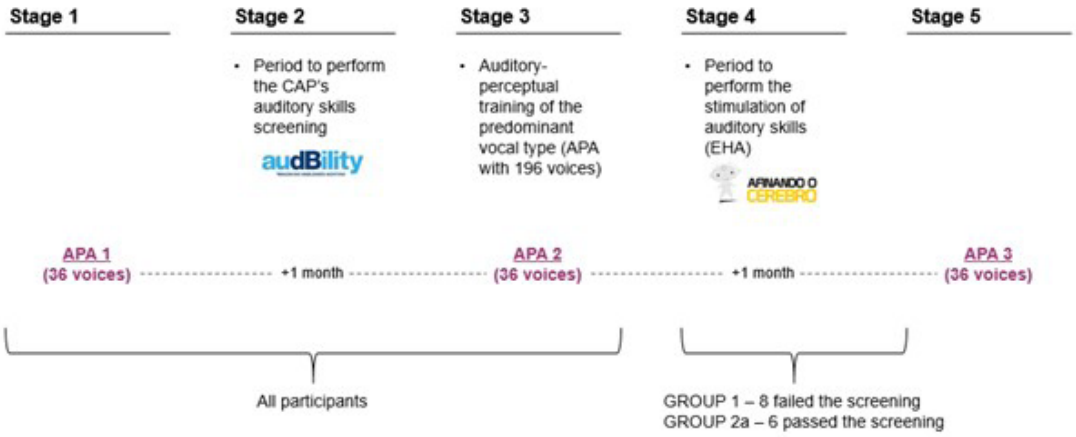


**Figure 1.** Schematic representation of the study design
**Subtitle:** APA1 = first performance of auditory-perceptual assessment of predominant vocal deviation; APA2 = second performance; APA3 = third performance; CAP = central auditory processing

- Stage 5: Post-intervention – auditory-perceptual assessment of predominant vocal deviation (APA3, final)

## Stage 1

In the first stage, the 26 participants were submitted to the first auditory-perceptual assessment of predominant vocal deviation - APA1, which evaluated the performance in the accuracy of the classification of the predominant vocal type and the intra-evaluator reliability.

In this evaluation, the participants had to assess the predominant vocal deviation (rough, breathy, and tense) of a sample of 30 voices, inherited from the voice bank of the *Clínica do Centro de Estudos da Voz* - CLINCEV*. In all, 36 voices were presented to the participants: the 30 samples selected, plus 20% repetition (six repeated voices). The voices were presented by one of the researchers, in the field, via a speaker, and the answers were recorded on an identified answer sheet, which was collected.

The accuracy of each participant was verified by comparing the response of each of the 30 samples with a template. The template was created by three speech-language pathologists specializing in voice, with more than 15 years of experience in CAP, who analyzed the predominant voice deviation of the 30 samples. The classification of the vocal predominance of each sample was performed by consensus of at least two evaluators. The reliability of each participant was verified by comparing the responses of the pairs of the six repeated samples that were added. In all, the first stage lasted 30 minutes.

## Stage 2

In the second stage, the participants were submitted to the screening of the CAP abilities through the AudBility program, from ProBrain, a web platform that allows the screening of auditory abilities, composed of ten self-administered tests[16]. For this, the participants received prior training on how to access and what precautions they should take when using the AudBility program: being in a silent environment, without external interference, with the use of headphones. In addition, everyone should carry out the sound calibration proposed by the program itself, at the beginning of each test, in which the participant listens to a sample of the emission of the stimulus that will be used and can calibrate the sound by increasing or decreasing its intensity, if necessary[17]. This training was delivered by a speech therapist with over 20 years of experience in CAP and an experienced user of the program.

Each participant received an Audbility login and password to access the screening and had a period of one month - the duration of the second stage - to individually perform the self-application of each of the ten AudBility tests. In this study, only nine were considered in the results, as the intensity pattern test is still in the validation process.

### *Test description:*

- Sound localization: assesses the individual's ability to locate the origin of a sound in the environment; the subject must answer from which side he/she heard the stimulus (right, left, above, behind).
- Consonant-vowel: a task that allows the identification of cerebral hemispheric dominance; the individual hears two syllables at the same time and must choose one.
- Dichotic digit (integration): assesses the ability to hear and identify two different numbers in each ear, presented at the same time.
- Sequential dichotic (disyllables): assesses the brain's ability to remember a sequence of four words, two of which are emitted separately and two simultaneously, one in each ear.
- Auditory Closure: Assesses the brain's ability to understand acoustically modified words.

