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# Effect of Anger on EMG Signals Generated in Occipitofrontalis Muscle for Palatal Consonants

**Teena Sharma[1],**
M.Tech., Dept. ECE, Beant College
College of Engineering and Technology,
Gurdaspur India[1]

**Mandeep Kour[2]**
HOD, Dept. ECE, Beant College
College of Engineering and Technology,
Gurdaspur India[2]

**Jang Bahadur Singh[3]**
Scholar, Dept of Physics and Electronics,
University of Jammu,
India[3]

**Parveen Lehana[4*]**
Associate Professor,
Dept of Physics and Electronics,
University of Jammu, India[4*]

***Abstract***— ***It is well known that a strong relationship exists between human speech and the movement of articulatory facial muscles. The movement is introduced by the signals called electromyographic signals. Electromyography (EMG) is a technique for evaluating and recording the electrical activity produced by muscles. An electromyography detects the electrical potential generated in the muscle cells when these cells are electrically or neurologically activated. The signals can be used to detect medical abnormalities, activation level, recruitment order, or to analyze the biomechanics of human or animal movement. The objective of the paper is to study the effect of normal and anger speech on EMG signals generated in occipitofrontalis muscle for palatal consonants. Recording was carried out using four subjects (two males and two females) in the age group of 22-25 years. Both speech and EMG signals corresponding to five vowel-consonants (VCVs) in Hindi were recorded at 16 KHz and 16-bit quantization. Log-spectral-distances (LSDs) between the EMG signals of the VCVs of anger in reference to EMG of normally spoken VCVs were computed. Analysis of the spectrograms and mean LSD showed that the anger introduces visible changes in the LSD.***

***Keywords— Speech, Speech generation, EMG signals, Unvoiced speech, Occipitofrontalis muscle.***

## I. INTRODUCTION

Electromyography (EMG) is an experimental technique concerned with the development, recording, and analysis of myoelectric signals. It is the study of muscle function through the electrical signals the muscles emanate. It is used to record and analyse the myoelectric signals which are formed by physiological deviations in the muscle fibber membranes [1]. Myoelectric signals are formed by physiological variations in the state of muscle fiber membranes [2].

The electromyographic signal measures electrical potential in muscles during its contraction representing neuromuscular activities. It is a result of the summation of all Motor Unit Action Potentials (MUAP) in the area close to the electrodes position. It is a stochastic signal. As raw EMG does not present important information in a particularly useful form therefore advance technologies of signal processing and mathematical models have been developed to detect and analysis the raw EMG. In the time domain, commonly used parameters are: the root-mean-squared (RMS) value and the average rectified value. They both are suitable for the measurements of the signal amplitude [3-5]. Mathematical models used for the analysis include wavelet transform (WT), time-frequency approaches, Fourier transform, Wigner-Ville distribution, statistical measures, and higher-order statistics [6]. It is important to note that the selection of suitable processing technique depends on the physiological characteristics of the muscles [7]. WT is a valuable tool to extract information from the signal [8]. It yields a high-dimensional feature vector [9], [10]. The common procedures for recording the EMG signal are surface and needle/wire electrode. Some applications of surface electromyography (SEMG) include estimation of muscle fiber conduction velocity, diagnosis, and clinical application with new electrode design, biomechanics and motion Analysis, speech recognition, and prosthetic device development [11].

The objective of the paper is to study the effect of normal and anger speech on EMG signals generated in occipitofrontalis muscle for palatal consonants. The basics of human speech production are presented in Section II. The methodology of the investigations is given in Section III. The results and conclusions are presented in Section IV.

## II. HUMAN SPEECH PRODUCTION

Speech is the vocalized form of human communication. It is based upon the syntactic combination of lexical and names that are drawn from very large (usually about 10,000 different words) vocabularies. Each spoken word is created out of the phonetic combination of a limited set of vowel and consonant speech sound units. Fig. 1 shows the human speech produced by vocal organs [12].

