Original Article

https://doi.org/10.1590/2317-6431-2024-3008en

Audiology Communication Research
ISSN 2317-6431

Auditory perception of voicing contrast in total laryngectomized speakers

Percepção auditiva do contraste de vozeamento em falantes laringectomizados totais

Rebeca Pereira Condori[1] *Nathalia Reis*[2] *Zuleica Camargo*[3]

ABSTRACT

Purpose: To evaluate the perception of voicing contrast in total laryngectomized speakers, tracheoesophageal speech users, in relation to the acoustic quality of alaryngeal phonation. **Method:** Participants were 34 judges who evaluated audio recordings of three speakers with alaryngeal phonation - ALA (Superior phonation quality - ALAa; intermediate - ALAb and inferior - ALAc) and one with laryngeal phonation (LAR). The speech samples evaluated present pairs of words pata/bata; tata/data; cata/gata that were presented to the group of judges for auditory identification tasks.To assess intra-judge consistency, 10% of the sample stimuli were repeated in a randomized manner. The data were treated in order to generate confusion matrices and auditory similarity indices of the perception of the voiced and unvoiced plosive consonants of the 04 speakers. Of a total of 34 responses received, 21 had their responses validated, based on consistency criteria (50% of the repetitions presented). **Results:** The ALAa and ALAb speakers received a similar pattern of responses, with higher rates of confusion of voiceless consonants being perceived as voiced, while the emissions from the ALAc speaker generated greater confusion in the perception of consonants both in the voicing and place of articulation features. The voiceless bilabial consonants produced by LAR speakers were the most perceptible. **Conclusion:** The perception of voicing contrast in alaryngeal speakers was related to the acoustic quality of this phonation.

Keywords: Laryngectomy; Speech alaryngeal; Phonetics; Auditory perception; Voice

RESUMO

Objetivo: avaliar a percepção do contraste de vozeamento/sonoridade em laringectomizados totais, com fala traqueoesofágica, em relação à qualidade acústica da fonação alaríngea. **Método:** participaram 34 juízes que avaliaram audiogravações de três laringectomizados totais com fala traqueoesofágica,(ALA) - qualidade de fonação superior-ALAa; intermediária-ALAb e inferior-ALAc - e um com fonação laríngea (LAR). As amostras de fala avaliadas apresentaram pares de vocábulos (pata/bata; tata/data; cata/gata) que foram apresentados ao grupo de juízes para tarefas de identificação auditiva de 79 estímulos. Para avaliar a consistência intrajuízes, foi repetidos 10% dos estímulos da amostra, de forma aleatorizada. Os dados foram tratados de modo a gerar matrizes de confusão e índices de similaridade auditiva da percepção das consoantes plosivas vozeadas e não vozeadas dos quatro falantes. A partir de 34 respostas recebidas, 21 tiveram foram validadas, com base nos critérios de consistência (50% das repetições apresentadas). **Resultados:** amostras dos falantes com qualidade de fonação superior e intermediária geraram similaridade no padrão de respostas, com maiores índices de confusões na percepção de consoantes não vozeadas como vozeadas, enquanto as emissões do falante com qualidade de fonação inferior geraram maiores confusões de percepção das consoantes, tanto no vozeamento, quanto no ponto de articulação. Amostras do falante com fonação laríngea revelaram maior percepção de desvozeamento da consoante bilabial. **Conclusão:** a percepção do contraste de vozeamento em falantes traqueoesofágicos revelou-se relacionada à qualidade acústica dessa modalidade específica de fonação.