* The voices were inherited from the CLINCEV voicebank, which consists of recordings of the sustained vowel /ɛ/. For the creation of the template, the voices were evaluated by three voice specialists, with more than 15 years of experience in auditory-perceptual assessment and, through consensus, were classified in relation to the predominant vocal deviation.

- Figure-ground (ipsilateral): assesses the ability to direct attention to a stimulus with the presence of a competitive message in the same ear as the main stimulus; the individual will hear a target phrase (stimulus) while listening to a story (competitive message).
- Temporal resolution: assesses the ability to identify intervals between two stimuli (intervals ranging from 0 ms, 2 ms, 5 ms, 10 ms, 15 ms, and 20 ms).
- Temporal ordering (frequency): assesses the ability to perceive and remember a sequence of three stimuli, identifying whether they are low-pitch or high-pitch.
- Temporal ordering (duration): evaluates the ability to perceive and remember a sequence of three stimuli, identifying whether they are short or long.
- Temporal ordering (intensity): evaluates the ability to perceive and remember a sequence of three stimuli, identifying whether they are strong or weak.

After one month, the performance obtained in each test was compared with the expected performance in each test. The 26 participants were divided into two groups: G1 = did not pass the screening (8; 31%); G2 = passed the screening (18; 69%). It was considered that those who did not achieve the expected performance in at least two of the tests applied[16] did not pass the screening.

## Stage 3

In the third stage, all participants underwent face-to-face training, lasting two hours, conducted by one of the researchers. The objective was to develop an auditory perception in identifying the predominant vocal deviation. For this, 196 samples of deviated voices were selected, whose speech material was the sustained vowel /ɛ/, extracted from a CLINCEV* voicebank, and previously classified concerning the predominant vocal deviation.

The voices were presented by one of the researchers, in the field, via a speaker. Initially, each of the 196 voices was presented individually with a maximum of three repetitions, if the participants requested it. At the end of the reproduction of each voice, the participants marked on an answer sheet the vocal deviation that they identified as predominant.

At the end of the task, one of the researchers presented all the voices again, analyzing them with the participants and providing feedback and feedback in real-time. This training took place in a single session, lasting three hours and 15-minute rest intervals in the middle of the presentation of the voices and at the end of the training. After training, all participants underwent a second auditory-perceptual assessment of predominant vocal deviation - APA2. This second application was identical to the first application (APA1).

## Stage 4

In the fourth stage, participants received an invitation to participate in training to stimulate auditory skills, along with instructions for accessing the web platform "Tuning the Brain", available at: https://afinandoocerebro.com.br/. This platform allows targeted stimulation of specific auditory processing skills through self-administered games. The invitation was made by the same speech therapist who carried out the previous training of the second stage.

For this, the authors selected the games that allow the targeted stimulation of auditory skills that were identified as the most altered in the screening through AudBility. They were: temporal resolution, temporal ordering of frequency, and temporal ordering of duration. In all, ten games** were selected and made available to all participants.

For G1 participants (those who did not pass the screening), the stimulation of auditory skills - EHA was mandatory and all performed it. As for the G2 students (who passed the screening), the EHA was optional and they could choose whether to do it or not. At the end of the stipulated period of one month, the 18 participants in G2 were subdivided into G2a = passed the screening and underwent EHA (6; 23%) and G2b = passed the screening and did not undergo EHA (12; 46%).

Participants were instructed to hold eight 30-minute sessions or 16 15-minute sessions, in which they had to play the selected games. There was no specific order for carrying out the games and each participant could choose among the ten selected games, which ones they would carry out in each session. They had one month to complete all sessions, often four times a week for 15 minutes, or twice a week for 30 minutes. In addition, participants were also instructed to access the platform with the selected games at home, or in a quiet place of their choice, always using headphones and adjusting the volume according to their level of listening comfort. The time of completion of the EHA was recorded by the platform itself and the results were collected after completion. A limitation of this study was to verify the time of completion only at the end of the EHA and not to have monitored it during the process, although there was a suggestion of the number of sessions and duration. This methodological decision considered the fact that the students reside in different Brazilian cities and states and their supposed maturity to assume the commitment to carry out the training, as they are professionals who, theoretically, understand the importance of training frequency for the results resulting from stimulation.

## Stage 5

In the fifth stage, the third analysis of the predominant voice disorder was performed - APA3, identical to APA1 and APA2, lasting 30 minutes and performed by all participants.