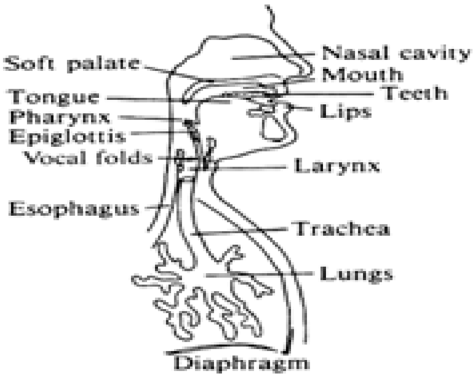


Fig. 1 Human speech production system [7].

Lungs are the main energy source with diaphragm. They force air flow through the glottis between the vocal cords and the larynx to the three main cavities of the vocal tract, the pharynx and the oral and nasal cavities. From the oral and nasal cavities the air flow exits through the nose and mouth, respectively. Glottis is the V-shaped opening between the vocal cords is the most important part in the sound source in vocal system. During speech production vocal cords may act in several different ways, the most important function is to modulate the air flow by rapidly opening and closing which cause buzzing sound from which vowels and voiced consonants are produced [13].

Several artificial vocal tract models have been developed to produce human speech by many researchers [14-19]. In this research paper two artificial models are discussed. Laine in 1982 introduced and patented PARCAS (Parallel-Cascade) model for speech synthesis in Finnish. Fig. 2 shows the PARCAS model and it consists of uniform function of vocal tract model with two partial transfer functions, each including formant of the transfer function. Coefficients k1, k2, and k3 are constants and chosen to balance the formant amplitudes in the neutral vowels to keep the gains of parallel branches constant for all sounds [20]. Sixteen control parameters are used by the PARCAS model are

- F0 and A0 - fundamental frequency and amplitude of voiced component
- Fn and Qn - formant frequencies and Q-values (formant frequency / bandwidth)
- VL and VH - voiced component amplitude, low and high
- FL and FH - unvoiced component amplitude, low and high
- QN - Q-value of the nasal formant at 250 Hz

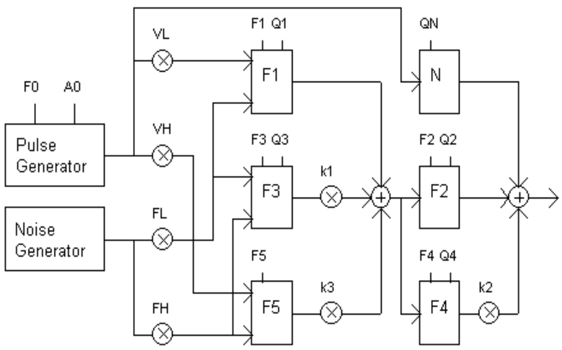


Fig. 2 Schematic of PARCAS model.

Second model PSOLA (Pitch Synchronous Overlap and Add) is a digital signal processing technique used for speech processing and more specifically speech synthesis. It can be used to modify the pitch and duration of a speech signal. PSOLA works by dividing the speech waveform in small overlapping segments. To change the pitch of the signal, the segments are moved further apart (to decrease the pitch) or closer together (to increase the pitch). To change the duration of the signal, the segments are then repeated multiple times (to increase the duration) or some are eliminated (to decrease the duration). The segments are then combined using the overlap adds technique. PSOLA can be used to change the prosody of a speech signal. Time domain version (TD-PSOLA) is commonly used due to its computational efficiency [21]. The basic algorithm consists of three steps: analysis step in which where the original speech is segmented; modification of each analysis signal to synthesis signal; synthesis step where these segments are recombined by means of overlap-adding. Small signals $x_m(n)$ are obtained from digital speech waveform $x(n)$ by multiplying the signal by a sequence of pitch-synchronous analysis window $h_m(n)$:

$$x_m(n) = h_m(t_m - n)x(n)$$

 

where $m$ is an index for the short-time signal. Hanning type window is usually used which are centred around the successive instants $t_m$, called pitch-marks. The segment recombination in synthesis step is performed after defining a new pitch-mark sequence.

## III. METHODOLOGY

In order to investigate the facial EMG patterns generated by uttering palatal consonants in VCV syllables for both normal and anger expressions, experiments were conducted with four subjects (two males and two females) having age between 22-25 years. The speech signals and the corresponding EMG signals were recorded using a data acquisition system at the sampling frequency of 16 kHz and 16-bit quantization. Electrodes were placed at occipitofrontalis minor, occipitofrontalis major, and mentalis points on the face. Block diagram of the experimental setup for recording is shown in Fig. 3. The recorded signals were segmented and labelled manually into separate files for each of the VCVs. The signals were analysed using time-domain patterns, spectrograms, and mean log-spectral-distances. For computing LSD, the normally spoken VCVs of each subject were taken as the reference.

