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Perceptual analysis of the tongue position in the production of [s] by SLP students

Identificação perceptiva do posicionamento da língua na produção de [s] por acadêmicos em Fonoaudiologia

Identificación perceptiva del posicionamiento de la lengua de la producción de [s] por académicos en Fonoaudiología

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Abstract

Introduction: the visual identification of articulator positioning and auditory perception in the phoneme [s] are needed for clinical decisions and treatment monitoring. This can be challenging for untrained evaluators. **Objective:** to verify whether untrained evaluators are able to visually identify typical and atypical tongue positions in the production of phoneme [s] and to auditorily perceive typical and atypical productions; as well as to understand which tongue adjustments are more difficult to be visually perceived and which auditory productions are more easily identified. **Methods:** ten speech-language pathology students analyzed 20 recorded speech samples, being 10 with typical speech production and

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10 atypical speech production regarding the [s] movement, and the answers were compared with a gold-standard evaluation. The Kappa agreement, Chi-squared test, Anova repeated measures and Student´s t-test were used with 5% of significance. **Results:** there was an association and agreement with the gold standard evaluation for tongue positioning, with a mean percentage of 40% for correct answers regarding typical position, 17.5% when the tongue was against the teeth and 10% when interposed. In the auditory perception; most evaluators did not show association and agreement with the gold standard evaluation, with an average percentage of 50% for correct answers in the absence of distortion and a significant reduction in the presence (18.5%). **Conclusion**: the students had difficulty in the visual identification of the tongue positioning for atypical speech productions, as well as in the auditory identification of typical or atypical productions, and the greater difficulty occurred when there was distortion.

Keywords: Tongue; Speech; Speech Disorders; Speech Perception.

Resumo

Introdução: a identificação visual do posicionamento dos articuladores e o resultado auditivo na produção de [s] são necessários para decisões clínicas e monitoramento de tratamento. Para avaliadores não treinados esta tarefa pode ser desafiadora. **Objetivo:** verificar se avaliadores não treinados são capazes de identificar visualmente posições normal e alterada da língua na produção do [s] e perceber, auditivamente, produções normais e alteradas; bem como buscar quais ajustes da língua são mais difíceis de serem percebidos visualmente e quais resultados auditivos são mais facilmente identificados. **Método:** dez acadêmicos de Fonoaudiologia analisaram 20 amostras de fala gravadas, 10 com produção normal e 10 alterada do fone [s], sendo as respostas comparadas a uma avaliação padrão-ouro. Na análise foi utilizada a concordância Kappa, o teste Qui-quadrado, o Anova de Medidas repetidas e o teste t Student, com 5% de significância. **Resultados:** houve associação e concordância com a avaliação padrão-ouro para a posição da língua, com porcentagem média de 40% de respostas corretas para a posição normal, 17,5% quando a língua estava contra os dentes e 10% quando interposta. No resultado auditivo, a maioria dos avaliadores não apresentou associação e concordância com o padrão-ouro, sendo a porcentagem média de 50% de respostas corretas na ausência de distorção e com redução significativa quando presente (18,5%). **Conclusão:** os acadêmicos tiveram dificuldade na identificação visual da posição da língua, particularmente, quando alterada, bem como na identificação auditiva das produções normal ou alterada, sendo maior quando a distorção estava presente.

Palavras-chave: Língua; Fala; Distúrbios da Fala; Percepção da fala.