## Statistical analysis

The responses of the auditory-perceptual assessment were compiled and sent for statistical analysis to compare the performance in the assessment and the intra-evaluator reliability of the groups in the three moments of application of the APA.

To compare performance (percentage of correctly classified responses), the ANOVA test of mixed factors (parametric) was initially used to observe the influence of the group variable (G1,

** The ten "Tuning the Brain" games used were: Against Time, Second Note, Hard Horns, Drops, Musical Staff, Are you in tune?, Young Witches, Singing Lesson, Time Perception, Following the Notes, available at http://afinandoocerebro.com.br

G2a, and G2b) and the moment of performance of the APA (APA1, APA2, and APA3) on performance. Subsequently, the one-way ANOVA test was applied to observe the evolution of the performance of each group throughout the study. The normality of the data was tested with the Shapiro-Wilk test and the Mauchly sphericity test was used to observe whether there was a violation of the sphericity assumption. The inferential analysis of agreement between two nominal qualitative variables was performed using the weighted Kappa coefficient. The Kappa interpretation proposed by Landi JR[18] was considered. The value of statistical significance adopted was equal to 5% ($p < 0.05$), using the SPSS Statistics software, version 25.0, and the theoretical basis described in detail by Field[19].

## RESULTS

The results of the screening of auditory abilities by AudBility are described in Table 1. A comparison of performance between groups (G1, G2a, and G2b), considering the three auditory-perceptual assessments (APAs) of the predominant voice type (APA1, APA2, and APA3), is described in Table 2. Table 3 explores how APA performance evolved in each group. The intra-evaluator reliability values are shown in Table 4.

When analyzing the performance of the groups in the ten tests of the screening of the auditory abilities of the AudBility, it was observed that the G1 presented a worse performance in the abilities related to the temporal processing (temporal ordering - frequency and duration - and temporal resolution), when compared to the G2a and G2b. The ability to order temporal frequency stands out, in which 75% of the participants in G1 had performance below expectations (Table 1).

To analyze the performance of the APA, two statistical analyses were carried out. The first, mixed-factor ANOVA, consisted of observing the influence that the groups (G1, G2a, and G2b) and the moment of application of APA (APA1, APA2, APA3) had on performance. When analyzing separately the influence of the group variable on the performance in the APA (Table 2), no influence was observed (p=0.656), that is, the groups had similar performance among themselves, in the three moments. However, when analyzing the influence of the moment of application alone, it was observed that it influenced the performance of the task (p=0.009), indicating that the performance varied in the different applications. Finally, no significant interaction was observed between the two variables (p=0.471), showing that both had a uniform influence throughout the study.

To explore the variation in performance across the three APAs, a second analysis, one-way ANOVA, was performed (Table 3). For G1 and G2a, the performance remained similar in the three moments (p=0.122 and 0.374 respectively). Only for G2b, the performance was different in the three moments (p=0.018), showing improvement of statistical significance from APA1 to APA3.

Table 4 shows that, for G1, the participants' Kappa agreement values ranged between 0.308 and 1.000 in APA1, between 0.182 and 0.750 in APA2, and between -2.000 and 1.000 in APA3. For G2a, the Kappa agreement values ranged between 0.205 and 1.000 in APA1, between 0.333 and 1.000 in APA2, and between 0.400 and 1.000 in APA3. For G2b, the Kappa agreement values ranged between -0.304 and 1.000 in APA1, between 0.207 and 0.750 in APA2, and between 0.100 and 1.000 in APA3.

**Table 1.** Performance in each CAP skills screening from AudBility by group

| Tests from CAP skills screening | Number of students who failed the screening (% of group total) | | |
|---|---|---|---|
| | G1 (n=8) | G2a (n=6) | G2b (n=12) |
| | Failed + EHA | Passed + EHA | Passed, without EHA |
| Sound localization | - | - | - |
| Consonant-Vowel | - | - | - |
| Dichotic Digits (integration) | - | - | - |
| Competing dichotic listening (disyllables) | 2<br>-25% | - | - |
| Auditory Closure | - | - | - |
| Figure-Ground (ipsilateral) | - | - | - |
| Temporal Resolution | 4<br>-50% | - | - |
| Temporal Ordering (pitch) | 6<br>-75% | - | - |
| Temporal Ordering (duration) | 4<br>-50% | 1<br>-17% | - |