Palavras-chave: Laringectomia; Voz alaríngea; Fonética; Percepção auditiva; Voz

Study carried out at Pontifícia Universidade Católica de São Paulo – PUC-SP – São Paulo (SP), Brasil.
[1]Curso de Fonoaudiologia, Faculdade de Ciências Humanas e da Saúde, Pontifícia Universidade Católica de São Paulo – PUC-SP – São Paulo (SP), Brasil.
[2]Hospital Israelita Albert Einstein – HIAE – São Paulo (SP), Brasil.
[3]Programas de Pós-Graduação em Linguística Aplicada e Estudos da Linguagem – LAEL, Comunicação Humana e Saúde – CHS, Pontifícia Universidade Católica de São Paulo – PUC–SP – São Paulo (SP), Brasil.
Conflict of interests: No.
Authors' contribution: RPC was responsible for data collection, preparation of the spreadsheet, writing and editing of the manuscript; NR was responsible for study design, preparation of tables, writing and review; ZC was responsible for study design, preparation of tables, writing and review.
Data availability: Research data is available in the body of the article.
Funding: Conselho Nacional de Desenvolvimento Científico e Tecnológico – bolsa de Produtividade em Pesquisa -CNPq-Pq, nº 311596/2022-3. Plano de Incentivo à Pesquisa – Pontifícia Universidade Católica de São Paulo - PIPEq-PUC-SP, nº 21945.
Corresponding author: Rebeca Pereira Condori. E-mail: rebecacondori.pesquisa@gmail.com
Received: December 03, 2024; **Accepted:** March 07, 2025
Editor-in-Chief: Renata Mota Mamede Carvallo.
Associate Editor: Leonardo Wanderley Lopes.

INTRODUCTION

Laryngeal neoplasia significantly impacts the socio-emotional well-being of patients[1-3]. Cancer is manifested through the disordered proliferation of atypical cells in a specific region of the body[4]. The diagnostic process typically begins with the presentation of hoarseness, which may initially be intermittent and gradually become constant, often accompanied by symptoms such as dyspnea and/or severe dysphagia, as well as the presence of cervical nodules[5].

Clinical examination and the application of the malignant tumor classification system (TNM) facilitate the staging of the lesion, which is essential for defining treatment guidelines across surgical, radiotherapeutic, and chemotherapeutic modalities, including their combinations[6,7]. If total removal of the organ is required, significant impacts on oral communication and breathing are anticipated, along with psychological repercussions[8,9].

In the unique condition of total laryngeal loss, the vibratory mechanism of the vocal folds is replaced by an alternative voicing pattern, which may variably impact both segmental and prosodic aspects, potentially compromising the intelligibility of laryngeal speech. A tracheoesophageal prosthesis incorporates a one-way valve that enables patients to direct expiratory lung air into the esophagus. As the air passes into the upper esophagus, it induces a vibratory pattern in the pharyngoesophageal segment, facilitating speech production[9-13].

This mechanism yields high-quality phonation due to the use of lung air, producing a voice with greater loudness compared to esophageal phonation[1]. Acoustic measurements of average fundamental frequency (f0) and average habitual intensity of such emissions are considered adequate for effective oral communication[12].

Acoustic analysis serves as a valuable tool in Phonetic Sciences for studying speech and is particularly important for investigating vocal quality in individuals who have undergone total laryngectomy and utilize tracheoesophageal prostheses[13]. The acoustic theory of speech production[14,15], which encompasses the linear source-filter model, conceptualizes speech production as being generated by one or more energy sources then modified by a filter.

Research on the acoustic aspects of stop consonant production by laryngeal speakers using tracheoesophageal prostheses has predominantly focused on duration measurements, leaving other important acoustic metrics related to voicing contrast implementation underexplored. Concerning the perception of voicing contrasts in stop and fricative sounds, studies employing the identification of target sounds in the initial position of words have demonstrated lay listeners' challenges in accurately identifying the targeted consonants, often misrecognizing voiceless sounds as voiced[16-29].

Vocal quality, as a perceptual phenomenon, is best assessed through perceptual evaluation, considered the gold standard in clinical assessment. However, the limitations of perceptual assessment include potential discrepancies among listeners regarding vocal quality, largely influenced by their training and experience. Such challenges prompt researchers to adopt inter- and intra-examiner reliability criteria in their investigations[26].

A study[27] utilizing the Vocal Profile Analysis Scheme (VPAS)[28] in cases with anatomical restrictions due to subtotal laryngectomy assessed groups of speakers categorized by recent and late postoperative periods. Findings indicated that in the recent postoperative group, vocal quality settings involving the lips, jaw, and tongue body, alongside decreased extension and pharyngeal constriction, were prominent. Additionally, hyperfunctional settings in the vocal and laryngeal tract were present across all patients. In terms of vocal dynamics, the following settings were observed: elevated habitual pitch, pitch and loudness with decreased extension, and inadequate respiratory support.

