SOME ACOUSTIC-PHONETIC PARAMETERS OF THE LOMBARD EFFECT FOR THE VOICE TRAINED

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ABSTRACT

Continuous speech of 23 subjects was recorded with and without masking noise. The group was composed of Voice Trained (n=12) and Untrained (n=11) Male and Female Francophone subjects. The objective of the investigation was to find out how are *spectral levels* and *voice quality* affected under masked conditions for the different groups. Results show:1.Voice Trained subjects increase vocal levels less than Untrained subjects under masked conditions, therefore showing an attenuated Lombard effect. 2. Some reported voice quality measurements (1.αAB= >1000Hz / <1000Hz, 2.θ=F1 / F0) do not seem to apply to speech of Francophones.

1. INTRODUCTION

It is well known that the presence of noise produces an increase in vocal levels ([3]Lombard, 1911; [2]Lane and Tranel, 1971). Recently [4] Pick Jr. et al. (1989) suggested that through training the effect could either be enhanced or reduced but not completely eliminated.
It is quite possible that people with voice training would be more apt to react differently to that effect. It has been shown, for example, that when singing in noise, trained singers' performance deteriorates less than that of amateur musicians ([6]Ward & Burns, 1978). That is attributed to a process of kinesthetization, whereby vocal experience allows the performer to monitor the voice by proprioceptive rather than by auditory cues. Less dependent on auditory feedback, voice trained subjects would be less perturbed by noise and would therefore have the ability to preserve their voice quality. That ability should also be present in running speech. The objective of this study is to verify how are vocal levels of voice trained subjects affected when speaking in noise and whether voice quality is affected.
The research quastions are the following: 1.Are there long-term *spectral* level differences, at particular frequency intervals, of continuous speech, between voice trained and untrained subjects when speaking in noise?
2.Are there long-term *voice quality* differences, of continuous speech, between voice trained and untrained subjects when speaking in noise?

2. METHOD

2.1. Voice quality measurements

An acoustic measure of voice quality was proposed by [1]Frokjaer-Jensen and Prytz (1976) as α=intensity above 1kHz / intensity below 1kHz. [7]Wedin et al. (1978) seemed to confirm the utility of this measure in speech with a group that had undergone voice training. [5]Sundberg and Gauffin (1978), seemed to suggest that in singing, judging the higher spectra as a measure of good quality is misleading because it could be obtained with an increased vocal effort ("pressed" phonation) which is not characteristic of trained male singers. They proposed that a measure of good quality is a higher increase of energy in the F0 area relative to the F1 area of trained subjects ("flow" phonation). In order to utilize these voice quality acoustic measurements, this experiment extracted Long Term Average Spectra for the following intervals:
F0e:Log energy at interval 80-160Hz for men, 160-250Hz for women
F1e: Log energy at interval 315-600Hz
B1K: Log energy below 1kHz (80-800Hz)
A1K: Log energy above 1kHz (1000-5000Hz)
θF1F0: F1e minus F0e
αAB= A1K minus B1K

These intervals also served to compare spectral levels.

2.2. Subjects

The group of 23 subjects was composed of 1. Voice Trained (n=12) and Untrained subjects (n=11). Subjects with abnormal hearing or with mother tongues other than Canadian French (Francophones) were excluded. The trained subjects were either members of a well known choir or professional actors and radio announcers. The subjects donated their time without pay.

2.3. Materials

The French text, of phonetically balanced contents lasting approximately one minute of reading time, was edited from existing literary materials.

2.4. Procedure

The subjects were recorded while reading the same one minute text under three conditions: 1.Normal reading (S); 2.With right ear masked with a 75dB white noise(SRM); 3.With left ear masked with a 75dB white noise(SLM).
All the recordings, and the audiometric screening, were conducted in a soundproof cabin (I.A.C.). The microphone was a Sennheiser MD441-U (filtration switch on 'M'), the tape recorder a full track Revox 77A (tape speed 15 ips), and the tapes Ampex 406.
The masking noise was produced with the Maico Precision Hearing Test Instrument MA-24, through Maico headphones with one earphone removed. In the conditions of masking, the subjects had one ear masked with noise whereas the other remained free. This procedure was adopted for future analysis of

laterality effects. The recordings were performed at one foot distance from the microphone and the order of the three conditions was systematicaly varied for succeeding subjects.

2.5. Analyses

The recorded samples were analyzed with an Ono Sokki CF300 spectral analyzer for Long Term Average Spectra at 1/3 octave intervals, 16-kHz range, for 128 spectra. The data was transfered and digitized in an IBM microcomputer through a software package designed for the project and then transfered to the mainframe computer where Spectral levels were determined for each of the three recording conditions.