**Subtitle:** EHA = stimulation of auditory skills; G1 = group that didn't pass the screening of auditory skills and performed EHA; G2a = group that passed the screening of auditory skills and performed EHA; G2b = group that passed the screening of auditory skills and didn't perform EHA; - = no student failed this test

**Table 2.** ANOVA test to analyze the influence on the APA performance of the variables group and moment of performance of the auditory-perceptual assessment

| p-value | Variables that influence performance in the APA | | |
|---|---|---|---|
| | Group | Moment of APA | Moment of APA x Group |
| | 0.656 | 0.009* | 0.471 |

Mixed factor ANOVA with two variables *Statistically significant value at the 5% level ($p < 0.05$)

**Subtitle:** APA = auditory-perceptual assessment

## DISCUSSION

The main objective of this study was to verify the impact of the stimulation of auditory skills on the performance in the auditory-perceptual assessment of the predominant type of voice of speech therapists attending a specialization course in voice. The secondary objective was to verify whether the stimulation of auditory skills interferes with the evaluator's reliability.

It is important to mention that all participants were young, did not have hearing complaints, and did not have alterations in the sound localization test in the screening of auditory abilities. Therefore, the hypothesis of the presence of peripheral hearing loss or asymmetric hearing was excluded, since, in these cases, the sound localization ability would be affected as it results from interaural differences in the duration and intensity of the sound stimulus[20].

The result of the auditory skills screening showed that the tests that most students failed were those that assessed temporal processing skills, which involve the perception and/or processing

**Table 3.** Performance in the analysis of the predominant vocal deviation of the three groups, according to the moments of the auditory-perceptual assessment

| Group | APA1 – Pre - EHA | | APA2 – Post-vocal deviation training | | APA3 – Post - EHA | | P-value |
|---|---|---|---|---|---|---|---|
| | Average (%) | SD (%) | Average (%) | SD (%) | Average (%) | SD (%) | |
| G1 (n=8) Failed + EHA | 70.8 | 4.27 | 74.2 | 7.51 | 76.7 | 6.17 | 0.122[b] |
| G2a (n=6) Passed + EHA | 72.2 | 10.89 | 77.8 | 6.89 | 75.0 | 5.48 | 0.374[a] |
| G2b (n=12) Passed, without EHA | 72.2 | 6.72 | 75.0 | 7.04 | 80.3 | 5.77 | 0.018*[a] |

ANOVA with a repeated measures factor ([a]) e Friedman's ANOVA ([b]) *Statistically significant value at the 5% level ($p < 0.05$)

**Subtitle:** EHA = stimulation of auditory skills; SD = standard deviation; APA1 = first performance of auditory-perceptual assessment of predominant vocal deviation; APA2 = second performance; APA3 = third performance; G1 = group that didn't pass the screening of auditory skills and performed EHA; G2a = group that passed the screening of auditory skills and performed EHA; G2b = group that passed the screening of auditory skills and didn't perform EHA; n = number of participants; % = percentage

**Table 4.** Agreement values for the intra-evaluator reliability of the auditory-perceptual assessment of the predominant vocal deviation of the participants of each group, in the three evaluation moments