Resumen

Introducción: identificar visualmente el posicionamiento del articulador y el resultado auditivo en la producción del [s] son necesarios para tomar decisiones clínicas y monitorear el tratamiento. **Objetivo:** verificar si los evaluadores no capacitados pueden identificar visualmente las posiciones normales y alteradas de la lengua en la producción del [s] y percibir auditivamente las producciones normales y alteradas; además buscar qué ajustes de la lengua son más difíciles de percibir visualmente y qué resultados auditivos se identifican más fácilmente. **Método:** estudiantes de Fonoaudiología analizaron 20 muestras de habla grabadas, 10 con producción normal y 10 con producción del fono [s] alterado. Compararon las respuestas con una evaluación patrón oro. En el análisis utilizaron la concordancia Kappa, la prueba Chi-cuadrado, el Anova de Medidas repetidas y la prueba t de Student, con 5% de significancia. **Resultados:** hubo asociación y concordancia con la evaluación patrón oro para la posición de la lengua, con media de 40% de respuestas correctas para la posición normal, 17,5% con la lengua contra los dientes y 10% cuando interpuesta. En el resultado auditivo, la mayoría de los evaluadores no presentaron asociación y concordancia con el patrón oro, con media de 50% de aciertos en ausencia de distorsión y con reducción significativa cuando presente (18,5%). **Conclusión:** los estudiantes tuvieron dificultad en identificar visualmente la posición de la lengua, particularmente cuando alterada, y en la identificación auditiva de producciones normales o alteradas, siendo mayor con la distorsión presente.

Palabras clave: Lengua; Habla; Trastornos del Habla; Percepción del Habla.

Introduction

The production of speech sounds with precise adjustments of articulatory organs, especially those involved in the production of fricative sounds, is necessary for effective oral communication. In this sense, the phoneme [s] is produced from the formation of a narrow channel for the passage of air, requiring a lowering of the central part of the tongue in relation to its lateral edges[1,2], so that the quality of the sound produced depends on the shape and the size of that space. The production of this phoneme also requires the mandible to be in a high position, in order to direct the air flow to the articulators involved in the emission[3].

With regard to the articulatory place, the phoneme [s] is described, under usual conditions, as alveolar and may involve constriction of the lamina or apex of the tongue in partial contact with the upper alveoli[4]. These possibilities of constriction are noted in adult speakers of Portuguese Brazilian, with typical speech[5].

However, the articulatory characteristics involved in the production of the phoneme [s] make it vulnerable to alterations/adaptations[6,7]. Thus, alterations in the production of the phoneme [s] may be present and have different etiologies in children, adolescents and adults[7-15]. In this sense, changes in the production of the phoneme [s] may occur to a greater or lesser extent and, depending on the severity, may require intervention[3,9].

It should be noted that the altered positioning of the tongue during the production of the phoneme [s] may or may not result in distortions auditorily identified by the listener[11]. In this context, these distortions would be adjustments or compensations for the production of a phoneme and, in the area of Orofacial Motricity, lisping would be included the group of distortions[10].

Since information arising from a detailed clinical evaluation is essential for establishing an appropriate diagnosis and therapeutic planning, speech-language pathologists who work with speech disorders must be able to visually identify the positioning of the tongue in the production of the phoneme [s] and the auditory result of this positioning[8,9,16].

Clinically, the speech therapist must identify alterations in the production of the phoneme [s] through auditory and visual perceptual analysis of the movements of the articulators involved in the production of this phoneme[8-10]. Therefore, the use of video recordings is recommended[10,11,16] in the evaluation process in order to allow a detailed posterior analysis of the adjustments of articulators such as lips, tongue and jaw, involved in the production of the phoneme [s], as well as the auditory result of the production[11]. Combined with clinical evaluation, which is subjective, objective evaluations, such as ultrasonography[14,17-22] and acoustic analysis[7,23,24], can complement the diagnosis, since they allow the visualization of the contour of the tongue in real time (ultrasonography)[25] or infer about articulatory adjustments (acoustic analysis) that are not typical in the production of sounds[7], thus corroborating with the perceptive information, including fricative sounds[7,19]. In addition, ultrasonography also allows a better understanding of typical productions[25,26], allowing comparisons with non-typical productions[19, 27]. The relevance of using ultrasonography in the analysis of fricative sounds produced by Brazilian Portuguese speakers, in particular, lies in the fact that the variations that occur in the movements of the tongue in the production of these (gradient productions) are not always easily rescued auditorily[27]. Therefore, ultrasound is considered an important tool that can be combined with perceptual assessments in the diagnostic process of speech alterations, as well as in the therapeutic process (use of biofeedback in the therapeutic context), including for speech alterations of a phonetic nature[14].