The auditory perception deviations generated by alaryngeal phonation are clinically acknowledged, underscoring the necessity for studies that analyze the impact of vocal quality on the phonatory activities of this population. Such research may lead to advancements in understanding speech perception and stimulate discussions regarding the refinement of therapeutic resources for individuals undergoing total laryngectomy, particularly concerning their communication skills.

This finding underscores the importance of research focusing on the voicing/sonority contrast in the production of stop consonants among alaryngeal speakers, facilitating the exploration of the speech compensation mechanisms they employ.

Considering various acoustic characteristics of tracheoesophageal speech documented in the literature—such as reduced pitch and loudness, along with a pronounced degree of roughness and the voicing of voiceless stop consonants—this study investigated the impact of total laryngectomy and the quality of alaryngeal phonation in tracheoesophageal speech on the perception of stop consonants in Brazilian Portuguese. The focus was on the effects that these differentiated sonority characteristics may have on listeners. To achieve this, the study drew upon previous research on the production of stop consonants in Brazilian Portuguese, particularly regarding the implementation of voicing contrast[13], and was grounded in the theoretical principles of Acoustic and Perceptual Phonetics, which integrate perception and sound production mechanisms[29].

The primary objective of this study was to evaluate the perception of the voicing/sonority contrast in patients who have undergone total laryngectomy and utilize tracheoesophageal speech, in relation to the acoustic quality of their phonation.

METHODS

The project received approval from the Ethics Committee of the Pontifical Catholic University of São Paulo (CEP-PUC/SP), under the reference number CAAE 0940114.0.0000.5482.

The research corpus was composed of perceptual judgments derived from audio recordings available in the institution's laboratory database. This corpus included speech samples from 17 male subjects who had undergone total laryngectomy and utilized the Provox® brand fixed low-resistance unidirectional airflow tracheoesophageal prosthesis, along with samples from five laryngeal speakers of the same age range and social group. The material was collected from prior research[15] and integrated into the voice quality database.

Inclusion criteria for the alaryngeal speaker samples included: having undergone total laryngectomy due to squamous cell carcinoma (SCC) of the larynx, primary creation of a tracheoesophageal fistula (TEF), subsequent insertion of a tracheoesophageal prosthesis (TEP), and using the TEF as the predominant means of communication.

For this study, audio recordings of four male speakers were selected, consisting of three alaryngeal speakers and

one laryngeal speaker. The three alaryngeal speakers (ALA) were identified based on their previous acoustic analysis[13]. Samples were selected from an alaryngeal speaker with superior phonation quality (designated ALAa), one with intermediate quality (ALAb), and one with inferior quality (ALAc), based on acoustic parameters such as duration, fundamental frequency, and formant transitions of vowels. This dynamic exploration of speech included the analysis of consonant segments and adjacent vowel sounds[13]. The samples from the laryngeal speaker (LAR) served as a reference for Brazilian Portuguese (BP) parameters for the specified age group, adhering to the same sociophonetic parameters as those of the alaryngeal speakers.

The corpus was structured around the most common syllabic and accentual pattern in Brazilian Portuguese, the paroxytone disyllable. Accordingly, six disyllabic paroxytone words were selected, featuring a CVCV structure (stop consonant - vowel - stop consonant - vowel) with voicing/sonority contrasts among them (e.g., *pata* and *bata*; *tata* and *data*; *cata* and *gata*). Each word was repeated three times by each speaker, yielding a total of 79 samples.

The audio recording samples were labeled, edited, and annotated using the Praat software, version 6.2.17[30]. The target words within the carrier sentences, which included the aforementioned CVCV combinations, were individually edited to incorporate a five-second silence interval at both the beginning and end of each word. These audio stimuli were then converted into video format for a YouTube® channel, from which they were linked to an electronic form (Google Forms) to conduct an electronic survey known as the Alaryngeal Speech Perception Test. Seven stimuli (10% of the total) were randomly selected for repeated presentation in the test order to analyze intrajudge consistency.

The test was administered electronically, with invitations to participate in the Alaryngeal Speech Perception Test disseminated via social networks including WhatsApp®, Instagram®, and Facebook®, as well as at relevant events. All participants in the perception test provided their consent for the use of their responses by digitally signing the Free and Informed Consent Form (FICF), which outlined the responsibilities and guidelines for participation in the study.

