Analysis of reporters' vocal changes in the presence of noise

Análise das modificações vocais de repórteres na situação de ruído

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ABSTRACT

Purpose: To investigate and compare the occurrence of vocal changes in the presence of masking noise between reporters and other professionals. **Methods:** Participants were 46 subjects with normal hearing, 23 reporters (study group) and 23 non-reporters (control group). Participants read an excerpt from a TV news broadcast in three listening situations: without masking noise, with 50 dB white noise, and with 90 dB white noise. The narrations were recorded and then submitted to auditory-perceptual and acoustic analyses. The auditory-perceptual analysis was performed by a speech-language pathologist specialized in voice. The acoustic analysis used the software Voxmetria (CTS *Informática*) to perform the acoustic measurements. **Results:** In the situation with 50 dB masking noise, individuals in the control group had higher increase of the following parameters, when compared to the group of reporters: pitch (82.6%), loudness (91.3%), and strain (82.6%). The same occurred in the situation with 90 dB masking noise for the same parameters: pitch (95.7%), loudness (100%) and strain (91.3%). **Conclusion:** The negative consequences of the Lombard effect occur in both groups; however, reporters showed the ability to partially inhibit the negative impact of noise situations, probably due to the stability of the professional speech production and activation of other feedback pathways.

Keywords: Voice; Voice quality; Perceptual masking; Voice training; Noise effects; Loudness perception

INTRODUCTION

Auditory feedback plays an important role in the voice control due to the regulation of respiratory and phonatory processes[1,2]. In addition, feedback is considered an important resource in the control of frequency, intensity and voice quality parameters[3,4,5]. Several studies reinforce the importance of auditory feedback on phonatory processes, claiming that it is crucial for the organization of vocal production, since it is through this system that individuals monitor and confirm the effectiveness of their communication[6].

Some parameters of voice production undergo changes when there is impairment or interruption of the auditory feedback. The presence of environmental noise is a condition that can impair voice auditory feedback, hindering communication. As an effect of the presence of noise, vocal intensity increases automatically. This phenomenon was described by Etiene Lombard in 1911[7], and it is known as the Lombard Reflex or the Lombard Effect.

The reporter's professional performance depends on the use of voice, and a mild vocal deviation may affect the career of this professional[8]. The quantity and quality factors of voice usage associated with some recording situations, such as the presence of environmental noise, put these professionals at risk for developing voice problems[9,10]. This occurs because increased vocal intensity is a type of phonotraumatic situation, which may contribute to the development of voice disorders[11,12].

In addition to good voice quality, the reporter should be able to keep the viewer's attention and to convey the message clearly. Frequently, there are different recording situations for the same story. The out of vision – OOV (part of the story in which the reporter's voice is heard while images are shown on screen) can be recorded in a booth or in a silent room (when the reporter is out of the TV station), and the standup (part of the story in which the reporter appears in the video at the news site) might be held in a noisy place. However, large discrepancies in the reporter's voice in these two situations (OOV and standup) should not happen, because they will be part of the same story. This fact leads us to hypothesize that, in addition to the auditory pathway, reporters use other means of monitoring the voice.

Studies with trained singers suggest the existence of a second phonatory control circuit based on kinesthetic clues[3]. The hypothesis of kinesthetic feedback arose based on the evidence that singers are able to maintain the accuracy of speech even when they do not hear their own voices. Thus, two systems of neuromuscular control seem to act during phonation: the circuits of auditory and kinesthetic feedback. Findings suggest that kinesthetic feedback acts more efficiently

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in singers than in non-singers when there is an interruption of auditory feedback[13,14].

As reporters deal with noisy environmental conditions and need to maintain a good voice quality and communicative performance in a high vocal demand context, it is clinically relevant to know the vocal behavior of this group in noisy situations[10]. Although the importance of auditory feedback in voice control is known, it is observed that even in noisy situations some reporters have little voice changes. Thus, this study had the aims to verify and compare the occurrence of voice changes in reporters and non-reporters in the presence of noise, and also to characterize the nature of these deviations and establish a parallel between voice changes in reporters and their work experience and previous auditory training.