On the other hand, as the resources for objective evaluations are not always available, training is essential to enable the evaluator's experience in visually identifying the positioning of the articulators and the auditory result of this production. It should be noted that these factors can influence the result of the perceptual assessment and even the decisions regarding the need or not for intervention. Therefore, perceptual assessments, both visual and auditory, should be performed by speech-language pathologists trained for this task, using facilitating resources, such as video recordings.

In this sense, although theoretical information about normal and altered speech production is presented in the initial grades of the Speech-Language Pathology Course, professional training begins during clinical experiences at undergraduate studies. Therefore, it is necessary to know whether Speech-Language Pathology students, without previous clinical experience, are able to visually identify

the adjustments in the positioning of the tongue that allow differentiating normal/altered conditions and, above all, which adjustments would be more difficult to be identified visually. It is also important to verify whether these students are able to auditory identify the auditory result of the productions and, particularly, whether there is a difference in the auditory results resulting from the positioning of the tongue, under normal or altered conditions.

Thus, this study aims to verify whether untrained evaluators are able to visually identify the positioning of the tongue in the production of the phoneme [s] in normal and altered conditions (tongue against the teeth or placed between them), as well as to identify auditorily normal and altered productions. In addition, the study also aims to define the tongue adjustments that are more difficult to be perceived visually and the auditory results that can be more easily identified by such evaluators.

It is expected that students will be able to identify, visually and auditorily, more easily, the normal patterns and that they will have difficulty visually identifying the altered tongue positioning patterns, as well as having difficulty auditorily identifying the altered productions of the phoneme [s]. In this context, it is believed that this information can contribute to the knowledge of professors regarding strategies that can optimize the identification of articulatory adjustments during the clinical evaluation of speech in the period of training of speech-language pathologists, since the decision-making regarding recommending intervention depends on this training.

Methods

This is a cross-sectional, observational, analytical and comparative study that is characterized as a subproject of a broad study, approved by the Research Ethics Committee with Human Beings (CAAE *[Certificate of Presentation for Ethical Consideration]* No.: 90242218.1.0000.5406).

The study included a convenience sample consisting of 10 speech-language pathology students, monolingual, Brazilian Portuguese speakers, from the State of São Paulo, with no hearing or vision complaints. Study participants were selected from a brief questionnaire, in which the exclusion criterion was to have experience in clinical experiences in Speech-Language Pathology in curricular internships of the Speech-Language Pathology course in the areas of language, speech, fluency or orofacial motricity and/or to have received previous Speech-Language Pathology care for speech and/or orofacial motricity alterations. All participants had completed the second year of the Speech-Language Pathology Course and had attended theoretical subjects addressing basic contents on the speech production process, classification and phonetic description of different phonemes in Brazilian Portuguese, as well as fundamentals of orofacial motricity, at which time they did not receive any training regarding the identification of phonetic alterations in speech. It should be noted that all participants signed the Informed Consent Form.

Speech samples

Prior to carrying out this study, three speech-language pathologists with experience in identifying speech disorders in adults were asked to analyze speech samples from a database of the laboratory of the institution. The samples consisted of speech recordings of the days of the week and counting of numbers from 1 to 20 and from 60 to 70, recorded in a silent environment, using a video camera positioned in front of the face, capturing an image of the region between the nose and the lower third of the face. The assessments were carried out individually and there was consensus in the evaluators' responses regarding the visual identification of normal or altered tongue positioning (tongue against the teeth or interposition). There was also consensus regarding the presence or absence of auditory distortion, regardless of the degree. The consensual results of the assessments of the three speech therapists constituted the gold standard evaluation for this study.