With regard to the 34 judges participating in the study, the average age was 31 years, with a minimum age of 18 and a maximum of 57. For the sake of convenience, the participants included both speech therapy students and practicing speech therapists. Among them, ten had experience in treating oncology patients, while another ten held graduate degrees. All participants were native speakers of Brazilian Portuguese and reported normal hearing function.

The auditory perception test conducted in this study aimed to assess word recognition in the absence of a linguistic context. A total of 79 stimuli were presented, featuring contrasts in voicing/sonority (e.g., *pata* vs. *bata*; *tata* vs. *data*; *cata* vs. *gata*), in a randomized order concerning both the words and the speakers. The word recognition test was designed without distractors and allowed participants unlimited listening time to each auditory stimulus prior to responding. Participants were informed that the average duration of the perception test would be 15 minutes, which was communicated before participation.

Thirty-four judges completed the test and met the initial criteria for inclusion in the group for the Alaryngeal Speech Perception Test. Valid responses were defined by the judges' consistency, requiring coherence in at least four of the seven stimulus repetitions. Specifically, a judge's responses were considered valid only if they demonstrated consistency above 50% across the repeated samples. Following the initial analysis, 21 judges' responses were deemed valid for the Alaryngeal Speech Perception Test data analysis.

The collected data were processed to generate confusion matrices, from which similarity indices of the stop consonants were derived. This methodological approach, alongside the discussion of perceptual findings, was grounded in studies of Perceptive Phonetics[29], initially focusing on the relative calculation of perceptual judgments for each evaluated consonant using the generated confusion matrix. Subsequently, the Shepard method was applied to compute the similarity between selected consonant pairs ([p] and [b]; [t] and [d]; [k] and [g]). This involved calculating the ratio of perceptual deviations between the two sounds and their correct identifications. For instance, the similarity between [p] and [b] (denoted as Spb) is calculated using the ratio of the sum of perceptual deviations where [p] was identified as [b] (Ppb) and [b] as [p] (Pbp), relative to the total hits for [p] (Ppp) and [b] (Pbb).

$$Spb = \frac{Ppb + Pbp}{Ppp + Pbb} \quad (1)$$

The data were presented through confusion matrices and similarity values, with discussions grounded in the perceptual approach in Phonetic Sciences.

RESULTS

The results of auditory perception for the segments [p] and [b], [t] and [d], as well as [k] and [g], derived from the Alaryngeal Speech Perception Test (e.g., *pata* vs. *bata*; *tata* vs. *data*; *cata* vs. *gata*), are organized in confusion matrices for each alaryngeal speaker (ALAa, ALAb, and ALAc) and the laryngeal speaker (LAR). These findings are detailed in Tables 1, 2, 3, and 4.

Additionally, the results of auditory perception are further analyzed through the calculation of auditory similarity between pairs of contrastive consonants based on voicing/sonority for each alaryngeal speaker (ALAa, ALAb, and ALAc) and the laryngeal speaker (LAR), as presented in Table 5.

DISCUSSION

Through this study[13], we aimed to investigate the impact of the new phonatory pattern on communication among patients and to encourage speech therapists to implement strategies that facilitate overcoming these challenges. Specifically, we analyzed the perception of stop consonants in Brazilian Portuguese spoken by total laryngectomized patients utilizing tracheoesophageal prostheses (TEPs).

The data from speaker ALAa, who exhibited superior quality of alaryngeal phonation (Table 1), indicated confusions in the perception of voicing contrasts that decreased in clarity from the pair [p] and [b] to [t] and [d], and finally to [k] and [g]. Notably, there were virtually no perceptual confusions related to the point of articulation. Interestingly, the perception of contrasts was more accurate for posterior points of articulation. This suggests that the integration of acoustic and articulatory cues is essential

Table 1. Confusion Matrix of Auditory-Perceptual Judgments of Alaryngeal Speaker Productions with Superior Phonation Quality in Relation to the Implementation of Voicing Contrast for Stop Consonants, Assessed by a Group of Trained Speech Therapy Listeners