METHODS

This study, approved by the Ethics Committee of Centro de Estudos da Voz under number 716/08, was conducted with reporters from a TV station in Brazil. Participants were 46 subjects: 23 reporters (Study Group) and 23 non-reporters (Control Group). All the participants signed the Free and Informed Consent Term.

In the group of reporters, there were 10 men (43.5%) with mean age of 33.7 years (±7.77), and 13 women (56.5%) with mean age of 27.6 years (±7.77). For the Control Group, we selected non-reporters, employees from the same TV station, who did not use their voice professionally and had not undergone previous vocal or auditory training. In this group, 12 subjects were men (52.1%) with mean age of 30.5 years (±3.39), and 11 were women (47.9%) with mean age of 31 years (±5.60). The number of men and women in both samples was balanced. All participants underwent audiometry, with results within normal limits.

A speech sample was collected from the reading of the following excerpt from a TV news broadcast story: "*A fila só não ficou maior e os preços não subiram ainda mais, porque nunca houve tanto financiamento para a casa própria. Como mais gente consegue comprar um imóvel aumenta a oferta no mercado de locação*".

Subjects got familiarized with the text by reading it once prior to recording. We did not provide any information regarding voice control during the recording. Both groups read the same passage in three different moments: the first without masking noise and the other two with white noise at 50 dB and 90 dB, respectively. Recordings were conducted in a silent room, with the subject standing, and the microphone positioned at 45° and 5 cm away from the mouth of the participant.

We used the following equipment: HP Pavillion® laptop, Shure® SM58 microphone, Sony® MDR-7506 professional headphone. For introducing the white noise and registering the recording, we used the masking tool of the software Fonotools 1.5 (CTS *Informática*).

The speech samples collected were submitted to auditory-perceptual and acoustic analyses. The auditory-perceptual analysis was conducted by a speech-language pathologist (SLP) specialized in voice without previous knowledge of the recording situation (with or without noise), according to the parameters: loudness, pitch, strain, speech rate, and articulatory precision. The recordings were presented in random order, without identification, and compared in pairs according to the following groups: 50 dB in relation to 0 dB, 90 dB in relation to 50 dB, and 90 dB in relation to 0 dB. The SLP should identify whether the vocal parameters had increased, decreased or remained, compared with the other recording. The extraction of the following acoustic measurements was performed using the software VoxMetria 3.0 (CTS *Informática*): mean frequency in Hz, minimum and maximum frequency in Hz, duration of the segment in seconds, mean intensity in dB, and variability in Hz.

All analyses for the Study Group were made taking into account the reporter's work experience and the report of previous auditory training. Work experience was classified according to three subgroups: 0-5 years (n=9), 6-10 years (n=8) and >11 years (n=6). With regards to previous auditory training, the group of reporters was divided into two subgroups: trained (n=7) and untrained (n=16).

Non-parametric statistical tests (Equality of Two Proportions, Mann Whitney and Kruskal-Wallis) were used for the analysis of auditory-perceptual and acoustic data. We adopted the significance level of 0.05 (5%). The calculations performed using the Minitab software showed that the sample of 23 subjects for each group has a high power, with value of 78.31% (0.7831).

RESULTS

For the analysis of the auditory-perceptual data, we used the Equality of Two Proportions test. In the presence of 50 dB of masking, the parameters loudness, pitch and strain were better preserved in the Study Group when compared to the Control Group. The same occurred for the situation with 90 dB of masking. In both moments, the most deviated parameters in the Control Group were: increased loudness, higher pitch, and increased strain. Moreover, under 90 dB masking, there was a statistical tendency of increased speech rate and articulatory precision. Although the auditory-perceptual parameters increased in both groups, a larger number of subjects in the Study Group preserved the parameters loudness, pitch and strain when 50 dB and 90 dB of masking were inserted, even without instruction (Table 1).

There were no changes in auditory-perceptual parameters in the presence of 50 dB in relation to 90 dB of masking. Thus, it was observed that, regardless of the amount of masking increased, the responses were uniform and more evident for the Control Group (Table 2).