Thus, speech samples recorded on video belonging to 20 young females were used, being 10 with normal tongue positioning in the production of the phoneme [s] and 10 with altered tongue positioning in the production of this phoneme. These 20 young women had Angle Class I occlusion, with or without individual dental alterations, according to a previous evaluation performed by an orthodontist. The sample record was edited to

provide continuous presentation, being randomly recorded and filed in a folder.

Perceptual analysis (visual and auditory) by students

The perceptual analyses (visual and auditory) of the speech samples were performed by the students in a speech laboratory, in a face-to-face format, with the examiner (first author) controlling the experimental session. Initially, each student individually received a brief explanation provided by the examiner. This explanation included audio-visual resources with illustrative dynamic images, indicating the positioning of the normal tongue during the production of the phoneme [s], as well as the altered positioning and, also, the auditory distortion in the production of the phoneme [s]. Students were instructed to answer "normal" tongue positioning when they did not visualize the parts of the tongue (anterior and lateral) in the production of the phoneme [s], inferring that it was in a typical position. In turn, the students were instructed to respond that the tongue had an "altered" position when they observed the tongue (or part of it) in a position against the teeth, but without going beyond them, in the production of the phoneme [s]. Finally, the students were instructed to respond that the tongue was positioned "interposed between the teeth", when they observed the tongue (or part of it) interposed between the teeth, in the production of the phoneme [s]. A response was considered "altered" when unexpected adjustments in tongue positioning occurred at least three times in the speech samples presented in the videos. In case of doubts, the student could listen again to the speech samples presented by the examiner.

All responses given by students were recorded on a form specifically designed for this purpose. In order to participate in the study, students were asked to watch each video twice, the first time at normal speed and the second at reduced speed, to then indicate their response.

Analysis of results

Data are described by absolute (N) and relative (%) frequency distribution. The association between qualitative variables (responses of each participant versus the gold standard assessment) was analyzed using the Chi-squared test for association and the Cohen's kappa coefficient (k) was obtained to analyze the agreement between each participant and the gold standard assessment, interpreted in accordance with the proposal by LANDIS; KOCH (1977)[28].

Quantitative variables are described by mean and standard deviation (SD). Normality was analyzed using the Shapiro-Wilk test. In turn, the Student's t-test for paired samples was used to compare two means. For the analysis of three conditions, the Anova test of repeated measures was performed based on the assumption of sphericity by the Mauchly's sphericity test. And *Post hoc* analyzes were performed using the Bonferroni's correction. All analyzes were performed using the SPSS v19.0 for Windows, with a significance level of 5% ($p<0.05$).

Results

As for the visual identification of tongue positioning, Table 1 shows the result of the concordance analysis and the association between the responses of each student with the gold standard assessment.

Table 1. Agreement analysis and association between each student's responses with the Gold Standard assessment of tongue positioning