	Estimated							
Shown	**"p"**	**"b"**	**"t"**	**"d"**	**"k"**	**"g"**	**"Others"**	**TOTAL**
[p]	**34**	24	0	0	0	0	5	63
[b]	1	**54**	0	0	0	0	7	62
[t]	4	1	**32**	13	0	0	5	55
[d]	0	0	0	**77**	0	0	3	80
[k]	0	0	0	0	**73**	5	2	80
[g]	0	0	0	0	1	**58**	1	60
TOTAL	**39**	**79**	**32**	**90**	**74**	**63**	**23**	**400**

Source: prepared by the authors themselves (2024)

Table 2. Confusion Matrix of Auditory-Perceptual Judgments of Alaryngeal Speaker Productions with Intermediate Phonation Quality Concerning the Implementation of Voicing Contrast for Stop Consonants, Evaluated by a Group of Trained Speech Therapy Listeners.

	Estimated							
Shown	**"p"**	**"b"**	**"t"**	**"d"**	**"k"**	**"g"**	**"Others"**	**TOTAL**
[p]	**54**	8	0	0	0	0	1	63
[b]	7	**52**	0	0	0	0	3	62
[t]	0	0	**29**	21	2	0	4	56
[d]	0	0	1	**59**	0	0	0	60
[k]	0	0	0	0	**44**	17	0	61
[g]	0	0	0	0	0	**83**	0	83
TOTAL	**61**	**60**	**30**	**80**	**46**	**100**	**8**	**385**

Source: prepared by the authors themselves (2024)

Table 3. Confusion Matrix of Auditory-Perceptual Judgments of Alaryngeal Speaker Productions with Inferior Phonation Quality Regarding the Implementation of Voicing Contrast for Stop Consonants, Assessed by a Group of Trained Speech Therapy Listeners

	Estimated							
Shown	**"p"**	**"b"**	**"t"**	**"d"**	**"k"**	**"g"**	**"Others"**	**TOTAL**
[p]	**38**	44	0	0	0	0	2	84
[b]	16	**16**	0	0	0	0	47	79
[t]	0	0	**16**	35	0	0	6	57
[d]	0	0	23	**27**	1	0	11	62
[k]	0	0	0	0	**4**	58	0	62
[g]	6	15	0	0	0	**62**	1	84
TOTAL	**60**	**75**	**39**	**62**	**5**	**120**	**67**	**428**

Source: prepared by the authors themselves (2024)

Table 4. Confusion Matrix of Auditory-Perceptual Judgments of Laryngeal Speaker Productions Regarding the Implementation of Voicing Contrast for Stop Consonants, Evaluated by a Group of Trained Speech Therapy Listeners

	Estimated							
Shown	**"p"**	**"b"**	**"t"**	**"d"**	**"k"**	**"g"**	**"Others"**	**TOTAL**
[p]	**60**	1	0	0	0	0	0	61

Source: prepared by the authors themselves (2024)

Table 4. Continued...

	Estimated							
Shown	**"p"**	**"b"**	**"t"**	**"d"**	**"k"**	**"g"**	**"Others"**	**TOTAL**
[b]	16	**66**	0	2	0	0	0	84
[t]	6	0	**44**	5	1	0	1	57
[d]	0	0	2	**59**	0	1	1	63
[k]	0	0	0	0	**59**	3	1	63
[g]	0	0	0	0	0	**62**	0	62
TOTAL	**82**	**67**	**46**	**66**	**60**	**66**	**3**	**390**

Source: prepared by the authors themselves (2024)

for effective perception. The data on perceptual similarity for the voicing contrasts between [p] and [b] demonstrated the highest resemblance, followed by [t] and [d]. This indicates that, despite the presence of favorable laryngeal phonation conditions, articulatory factors remain significant in the speech therapy process[13-16].

For speaker ALAb, who exhibited intermediate quality of laryngeal phonation (Table 2), the data revealed similar confusions in the perception of voicing contrasts, with a decline from the pair [t] and [d] to [k] and [g], and then to [p] and [b]. Like ALAa, ALAb showed minimal perceptual confusion regarding the point of articulation. A distinguishing factor for this speaker was his history of radiotherapy. Both speakers were of similar age, being among the oldest in the group. The analysis of perceptual similarity for voicing contrasts indicated the lowest similarity indices within the group, with the highest proximity observed for the pair [t] and [d], reflecting patterns akin to those of ALAa[17-20].