The results of acoustic analysis showed that, in the presence of 90 dB of masking, the minimum fundamental frequency was higher for the Control Group, whereas the variability of fundamental frequency in Hz remained higher for the Study Group. This difference remained constant even when there was an increase in the intensity of masking (Table 3). Both groups showed increase in intensity and frequency means when 50 dB and 90 dB of masking were inserted.

In order to characterize and better understand the Study Group, we performed the analysis of acoustic and

Table 1. Comparison of auditory-perceptual parameters between Study (reporters) and Control (non-reporters) groups

Parameter	Group	Intensity											
		50 dB Increased			50 dB Remained			90 dB Increased			90 dB Remained		
		n	%	p-value	n	%	p-value	n	%	p-value	n	%	p-value
Loudness	Case	13	56.5	0.007*	10	43.5	0.007*	17	73.9	0.009*	6	26.1	0.009*
	Control	21	91.3		2	8.7		23	100		0	0.0	
Pitch	Case	10	43.5	0.006*	12	52.2	0.013*	17	73.9	0.040*	6	26.1	0.040*
	Control	19	82.6		4	17.4		22	95.7		1	4.3	
Strain	Case	11	47.8	0.013*	12	52.2	0.013*	13	56.5	0.007*	9	39.1	0.016*
	Control	19	82.6		4	17.4		21	91.3		2	8.7	
Speech rate	Case	6	26.1	0.345	12	52.2	0.234	5	21.7	0.063#	12	52.2	0.070#
	Control	9	39.1		8	34.8		11	47.8		6	26.1	
Articulatory precision	Case	7	30.4	0.134	15	65.2	0.234	8	34.8	0.039*	15	65.2	0.039*
	Control	12	52.2		11	47.8		15	65.2		8	34.8	

* Significant values (p<0.005) – Test of Equality of Two Proportions
# Differences that tend to be significant

Table 2. Comparison of perceptual parameters, 90-50 dB relation, between Study (reporters) and Control (non-reporters) groups

Parameters	Group	Intensity					
		90-50 dB Increased			90-50 dB Remained		
		n	%	p-value	n	%	p-value
Loudness	Case	13	56.5	0.765	10	43.5	0.765
	Control	14	60.9		9	39.1	
Pitch	Case	11	47.8	0.375	10	43.5	0.765
	Control	14	60.9		9	39.1	
Strain	Case	10	43.5	0.555	13	56.5	0.555
	Control	12	52.2		11	47.8	
Speech rate	Case	4	17.4	0.179	15	65.2	0.139
	Control	8	34.8		10	43.5	
Articulatory precision	Case	7	30.4	0.227	16	69.6	0.227
	Control	11	47.8		12	52.2	

Test of Equality of Two Proportions (p<0.005)

Table 3. Comparison of acoustic parameters, absolute values, between the Study (reporters) and Control (non-reporters) groups

Parameters	Group	Intensity					
		0 dB		50 dB		90 dB	
		Absolute value	p-value	Absolute value	p-value	Absolute value	p-value
F0 min	Case	107.50	0.339	109.12	0.215	106.49	0.042*
	Control	116.36		118.71		125.32	
F0 max	Case	322.67	0.106	335.12	0.184	333.70	0.503
	Control	288.96		312.59		319.87	
F0 mean	Case	194.55	0.386	201.31	0.801	206.40	0.991
	Control	183.83		200.35		208.56	
Variability Hz	Case	215.17	0.007*	226.00	0.016*	227.20	0.040*
	Control	172.6		193.88		194.53	
Mean Intensity	Case	56.69	0.510	59.94	0.198	61.62	0.029*
	Control	56.20		61.30		63.68	
Duration of segment	Case	12.45	0.253	12.57	0.187	12.77	0.006*
	Control	12.27		12.21		12.06	

* Significant values (p<0.005) – Mann-Whitney Test

auditory-perceptual data relating the work experience and previous auditory training. Statistical analysis showed that there were differences in the parameters articulatory precision and speech rate with 50 dB of masking, and in the parameters loudness, pitch, strain, and speech rate with 90 dB, when auditory training was taken into consideration. However, the same pattern did not happen with the variable work experience. Thus, it was ascertained that there was greater increase in