| Group | Participant | APA1 | | APA2 | | APA3 | |
|---|---|---|---|---|---|---|---|
| | | Kappa | p-value | Kappa | p-value | Kappa | p-value |
| G1 | 1 | 1.000 | 0.001* | 0.400 | 0.050 | 1.000 | 0.001* |
| | 2 | 0.333 | 0.075 | 0.714 | 0.012* | 1.000 | 0.001* |
| | 3 | 1.000 | 0.001* | 0.455 | 0.135 | 0.333 | 0.257 |
| | 4 | 0.500 | 0.040* | 0.217 | 0.309 | -0.200 | 0.221 |
| | 5 | 0.714 | 0.012* | 0.750 | 0.007* | 0.739 | 0.007* |
| | 6 | 0.429 | 0.109 | 0.182 | 0.439 | 0.700 | 0.024* |
| | 7 | 0.308 | 0.186 | 0.500 | 0.040* | 0.500 | 0.040* |
| | 8 | 0.538 | 0.021* | 0.500 | 0.040* | 1.000 | 0.001* |
| G2a | 1 | 1.000 | 0.001* | 1.000 | 0.001* | 0.714 | 0.012* |
| | 2 | 0.250 | 0.303 | 0.700 | 0.024* | 0.500 | 0.083 |
| | 3 | 1.000 | 0.001* | 0.739 | 0.007* | 0.714 | 0.023* |
| | 4 | 0.500 | 0.040* | 0.333 | 0.273 | 0.400 | 0.050 |
| | 5 | 0.250 | 0.257 | 1.000 | 0.001* | 0.739 | 0.011* |
| | 6 | 1.000 | 0.001* | 0.500 | 0.083 | 1.000 | 0.001* |
| G2b | 1 | 0.520 | 0.035* | 0.750 | 0.007* | 0.750 | 0.007* |
| | 2 | 0.500 | 0.046* | 0.250 | 0.317 | 0.250 | 0.303 |
| | 3 | 1.000 | 0.001* | 0.714 | 0.012* | 0.700 | 0.024* |
| | 4 | 0.520 | 0.035* | 0.739 | 0.007* | 0.714 | 0.012* |
| | 5 | -0.304 | 0.292 | 0.750 | 0.007* | 0.333 | 0.098 |
| | 6 | 0.500 | 0.046* | 0.714 | 0.012* | 0.333 | 0.098 |
| | 7 | 0.714 | 0.012* | 0.500 | 0.070* | 0.750 | 0.007* |
| | 8 | 1.000 | 0.001* | 0.217 | 0.309 | 0.750 | 0.007* |
| | 9 | 0.714 | 0.012* | 0.714 | 0.012* | 1.000 | 0.001* |
| | 10 | 0.700 | 0.024* | 0.667 | 0.083 | 0.100 | 0.748 |
| | 11 | 0.739 | 0.007* | 0.750 | 0.007* | 1.000 | 0.001* |
| | 12 | 0.500 | 0.046* | 0.520 | 0.035* | 0.400 | 0.050 |

*Statistically significant value at the 5% level ($p < 0.05$)

**Subtitle:** APA1 = first performance of auditory-perceptual assessment of predominant vocal deviation; APA2 = second performance; APA3 = third performance; G1 = group that didn't pass the screening of auditory skills and performed EHA; G2a = group that passed the screening of auditory skills and performed EHA; G2b = group that passed the screening of auditory skills and didn't perform EHA

of two or more auditory stimuli in their order of occurrence in time. These tests are related to the task of identifying the tone of voice, speech prosody, and perception of the difference between voiceless and plosive sounds[21-23]. Specifically, in this study, the temporal ordering of frequency skill was the skill with the highest occurrence of failures in participants who had difficulties in auditory skills (75% failures in G1).

The temporal frequency ordering skill involves the ability to discriminate a sequence of sounds in terms of frequency (low/high) and is directly related to the perception of vocal pitch (subjective frequency sensation), modeled by the glottal repetition rate and spectral content. of the vocal tract[24]. Predominantly rough voices tend to have a lower pitch, due to the irregularity of the glottic cycles, while more tense voices tend to be higher since the more rigid and elongated vocal fold mucosa produces more cycles per second[25]. Considering that in the auditory-perceptual assessment, the evaluators must identify the predominant vocal deviation (rough, breathy, or

tense voice), it is possible to suggest that difficulty in this skill may compromise this assessment capacity.

In this study, when comparing the result of the auditory-perceptual assessment, it was observed that all groups presented similar performance among themselves, in the three APAs. Even after the proposed EHA, no statistically significant improvement was observed in the performance of G1 and G2a (who underwent EHA), pre and post-intervention. Only for G2b, a statistical improvement was observed between the results of APA1 and APA3. G1 was the group that did not pass the screening and underwent mandatory EHA. G2a, consisting of people who passed the screening, spontaneously chose to undergo EHA. That is, it can be considered that they perceived an opportunity to improve their hearing skills. Concerning the G2b group, made up of people who passed the screening and chose not to undergo the EHA, it can be assumed that they are individuals with more consistent auditory behaviors, who did not feel the need to stimulate auditory skills; because they have good auditory skills, they effectively benefited from the auditory-perceptive training of vocal deviation. This finding may be an indication that individuals with good hearing skills have physiological conditions conducive to responding positively to the perceptual-auditory training of the predominant vocal deviation[2,7].

In the groups whose participants passed the auditory skills screening (G2a and G2b), when comparing intra-evaluator reliability, considering the evaluation of identical emissions of six vocal samples in the same APA, most participants obtained a Kappa classified as substantial (between 0.61 and 0.80) or almost perfect (between 0.81 and 1.00)[18]. For G1, a group of participants who did not pass the screening, this was only observed in APA3, post-intervention of auditory skills stimulation, while in APA1 and APA2, pre-intervention, most participants had moderate to substantial Kappa (lower than 0.61). In other words, although the EHA proposed in the present study did not have a positive impact on the accuracy of the auditory-perceptual assessment of vocal samples, there were indications that it may have positively influenced the internal reliability of participants with difficulties in hearing skills.