Considering the specificities of the speakers, ALAa and ALAb exhibited similarities in the response patterns generated among the listener group. In contrast, the data from speaker ALAc, who demonstrated a lower quality of alaryngeal phonation (Table 3), distinguished him from the other alaryngeal speakers. Notably, the confusions in the perception of voiceless consonants (which were incorrectly identified as voiced) surpassed the rate of correct responses. Furthermore, there were significant confusions related to the place of articulation, particularly concerning the velar consonant [g]. The number of responses categorized as "others" was higher for this speaker compared to both the other alaryngeal speakers and the laryngeal speaker[21,22]. It is important to highlight that ALAc was the youngest patient in the group and had no history of adjuvant treatments such as radiotherapy or chemotherapy.

The analysis of perceptual similarity for voicing contrasts (Table 5) indicated the highest auditory proximity indices for all consonant pairs, especially for the more anterior pairs [p] and [b] and [t] and [d]. Remarkably, the overall highest similarity values were observed for this speaker, suggesting that, despite inferior laryngeal phonation quality, the ability to perceive voicing/sonority contrasts and even the points of articulation was significantly compromised. This underscores the necessity for developing clinical monitoring strategies to enhance speech intelligibility.

Regarding the data from the laryngeal speaker LAR (Table 4), it is essential to note that this speaker was used as a reference for sound perception in Brazilian Portuguese within the specified age group. Additionally, LAR served to provide stimuli familiar to listeners, aiding in assessing the degree of difficulty encountered in the Laryngeal Speech Perception Test. The data revealed an intriguing phenomenon concerning the confusion in perception, particularly the devoicing of [b], which is more characteristic of laryngeal speech, especially in children's speech. Although a few confusions were noted regarding the voicing of [t] and [k], they occurred with less frequency compared to the alaryngeal speakers.

Moreover, no perceptual confusions were identified related to the place of articulation. The analysis of perceptual similarity for voicing contrasts indicated that the pair [p] and [b] exhibited a similarity index distinct from those of

Table 5. Auditory Similarity Indexes of Stop Consonants Produced by Alaryngeal and Laryngeal Speakers, Based on Auditory-Perceptual Judgments by a Group of Trained Speech Therapy Listeners

ALARYNGEAL SPEAKERS		
ALAa	Spb	0,34
	Std	0,14
	Skg	0,03
ALAb	Spb	0,13
	Std	0,25
	Skg	0,15
ALAc	Spb	1,10
	Std	1,07
	Skg	0,84
LARYNGEAL SPEAKER		
LAR	Spb	0,76
	Std	0,06
	Skg	0,02

Subtitle: ALAa = alaryngeal speaker with superior phonation quality; ALAb = alaryngeal speaker with intermediate phonation quality; ALAc = alaryngeal speaker with inferior phonation quality; LAR = laryngeal speaker; S = similarity; pb/td/kg = consonants. **Source:** prepared by the authors themselves (2024)

[t] and [d] as well as [k] and [g]. This reinforces the notion that factors beyond alaryngeal phonation conditions can contribute to confusion in speech perception among adults in the studied age group[23,24].

In light of the details presented, the hypothesis that the quality of alaryngeal phonation may influence the perception of the voicing/sonority contrast of stop consonants in Brazilian Portuguese is supported by the data. This highlights that additional factors may also affect the speech production of these individuals, thereby impacting the generation of the acoustic signal and, consequently, the perception of listeners experienced in analyzing speech data[25-27].

These influencing factors may be related to age and the structural changes in the vocal apparatus that accompany it, as well as potential presbycusis. Such conditions may lead both alaryngeal and laryngeal speakers to experience difficulties in controlling nuanced aspects of their speech gestures. Regarding age, it is important to note that alaryngeal speakers may exhibit signs of presbyphonia due to the effects of aging on their "new vocal apparatus."

In the theoretical framework established, the objective was not only to quantify errors and successes in relation to a target but also to qualify and comprehend the intricate relationship between speech perception and production within this unique population. This approach facilitated a departure from the binary classification of normal versus altered or typical versus atypical speech productions, advancing toward a nuanced mapping of the relationships between the perception and production of alaryngeal speech under specific conditions.