S	Tongue Position	Gold Standard			X^2 p-value	Kappa Index of Agreement Weighted
		Normal N (%)	Against the teeth N (%)	Interposition N (%)		
1	Normal	8 (40,0) ‡	2 (10,0)	0 (0,0)	0,009 *	0,440 †
	Against the teeth	1 (5,0)	3 (15,0) ‡	1 (5,0)		
	Interposition	1 (5,0)	2 (10,0)	2 (10,0) ‡		
2	Normal	9 (45,0) ‡	1 (5,0)	0 (0,0)	0,001 *	0,520 †
	Against the teeth	1 (5,0)	3 (15,0) ‡	1 (5,0)		
	Interposition	0 (0,0)	3 (15,0)	2 (10,0) ‡		
3	Normal	7 (35,0) ‡	1 (5,0)	0 (0,0)	0,003 *	0,375 †
	Against the teeth	3 (15,0)	3 (15,0) ‡	1 (5,0)		
	Interposition	0 (0,0)	3 (15,0)	2 (10,0) ‡		
4	Normal	9 (45,0) ‡	0 (0,0)	0 (0,0)	0,001 *	0,605 †
	Against the teeth	1 (5,0)	4 (20,0) ‡	1 (5,0)		
	Interposition	0 (0,0)	3 (15,0)	2 (10,0) ‡		
5	Normal	10(50,0)‡	0 (0,0)	0 (0,0)	0,001 *	0,669 †
	Against the teeth	0 (0,0)	5 (25,0) ‡	2 (10,0)		
	Interposition	0 (0,0)	2 (10,0)	1 (5,0) ‡		
6	Normal	10(50,0)‡	2 (10,0)	0 (0,0)	0,001*	0,569 †
	Against the teeth	0 (0,0)	4 (20,0) ‡	2 (10,0)		
	Interposition	0 (0,0)	1 (5,0)	1 (5,0) ‡		
7	Normal	6 (30,0) ‡	1 (5,0)	0 (0,0)	0,004 *	0,373 †
	Against the teeth	4 (20,0)	4 (20,0) ‡	1 (5,0)		
	Interposition	0 (0,0)	2 (10,0)	2 (10,0) ‡		
8	Normal	7 (35,0) ‡	3 (15,0)	0 (0,0)	0,003 *	0,360 †
	Against the teeth	3 (15,0)	2 (10,0) ‡	0 (0,0)		
	Interposition	0 (0,0)	2 (10,0)	3 (15,0) ‡		
9	Normal	6 (30,0) ‡	0 (0,0)	0 (0,0)	0,002 *	0,416 †
	Against the teeth	3 (15,0)	3 (15,0) ‡	0 (0,0)		
	Interposition	1 (5,0)	4 (20,0)	3 (15,0) ‡		
10	Normal	8 (40,0) ‡	0 (0,0)	0 (0,0)	0,001 *	0,531 †
	Against the teeth	2 (10,0)	4 (20,0) ‡	1 (5,0)		
	Interposition	0 (0,0)	3 (15,0)	2 (10,0) ‡		

* Significant association by the Chi-squared test with Yates's correction for continuity for p≤0.05
† Significant agreement for Cohen's kappa coefficient for p≤0.05
‡ Agreement with the gold standard assessment
N Absolute frequency
S Students

In turn, Table 2 shows the comparison of the average results of the academics according to the type of tongue positioning: normal, against the teeth or interposition.

Table 2. Comparison of the mean results of students according to the type of tongue position: normal, against the teeth or interposition

Tongue Position	Mean (%)	SD	p-value
Normal	40,0a	7,45	
Against the teeth	17,5b	4,25	<0,001*
Interposition	10,0c	3,33	

* Significant difference by the Anova test of repeated measures for p≤0.05
Different letters indicate a significant difference by the Bonferroni's correction for p≤0.05.
SD Standard deviation

Kappa Index of Agreement and association between students' responses and the gold standard assessment for identifying auditory results are shown in Table 3.

Table 3. Kappa index of agreement and association between students' responses and the Gold Standard assessment for identifying auditory results

Students	Auditory Distortion	Gold Standard		X^2 p-value	Kappa Index of Agreement Weighted
		Absent	Present		
1	Absent	9 (45%) ‡	5 (25%)	0,749	-0,190
	Present	5 (25%)	1 (5%) ‡		
2	Absent	6 (30%) ‡	3 (15%)	1,000	-0,058
	Present	8 (40%)	3 (15%) ‡		
3	Absent	11 (55%) ‡	3 (15%)	0,456	0,286
	Present	3 (15%)	3 (15%) ‡		
4	Absent	10 (50%) ‡	2 (10%)	0,273	0,348
	Present	4 (20%)	4 (20%) ‡		
5	Absent	12 (60%) ‡	1 (5%)	0,014*	0,659†
	Present	2 (10%)	5 (25%) ‡		
6	Absent	9 (45%) ‡	2 (10%)	0,423	0,271
	Present	5 (25%)	4 (20%) ‡		
7	Absent	11 (55%) ‡	2 (10%)	0,152	0,432
	Present	3 (15%)	4 (20%) ‡		
8	Absent	12 (60%) ‡	2 (10%)	0,070	0,524†
	Present	2 (10%)	4 (20%) ‡		
9	Absent	8 (40%) ‡	2 (10,0%)	0,626	0,200
	Present	6 (30%)	4(20,0%) ‡		
10	Absent	12 (60%) ‡	1 (5,0%)	0,014*	0,659†
	Present	2 (10%)	5(25,0%) ‡		