Table 4. Analysis of perceptual parameters related to previous auditory training

Parameters	Training	Intensity											
		50 dB Increased			50 dB Remained			90 dB Increased			90 dB Remained		
		n	%	p-value	n	%	p-value	n	%	p-value	n	%	p-value
Loudness	With training	2	29	0.074#	5	71	0.074#	2	29	0.001*	5	71	0.001*
	Without training	11	69		5	31		15	94		1	6	
Pitch	With training	2	29	0.340	5	71	0.221	2	29	0.015*	5	71	0.001*
	Without training	8	50		7	44		13	81		1	6	
Strain	With training	2	29	0.221	5	71	0.221	2	29	0.074#	5	71	0.036*
	Without training	9	56		7	44		11	69		4	25	
Speech rate	With training	0	0	0.059#	6	86	0.033*	0	0	0.095#	6	86	0.033*
	Without training	6	38		6	38		5	31		6	38	
Articulatory precision	With training	0	0	0.036*	7	100	0.021*	1	14	0.106	6	86	0.106
	Without training	7	44		8	50		8	50		8	50	

* Significant values (p<0.005) – Test of Equality of Two Proportions
# Differences that tend to be significant

articulatory precision, loudness and pitch in the presence of 50 dB and 90 dB of masking in the group without training. The trained group showed little change in loudness, pitch, strain and speech rate in the presence of 90 dB of masking when compared to 50 dB (Table 4).

Acoustic data also revealed differences among subjects from the Study Group regarding auditory training. In the presence of 50 dB and 90 dB, the values of maximum and mean intensity for the untrained group were higher than for the group with previous training. The untrained subjects had higher values of maximum intensity (78.6 dB) when compared to trained subjects (76.1 dB) in the situation with 50 dB of masking. The same occurred with 90 dB of masking among untrained (80.3 dB) and trained subjects (76.8 dB). The acoustic parameter mean intensity was also superior in the untrained group in both situations, as follows: with 50 dB of masking, the mean intensity was 58.1 dB in the trained subjects and 60.8 dB in the untrained ones; with 90 dB, the mean was 59.3 dB in the trained group and 62.6 dB in the untrained group.

DISCUSSION

The increase in vocal intensity can be considered one of the phonotraumatic situations that most affects and endangers vocal health. Noise is considered one of the main factors that contribute to increase vocal intensity, as it interrupts the auditory feedback and compromises phonatory control. Several studies have sought to better understand the vocal behavior of individuals in noisy situations[(2,7,11,12,15,16)]. The results obtained in the present research answer the questions that guided the study.

According to these results, both groups in this study presented voice changes characterized by increased loudness, pitch and strain. Similarly, a survey conducted with individuals with Parkinson's disease showed improvement in their voice quality in the presence of noise, probably due to the increased loudness and strain, and better articulatory precision[(17)]. These data corroborate the findings of research that explain the Lombard effect[(7,18-21)]. Ramig et al. observed that the increase in vocal intensity is associated directly with a more precise articulation in individuals that were submitted to the LSVT® method[(22)]. As with the LSVT®, masked speech triggers the setting of increased intensity, and there is an improvement in other speech subsystems, working on joint action. Therefore, this statement explains the fact that the control group has increased articulatory precision in the presence of 90 dB of masking.

Both groups showed an increase in intensity and frequency means when 50 dB and 90 dB of masking were introduced. This result was observed in the literature, which states that the absence of auditory feedback causes changes mainly characterized by lack of control in intensity and shift of the fundamental frequency[(12,15)]. In the present study, the acoustic values of frequency variability in Hz were higher in the presence of masking noise. This result corroborates the findings of a study that had the aim to characterize the vocal capacity of 252 students and concluded that the increase in vocal intensity caused shift of the fundamental frequency[(23)].

The results of this study demonstrate that a larger number of subjects in the Study Group preserved the parameters loudness, pitch and strain in the presence of 50 dB and 90 dB of masking. This finding leads us to reflect on other ways of voice control and monitoring, because even with the impairment and interruption of auditory feedback, some professionals have managed to preserve vocal parameters. A survey with 28 singing students estimated the significance of auditory and kinesthetic feedback in the control of vocal frequency. The results showed that the accuracy of intonation was reduced with impairment of auditory feedback and, in these conditions, singers should rely on the kinesthetic feedback circuits[(13)].