The methodology employed here aimed not merely to identify "errors" in speech production and perception but to explore how the domains of speech production and perception are interwoven for each speaker studied[13]. Ongoing research involving new groups of speakers may further reinforce the findings from this initial stage of investigation.

This study concentrated on a specific audience, represented by a group of trained and in-training speech therapist judges. Future research should consider including the lay public as a group of judges (listeners) to assess the impact of alaryngeal speakers on everyday communication.

CONCLUSION

The perception of voicing contrast in alaryngeal speakers utilizing a tracheoesophageal prosthesis (TEP) has been shown to be closely related to the acoustic quality of this specific phonation modality.

In examining the perception of voicing contrasts in alaryngeal speakers under varying conditions of phonation quality, it was observed that perceptual confusions occurred, particularly regarding the voicing of stop consonants. In conditions of superior and intermediate phonation quality, these confusions were detected with a smaller proportion of stop consonants perceived as voiceless. Conversely, in conditions of inferior phonation quality, the confusions tended to exceed the correct identifications within the dimension of voicing contrast.

Research on the perception of alaryngeal speech is particularly relevant within the clinical context of Speech Oncology, as it provides valuable insights into the impact of speech emissions that deviate from familiar daily listening patterns.

REFERENCES

1. Carrara de Angelis E, Lemos Barbosa Furia C, Figueiredo Mourão L, Paulo Kowalski L. A atuação da fonoaudiologia no câncer de cabeça e pescoço. São Paulo: Lovise; 2000.
2. Davatz GC. Reabilitação vocal e qualidade de vida em laringectomizados totais [dissertação]. São Carlos: Universidade de São Paulo; 2011.
3. Pinho SMR. Fundamentos em fonoaudiologia: tratando os distúrbios da voz. 2. ed. Rio de Janeiro: Guanabara Koogan S.A; 2003.
4. da Silva Santos CC. Próteses fonatórias em doentes laringectomizados: o regresso da voz [dissertação]. Lisboa: Universidade de Lisboa; 2020.
5. Barros APB. Reabilitação na laringectomia total. In: da Silva Cleto ML. Fonoaudiologia em cancerologia. São Paulo: Fundação Oncocentro de São Paulo; 2000. p. 286.
6. UICC: Union for International Cancer Control. TNM Classification of Malignant Tumours [Internet]. 2024 [citado em 2024 Dez 3]. Disponível em: https://www.uicc.org/resources/tnm.
7. UICC: Union for International Cancer Control. About UICC [Internet]. 2024. [citado em 2024 Dez 3]. Disponível em: https://www.uicc.org/who-we-are/about-uicc.
8. Cocuzza S, Maniaci A, Grillo C, Ferlito S, Spinato G, Coco S, et al. Voice-related quality of life in post-laryngectomy rehabilitation: tracheoesophageal Fistula's Wellness. Int J Environ Res Public Health. 2020 Jun 26;17(12):4605. http://doi.org/10.3390/ijerph17124605. PMid:32604875.
9. Dornelas do Carmo R, Camargo Z, Némr K. Relação entre qualidade de vida e auto-percepção da qualidade vocal de pacientes laringectomizados totais: estudo piloto. Rev CEFAC. 2006 Out;8(4):518-28. http://doi.org/10.1590/S1516-18462006000400013.
10. McColl DA. Intelligibility of tracheoesophageal speech in noise. J Voice. 2006;20(4):605-15. http://doi.org/10.1016/j.jvoice.2005.09.005. PMid:16377128.
11. Cristina de Oliveira Cardoso E. Avaliação acústica da fala alaríngea [dissertação]. Porto: PSuperior de Engenharia do Porto; 2019.
12. de Assis Moura Ghirardi AC. Laringectomizados usuários de prótese traqueoesofágica: princípios e métodos da prática fonoaudiológica [dissertação]. São Paulo: Universidade Católica de São Paulo; 2007.
13. dos Reis N. Estudo acústico da fala traqueoesofágica [tese]. São Paulo: Universidade Católica de São Paulo; 2018.
14. Fant G. Acoustic theory of speech production. 2nd ed. Paris: Mouton Hague Paris; 1970.
15. Barbosa PA, Madureira S. Manual de fonética acústica experimental: aplicações a dados do português. São Paulo: Cortez.
16. Doyle PC, Danhauer JL, Reed CG. Listeners' perceptions of consonants produced by esophageal and tracheoesophageal talkers. J Speech Hear Disord. 1988 Nov;53(4):400-7. http://doi.org/10.1044/jshd.5304.400. PMid:3184901.
17. Doyle PC, Haaf RG. Perception of pre-vocalic and post-vocalic consonants produced by tracheoesophageal speakers. J Otolaryngol. 1989 Dez;18(7):350-3. PMid:2593219.
18. Miralles JL, Cervera T. Voice intelligibility in patients who have undergone laryngectomies. J Speech Lang Hear Res. 1995 Jun;38(3):564-71. http://doi.org/10.1044/jshr.3803.564.
19. Searl JP, Carpenter MA, Banta CL. Intelligibility of stops and fricatives in tracheoesophageal speech. J Commun Disord. 2001 Ago;34(4):305-21. http://doi.org/10.1016/S0021-9924(01)00052-1. PMid:11508897.