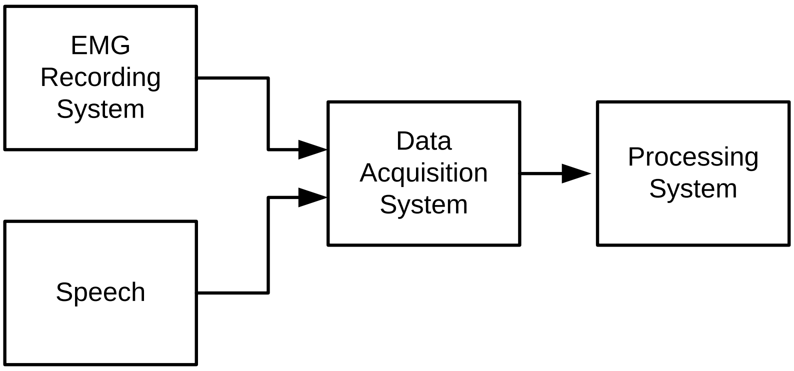


Fig. 3 Schematic block diagram for EMG signal acquisition

## IV. RESULTS AND CONCLUSIONS

The various investigations were carried out using time-domain signals and the corresponding spectrograms of the speech and facial EMG signals for five palatal consonants आचा, आछा, आजा, आझा, and आञा. Spectrograms along with the time-domain waveforms are shown in Fig. 4 and Fig. 5. Here the x-axis represents the normalized time and y-axis represents the normalized frequency. The signals and the corresponding spectrograms show that the signals generated vary across the subjects, syllables, and emotional content. Table I shows the means and standard deviations of LSD for one of the subject. For visual analysis, these are also plotted in Fig. 6 in the form of histograms.

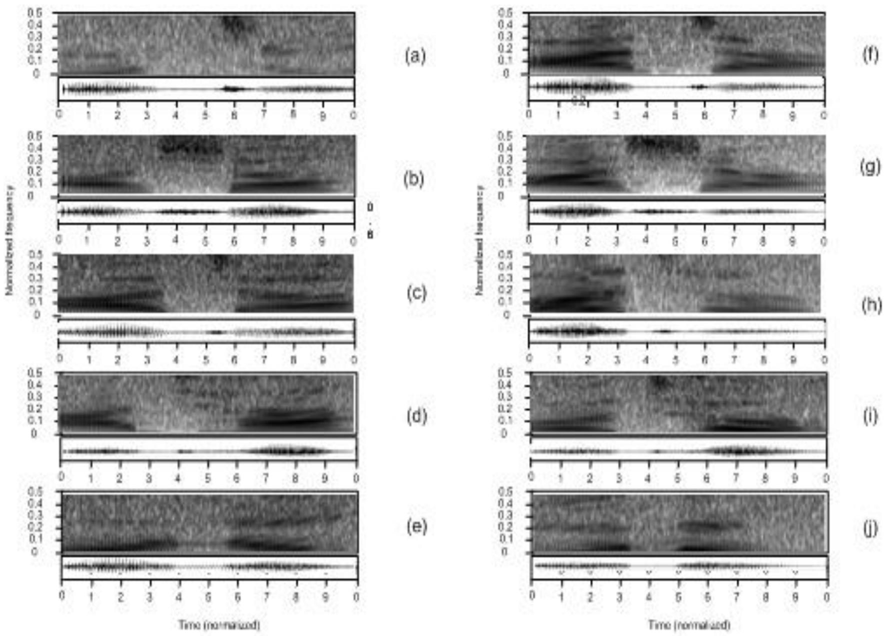


Fig. 4 Spectrogram of speech signals for palatal consonants (a) normal आचा (b) normal आछा (c) normal आजा (d) normal आझा
(e) normal आञा (f) anger आचा (g) anger आछा (h) anger आजा (i) anger आझा (j) anger आञा for Sp1.