* Significant association by the Chi-squared test with Yates's correction for continuity for p≤0.05
† Significant agreement for Cohen's kappa coefficient for p≤0.05
‡ Agreement with the gold standard assessment

Finally, Table 4 shows the comparison of the average of correct answers according to the auditory result: present or absent.

Table 4. Comparison of the mean and Standard Deviation (SD) according to the auditory result

Auditory Distortion	Mean	SD	p-value
Absent	50,0	10,0	<0,001*
Present	18,50	5,79	

* Significant difference by the Student's paired t-test for p≤0.05.

Discussion

This study investigated whether untrained evaluators, such as Speech-Language Pathology students, were able to visually identify the positioning of the tongue in the production of the phoneme [s] under normal and altered conditions. The results showed a significant association and agreement with the gold standard assessment, with moderate agreement for half of the students (N=5) and substantial agreement (N=2) or regular agreement (N=3) for the others. This variability found in agreement was expected, since the visual identification of tongue positioning can be a difficult task for students who do not have clinical experience or experience in speech assessment. One study[29] used recorded speech samples that were analyzed by multiple evaluators combined with an experienced professional in the area of Orofacial Motricity. The findings of this study reinforced the need for experience to identify alterations in speech sounds, including those involving the phoneme [s], which is in line with the suggestions of some authors[29]. In this direction, a study[10] applied training to standardize the results of speech production assessments even among experienced evaluators, which suggests that this can be a challenging task even for professionals who are familiar with identifying deviations in speech production. On the other hand, in order to avoid variations between evaluators in the results of the assessments of the production of speech sounds, including the phoneme [s], some authors used a single speech-language pathologist to carry out the analyzes of the participants' productions[8,9]. Thus, it is inferred that, in addition to clinical experiences, controlled training can be an important strategy to increase the level of agreement of responses between evaluators, as in the case of Speech-Language Pathology students, in relation to the gold standard evaluation.

This study found an average percentage of correct answers of 40% for the normal tongue positioning, with a reduction when the positioning was changed, against the teeth (17.5%) or interposed (10%). This percentage found (40%) refutes the hypothesis that evaluators without clinical experience would be able to visually identify the normal positioning of the tongue in the production of the phoneme [s].

This suggests that even in the presence of adequate positioning of the tongue in the production of the phoneme [s], inferred by the non-visualization of the anterior and/or lateral portion of the tongue during the production of this phoneme, the students were not sure when performing their analyses, resulting in an average percentage of correct answers of only 40%. However, it should be noted that these doubts may have been caused by the lack of clinical experiences and/or previous controlled training for the evaluation of speech sounds by students, as previously discussed.

In addition, the production of the phoneme [s] requires the lowering of the central part of the tongue in relation to its lateral edges[1,2] and the mandible must be in a high position. In this configuration, the airflow is directed towards the articulators involved in its production[3], while the apex or lamina of the tongue moves towards the superior alveoli[4,5]. As these articulator adjustments are expected in the typical utterance of the phoneme [s], the visual identification of other lingual configurations would not be expected in the study for speech samples classified with normal tongue positioning in the phoneme [s] under typical conditions.