3. RESULTS

Mean energy levels (dB) of voice TRAINED Francophones (N=12) and UNTRAINED Francophones (N=11) subjects for three speech production conditions measured over selected (1/3 octave) intervals.

Speech condition		F0e	F1e	θF1F0	B1K	A1K	αAB
		Interval (dB)					
Normal Speech(S)	Tr.Fra.:	-21.73	-22.14	-0.41	-17.93	-29.61	-11.67
	Untr.Fra.:	-20.96	-20.48	0.47	-16.53	-28.04	-11.51
		**	***		***	**	
Speech with right ear masked (SRM)	T:	-21.06	-19.86	1.20	-16.60	-26.64	-10.03
	U:	-18.28	-15.60	2.67	-12.66	-21.90	-9.24
		*	**		**	*	
Speech with left ear masked (SLM)	T:	-21.81	-20.84	0.97	-17.45	-27.29	-9.83
	U:	-18.54	-16.71	2.14	-13.62	-23.60	-9.98
		*	*		**		
S-SRM (R)	T:	-0.66	-2.28	-1.62	-1.32	-2.97	-1.64
	U:	-2.68	-4.88	-2.19	-3.87	-6.14	-2.26
		**	*		**		
S-SLM (L)	T:	0.08	-1.30	-1.38	-0.47	-2.32	-1.84
	U:	-2.11	-3.77	-1.66	-2.91	-4.43	-1.52

* significant at the 0.05 level
** significant at the 0.01 level
*** significant at the 0.001 level
F0e: Energy at interval 80-160Hz for men, 160-250Hz for women
F1e: Energy at interval 315-600Hz
B1K: Energy below 800Hz (80-800Hz in 1/3 octaves)
A1K: Energy above 1000Hz (1000-5000Hz in 1/3 octaves)

The table above shows the following results:

1. There are no significant differences in the Normal Speech condition for spectral levels (F0e, F1e, B1K, A1K) and voice quality (θF1F0, αAB) between trained and untrained subjects.
2. Spectral levels of voice trained subjects are significantly lower in both masked conditions (For SRM: F0e, $p<.01$; F1, $p<.0006$; B1K, $p<.0005$; A1K, $p<.002$; for SLM: F0e, $p<.02$; F1, $p<.002$; B1K, $p<.002$; A1K, $p<.04$).
3. There are no significant voice quality differences (θF1F0, αAB) in the masked conditions between trained and untrained subjects.

4. DISCUSSION

There are no significant voice quality differences either in the normal nor in the masked speech conditions for the two groups. It is possible that the voice quality measurement αAB proposed for speech is linguistically related and therefore not appropriate for French. Trained Francophones do not have more energy in the region above 1000Hz relative to the lower frequencies.
The other voice quality measurement, θF1F0, was proposed for singing. That might explain why it did not distinguish the speech of the voice trained.
When speaking in noise, lower vocal levels clearly distinguished the voice trained from the voice untrained and confirmed that voice training diminishes the Lombard effect.

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5. REFERENCES

[1] Frokjaer-Jensen, B., and Prytz, S. (1976). "Registration of voice quality," Bruel & Kjaer, Technical Revue, 3, 3-17.
[2] Lane, H. and Tranel, B. (1971). "The Lombard Sign and the Role of Hearing in Speech," J.Speech Hear.Res.14,677-709.
[3] Lombard, E. (1911). "Le signe de l'elevation de la voix," Annales des Maladies de l'Oreille et du Larynx, 37,101-119.
[4] Pick Jr., H.L., Siegel, G. M., Fox, P.W., Garber, S.R., Kearney, J.K.(1989). "Inhibiting the Lombard Effect," J. Acoust. Soc. Am. 85,2, 894-900.
[5] Sundberg, J., and Gauffin, J.(1978). "Waveforms and spectrum of the glottal voice source," Speech Transmis. Lab. Q. Prog. Stat. Rep. STL-QPSR 2-3, Royal Institute of Technology, Stockholm, Sweden, 35-50.
[6] Ward, W.D., and Burns, E.M.(1978). "Singing without auditory feedback," J. of Res. in Singing, 1, 2, 24-44.
[7] Wedin, S., Leanderson, R., and Wedin, L. (1978). "Evaluation of Voice Training. Spectral Analysis Compared with Listeners' Judgements," Folia Phoniatrica, 30, 103-112.