 

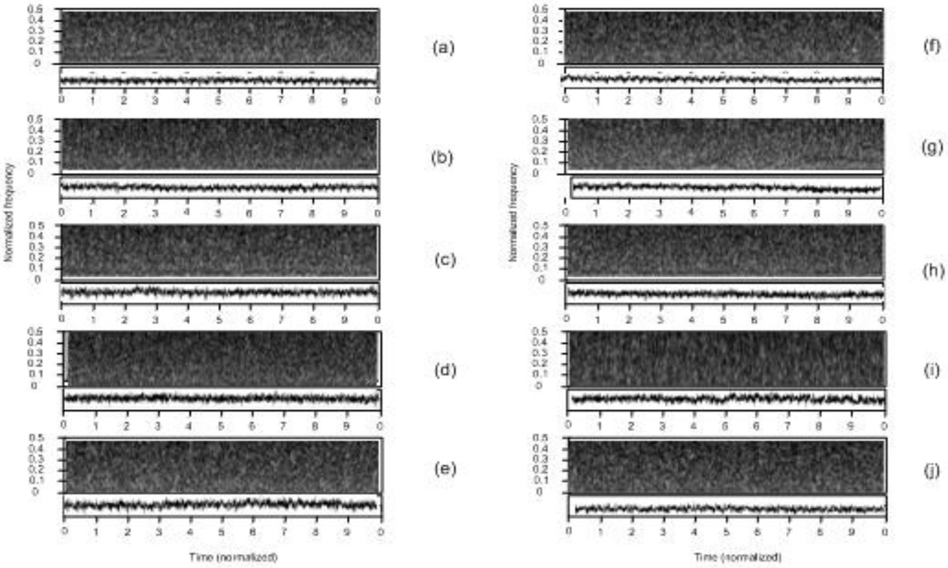


Fig. 5 Spectrogram of EMG signals for palatal consonants (a) normal आचा (b) normal आछा (c) normal आजा (d) normal आझा (e) normal आञा (f) anger आचा (g) anger आछा (h) anger आजा (i) anger आझा (j) anger आञा for Sp1.

Table I. Mean and standard deviation of LSD

| *VCB* | *Palatal consonants* | |
|---|---|---|
| | *Mean* | *S.D* |
| आचा | 7.844 | 0.711 |
| आछा | 8.090 | 0.816 |
| आजा | 7.704 | 0.717 |
| आझा | 7.812 | 0.655 |
| आञा | 7.957 | 0.648 |

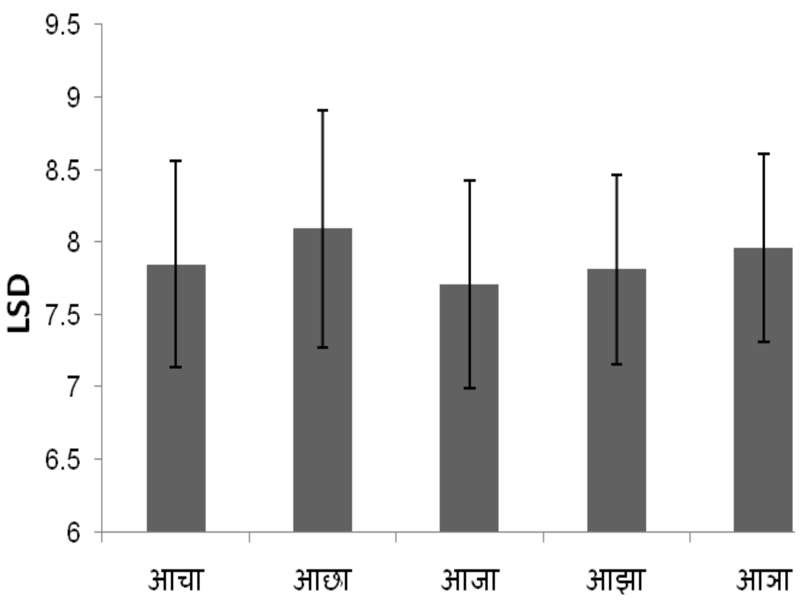


Fig. 6 Histograms of mean LSDs and SD for the Table I

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