In this study, a response was considered "altered" when unexpected adjustments in tongue

positioning occurred at least three times in the speech samples presented in the videos. Although the students were instructed to carry out their analyzes only in the production of the phoneme [s] and to consider the altered language positioning when it was present in at least three productions, they may have identified a more anterior position of the tongue during the production of other alveolar phonemes, such as [t], for example. This identification could explain the average percentage of correct answers of only 40%, in relation to the gold standard evaluation, when the tongue positioning was normal during the production of the phoneme [s].

The study also sought to particularly identify which language adjustments during the production of the phoneme [s] are more difficult to be visually perceived by students with no experience in speech assessment, whose results showed a significant difference in the comparison between the averages of the students' responses to the different types of tongue adjustments, that is, normal, against the teeth or interposed during the production of the phoneme [s]. The highest average percentage of correct answers was found in normal tongue positioning (40%), with a significant difference ($p<0.001$) of the lowest averages found for the two types of altered tongue positioning (17.5%, tongue against the teeth and 10% tongue between the teeth), thus confirming the hypothesis that evaluators without clinical experience have difficulty visually identifying the positioning of the tongue in the presence of subtle alterations during the production of the phoneme [s].

The articulatory characteristics involved in the production of the phoneme [s] make it vulnerable to alterations/compensations and, thus, unexpected lingual adjustments, to a greater or lesser extent, can occur in the production of the phoneme [s], making the visual identification of unexpected lingual adjustments a challenging task, especially in the case of subtle adjustments. All speech samples analyzed in this study were from young adults with normal occlusion, which may have resulted in subtle but unexpected tongue adjustments and, therefore, lower values of academic responses in relation to the gold standard, in the presence of altered tongue positioning were expected. Although a direct relationship cannot always be established, it is known that altered tongue positioning in the phoneme [s] may be related to malocclusion and, the greater the severity and disability of the malocclusion, the greater the chance of a speech change[11]. Other factors, such as individual variations in the teeth, may explain, at least in part, the unexpected lingual adjustments in the speech samples involving the phoneme [s] of the young women analyzed in this study and considered by the students.

The lowest average percentage of correct answers was observed when the tongue was interposed between the teeth (10%), with a significant difference in the average percentage of correct answers obtained for positioning the tongue against the teeth (17.5%), which suggests that students had greater difficulty in visually identifying the positioning of the tongue between the teeth than the positioning of the tongue against the teeth. Given that the study included a greater number of videos with speech samples involving positioning the tongue against the teeth (N=7) than between the teeth (N=3), there may have been a tendency for greater visual identification of this positioning language by students.

In order to enable a greater understanding of the results on the visual identification of tongue positioning, another data analysis was performed with grouping of results in dichotomous analysis (normal or altered tongue positioning), but did not show a significant difference ($p=0.107$) in the averages of the students' answers for visual identification of the positioning of the tongue in normal (40%) or altered (45%) conditions. Based on this analysis, the difficulty in performing this task would be similar in both conditions, both when tongue positioning is normal and altered.

This study also aimed to investigate whether untrained evaluators would be able to auditory identify normal and altered productions and, in this context, the results showed that most students did not present significant association and agreement with the gold standard evaluation. Regular (N=4), moderate (N=2), substantial (N=2) agreement was found, and there was no agreement in the answers for two participants, suggesting that the task of identifying the auditory result of tongue positioning was more difficult for students without clinical experience. Given that the fricative phoneme [s] is the most vulnerable to auditory perceived speech deviations[11], it is present in studies that investigate the speech of adults with distinct clinical alterations, including dentofacial and/or myofunctional alterations[8,9]. Some authors have argued that occlusal changes are predictive of deviations in sound

production and that the greater the severity of the occlusal change, the greater the expected deviation in speech production[11]. As the auditory alterations found in this study were subtle in most of the speech samples, which may have made the students' task more difficult, the variability in agreement with the gold standard assessment was expected.

A possible strategy to increase the level of agreement of answers between untrained evaluators, in comparison with the gold standard evaluation, could be a previous auditory training, using audio samples with normal and altered auditory results during the production of the phoneme [s].