20. Jongmans P, Wempe TG, van Tinteren H, Hilgers FJ, Pols LC, van As-Brooks CJ. Acoustic analysis of the voiced-voiceless distinction in dutch tracheoesophageal speech. J Speech Lang Hear Res. 2010 Abr;53(2):284-97. http://doi.org/10.1044/1092-4388(2009/08-0252). PMid:20360458.

21. Sleeth LE. Exploring intelligibility in tracheoesophageal speech. A descriptive analysis [dissertation]. Ontario: The University of Western; 2012.

22. Calzolari Soto N, de Carvalho Teles V, Erina Fukuyama É. Avaliação perceptivo-auditiva e acústica da voz traqueoesofágica. Rev CEFAC. 2005;7(4):496-502.

23. Miralles JL, Cervera T. Voice Intelligibility in patients who have undergone laryngectomies. J Speech Hear Res. 1995 Jun;38(3):564-71. http://doi.org/10.1044/jshr.3803.564. PMid:7674648.

24. Searl JP, Carpenter MA, Banta CL. Intelligibility of stops and fricatives in tracheoesophageal speech. J Commun Disord. 2001 Jul;34(4):305-21. http://doi.org/10.1016/S0021-9924(01)00052-1. PMid:11508897.

25. Cleybe Hiole Vieira C, Madureira S. Fala esofágica: dados anatomofisiológicos e acústicos. In: Camargo Z, organizador. Fonética clínica: interações [Internet]. São José dos Campos: Pulso Editorial; 2022 [citado em 2024 Dez 3]. p. 159. Disponível em: https://cienciaaberta.org/download/coletanea-fonetica-clinica-interacoes/.

26. van As-Brooks CJ, Koopmans-van Beinum FJ, Pols LC, Hilgers FJ. Acoustic signal typing for evaluation of voice quality in tracheoesophageal speech. J Voice. 2006;20(3):355-68. http://doi.org/10.1016/j.jvoice.2005.04.008. PMid: 16185840.

27. Barbosa Lemos Fúria C, Silva de Freitas A, Nery Teles Nogueira Silva G, Dornelas R, Camargo Z. Avaliação fonética de fala nos casos de restrições anatômicas: laringectomia subtotal. In: Camargo Z, editor. Fonética clínica: interações [Internet]. São José dos Campos: Pulso Editorial; 2022 [citado em 2024 Dez 3]. p. 159. Disponível em: https://cienciaaberta.org/download/coletanea-fonetica-clinica-interacoes/.

28. Laver J, Wirz S, Mackenzie J, Hiller S. A perceptual protocol for the analysis of vocal profiles. Edinburgh: Department of Linguistics; Edinburgh University; 1981. p. 139-55. (Work in Progress; no. 14).

29. Johnson K. Acoustic and auditory phonetics. Phonetica. 2004;61(1):56-8. http://doi.org/10.1159/000078663.

30. Boersma P, Weeninck P. Praat: doing phonetics by computer [Internet]. 2006 [citado em 2024 Dez 3]. Available from: https://www.fon.hum.uva.nl/praat.