Several studies have sought to better understand the vocal behavior of normal individuals[(2,6,14)], subjects with communication disorders[(12,17)], and professional voice users[(13,16)] in the presence of noise. Others have addressed the vocal training and the capacity to inhibit the Lombard effect. In this sense, experiments were conducted to test and inhibit the Lombard effect by means of instruction and/or training with visual feedback[16,20]. According to an experiment in which participants were separated into two groups (experienced in speaking in noisy situations group and inexperienced group), it was found that, when the instruction was provided, the experienced subjects had greater capacity to keep the vocal intensity constant, regardless of the noise. However, none of the groups was able to completely suppress the Lombard effect even when instructions were combined to visual feedback[20]. Following the same line of research, another study with 27 choir singers evaluated the effect of instruction in the inhibition of the Lombard effect[16]. The author concluded that instructions were effective to suppress the Lombard effect. Thus, singers can learn to resist and consciously regulate the automatic response of increasing the vocal intensity in noise. Therefore, in the present study, the findings of greater vocal control in the noise by the Study Group and especially by those who have had previous training, corroborate the data reported in literature, since the reporters, as well as singers, suffered interruption of auditory feedback by noise and needed to use other means for monitoring their voices.

In this study, there were no differences between the reporters' work experience and changes in acoustic and perceptual vocal parameters. However, it was observed that previous auditory training contributed in some extent to inhibit the negative consequences of the Lombard effect[16,20]. Although there is no information about the type, frequency and duration of the training performed by these reporters, we observed that this feature might help to control vocal parameters in noise. Hence, further research is needed to identify the ideal techniques to inhibit or minimize the Lombard effect. These studies may benefit professionals who use their voices in noisy environments, such as reporters, and therefore help to prevent vocal disorders arising from the use of voice in these environments.

CONCLUSION

In the presence of masking noise, reporters and non-reporters present changes in voice and speech production characterized by an increase in loudness, pitch, strain and articulatory precision, with major shifts in the non-reporters. Thus, professional voice users can minimize the negative consequences of the Lombard effect and maintain the stability of the emission when exposed to noise situations, probably due to activation of kinesthetic feedback pathways.

Reporters with previous auditory training demonstrate greater ability to suppress the Lombard effect, with minor changes in vocal parameters in the presence of noise. Work experience is not a determining factor for preserving vocal parameters in noisy situations.

RESUMO

Objetivo: Verificar e comparar a ocorrência das modificações vocais de repórteres e não-repórteres na presença de ruído mascarante. **Métodos:** Participaram 46 sujeitos, sendo 23 repórteres e 23 não-repórteres (grupo controle), todos com audição normal. Os participantes deveriam ler um trecho de uma matéria de telejornal em três situações de escuta: sem ruído mascarante, com ruído de 50 dB, e com ruído de 90 dB. As narrações foram gravadas e submetidas à avaliação perceptivo-auditiva (realizada por uma fonoaudióloga especialista em voz) e análise acústica (medidas extraídas por meio do Software Voxmetria – CTS Informática). **Resultados:** Com 50 dB de mascaramento, houve maior aumento nos parâmetros *pitch* (82,6%), *loudness* (91,3%) e tensão (82,6%) no grupo controle, quando este foi comparado ao grupo dos repórteres. O mesmo ocorreu com ruído de 90 dB para os parâmetros *pitch* (95,7%), *loudness* (100%) e tensão (91,3%). **Conclusão:** As consequências negativas do efeito Lombard ocorrem em ambos os grupos, porém, pelas respostas apresentadas, os repórteres demonstram conseguir inibir parcialmente o impacto negativo das situações de ruído, por provável estabilidade da emissão profissional e ativação de outras vias de monitoramento.

Descritores: Voz; Qualidade da voz; Mascaramento perceptivo; Efeitos do ruído; Treinamento da voz; Percepção sonora

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