This study also investigated which auditory results of the production of the phoneme [s] could be more easily identified by students, the results showed a mean percentage of correct answers of 50% in the absence of auditory distortion, with a significant reduction to 18.5% ($p<0.001$) when it was present. These results confirm the hypothesis that evaluators without clinical experience would have greater difficulty in identifying the presence of distortion. However, the data suggest that even in the absence of auditory distortion in the production of the phoneme [s], the students were not sure when performing their analyses, resulting in an average percentage of correct answers of only 50% in relation to the gold standard evaluation.

In general, the results of this study suggest worse results for students with no experience for the auditory identification task than for the visual identification task of tongue positioning during the production of the phoneme [s]. While the findings were lower in the presence of auditory distortion for auditory identification, the dichotomous analysis of visual identification suggested similar results for tongue positioning in normal and altered conditions. These results suggest that the auditory identification task was more difficult for the students than the visual identification task and point to the need for strategies that optimize the auditory identification of the result of the production of the phoneme [s] in clinical populations. A previous study[27] showed that the visual perceptual judgment of ultrasound images of gradient fricative productions was the most sensitive method for detecting the gradient production (intermediary productions between one phonic category and another) in the production of the fricative phonemes [s] and [ʃ], when compared to the auditory perceptual judgment of these productions. Based on these findings, ultrasound was identified as an important tool that can be used as a complementary method to auditory perceptual judgment in speech analysis. Although this study did not include an objective analysis of tongue movements, the visual perceptual judgment of tongue positioning based on video images also proved to be more sensitive than the auditory perceptual judgment for the tasks performed.

The perceptive analysis of the movements of the articulators during the production of the phoneme [s] and/or the auditory result of these movements is essential for the diagnosis and monitoring of the treatment of speech disorders[9,10]. In this sense, it is recommended that future studies investigate whether clinical experiences during undergraduate studies are sufficient to increase the agreement of evaluators with no experience with the gold standard assessment, or whether there is a need for controlled training for analysis of speech records. It should be noted that controlled training focusing on other speech disorders (hypernasality and/or active errors/compensatory articulations related to velopharyngeal function)[30] has been proposed. These trainings are an important strategy to increase the agreement of evaluators with no experience in the evaluation of speech disorders.

As for the possible limitations of this study, it is possible to list the limited number of videos with speech samples for analysis, the lack of equating the number of videos with the types of changes in tongue positioning and the lack of control over the severity of changes in tongue positioning and/or the auditory result of the productions included in these videos. In this sense, it is suggested that future studies increase the number of videos with speech samples from participants who present varying degrees of alteration in tongue positioning and auditory distortion in the production of the phoneme [s]. It is also suggested to include speech samples in videos of adults of both sexes. And also the inclusion of the repetition of a percentage of speech samples, in order to calculate the reliability of the students' answers.

This study also presents as a limitation the limited number of students who met the inclusion criteria and who participated, in face-to-face format, in the experimental task. With the resumption of academic activities, in face-to-face format, after challenges faced as a result of the new coronavirus pandemic (SARS-CoV-2), it will be possible to conduct studies including a larger number of stu-

dents without and also with clinical experiences, allowing the comparison of these students' answers.

The use of videos is an important resource that can be used for analyzes that require visual and/or auditory identification of productions. However, these analyzes can be more accurate with the incorporation of objective assessments derived from ultrasound and/or acoustic analysis. Thus, future studies may use objective assessments for the visual identification of language positioning, normal and altered, in the production of the phoneme [s] in Brazilian Portuguese speakers.

Conclusion

The findings showed a difficulty for students to visually identify the positioning of the tongue, particularly when altered, and also to identify different types of tongue adjustments in these conditions. In addition, the study also showed students' difficulties in auditory identification of productions, with and without distortions, and this difficulty was even greater when distortion was present.

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