With the average performance obtained in the APAs, it was found that it varied from 70.8% to 80.3% during the study. In another study, carried out with 54 undergraduate students in Speech-Language Pathology and Audiology, with minimal experience in auditory-perceptual assessment, the average performance observed was 52% to 54%[26]. Considering that, in the present study, the participants were trained speech therapists, taking a specialization course in voice, they most likely had greater clinical experience, a factor that is related to better performance in the task[1,6].

Other studies also observed the relationship between performance and reliability in the auditory-perceptual assessment with the presence of difficulties in temporal skills. There is a reference in the literature on the performance of individuals who presented normal results in the Frequency Pattern Test (FPT) presented to the left ear (LE) and had superior performance in relation to those who presented altered results, which was not observed in the FPT to the right ear (RE) and in the Duration Pattern Test (DPT). Regarding intra-evaluator reliability, regardless of the ear, individuals who had normal FPT and DPT results were more reliable[27]. In another study, an association was identified between the skills of temporal resolution and binaural interaction with the reliability of listeners in assessing the severity of vocal deviation. Listeners with difficulties in these skills showed lower reliability in the assessments[28]. Thus, the present study also supports the benefits that the training of auditory skills can be an ally in the training of speech therapists, especially for those who have difficulties in auditory processing skills.

Most likely, the EHA allows participants with difficulties in hearing skills to understand and interpret sounds more accurately. Stimulation of central auditory processing skills promotes neuronal reorganization of the auditory system and its connections with other sensory systems related to it while improving altered skills[14]. The literature shows that the method of stimulation of auditory skills used in this study promotes improvement in CAP skills. However, the auditory training protocol, including the same platform used in the present study, suggests sessions of 40 to 45 minutes of weekly training, for eight weeks[15]. Therefore, it is possible that the results of auditory training for a longer period, and with greater control of the frequency of performance, promote more positive results, both in intra-subject reliability and, possibly, in other aspects of APA.

It is worth mentioning that this study did not have the rigor to guarantee the time of stimulation of the auditory abilities of each participant, nor the distribution of this time in each of the ten games proposed in the EHA. This methodological decision considered the fact that the students reside in different Brazilian cities and states and their supposed maturity to assume the commitment to carry out the training, as they are professionals who, theoretically, understand the importance of training frequency for the results resulting from stimulation. Students were instructed to perform 240 minutes (four hours) of training, divided into eight 30-minute sessions or 16 15-minute sessions. As it is an online training, it was possible to verify the total time of each participant, which contradicted the initial expectation of adherence to the training proposal: G1 trained, on average, 152 minutes (maximum of 315 and minimum of 64 minutes), while G2a had an average duration of 117 minutes (maximum of 161 and minimum of 60 minutes), shorter than G1. Future studies should guarantee the time of self-stimulation with the EHA, the proportional distribution of dedication to the games, and their levels of difficulty and effort for all groups. Thus, it will be possible to observe if the beneficial effects also extend to students without difficulties in central auditory processing and/or if they need a more sophisticated and challenging auditory stimulation.

The innovation of the present study consists of the application of the EHA in speech-language pathologists attending a specialization course in voice, especially for those who have difficulties in hearing skills. Knowing how to correctly classify voices is a topic that has already been addressed in the literature and the performance of this skill is associated with repetition training and repetition strategies of anchor stimuli[26]. However, issues of auditory skills are not always considered. Thus, the present study sustains benefits, specifically in the intra-subject reliability, of those who have difficulties in auditory skills. In the future, more controlled studies can expand the knowledge of the dimension of the contribution of the EHA.

Speech-language pathologists who are specializing in the field of voice and who have some difficulty with auditory skills can therefore benefit from self-stimulation of these skills to be more reliable. The auditory-perceptual assessment is subjective and, indeed, the experience can and should be considered as a differential factor in the learning process. However, the reliability, which depends on the learning at that moment, showed that

the EHA can influence the performance of this task. For voice specialization students, just as important as correctly identifying the type of voice is being reliable in your assessments.

## CONCLUSION

The proposed auditory skills stimulation did not impact the accuracy of the auditory-perceptual assessment of the predominant vocal deviation. However, it may have influenced the intra-evaluator reliability of speech pathologists with difficulties in the auditory skills of the CAP.

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