Effect of Noise on Facial EMG

Sanjay Kumar*(1), Dinesh Kant Kumar (2), Melaku Alemu (1), and Mark Burry (1)

(1) Spatial Information Architecture Laboratory, RMIT University GPO BOX 2476 Melbourne VIC 3001,Australia, Phone-61-03-99259578 Fax-61-3-99253460, E-mail: Sanjay.Kumar@rmit.edu.au

(2) School of Electrical and Computer Engineering, RMIT University GPO BOX 2476 Melbourne VIC 3001,Australia, Phone-61-03-99251954 Fax-61-3-99252007, E-mail : dinesh@rmit.edu.au

Abstract

Noise is the single biggest source of complaints in large cities around the world and is a cause of stress and reduced human efficiency. In the past, questionaries have been widely used in order to assess the effects of noise on human. The difficulty with this technique is the lack of objectivity leaving a room for doubt. This paper presents a result of a preliminary investigative work in which facial electromyography (EMG) is monitored while experimental subjects are exposed to noise. Sound or noise stimuli with varying properties at different level have been used and facial EMG observed. Facial EMG activities in facial muscles (M. *frontalis laterali*, M. *orbicularis oculi*, and M. *zygomaticus major*) have been recorded and investigated. The preliminary experimental outcomes indicate that there is an increase in the activity of the facial EMG as the level of the noise increases. It has been also observed that in order to draw a pattern between the emotional state of humans and the level of a given noise or sound, more enhanced analysis techniques as well as a larger number of subjects are required.

Introduction

Noise is the single biggest source of complaints in large cities around the world and is a cause of stress and reduced human efficiency. Stress has been identified as the major health risk contributing to major chronic diseases which cause heart attacks, cardiovascular effects, increased blood pressure, increased intestinal motility and activity correlated with ulcer formation, depression, emotional illness and antisocial behaviour [1-3]. Many other problems arise from noise: annoyance, interference with conversation, leisure or sleep, effects on the efficiency of work. In any of the above-mentioned circumstances, it is necessary to note the obvious complication that the sounds, which may offend some people, may be regarded by others as desirable. The offending noise may even be intentionally produced as a source of pleasure and enjoyment. Music, for example, can be seen as a source of conflict depending on individual taste. Currently, there is no debatable method of measuring annoyance as such, but it is possible to obtain a subjective indication of the level of annoyance by asking a sufficient number of people about their reactions.

Investigations of the effects of noise on human emotions have been conducted using subjective techniques such as questionnaire [4-5]. However, it has been observed that the use of questionaries is often flawed and unsatisfactory because it carries with it factors not related to the experiment. To overcome this shortcoming, this research reports the use of some objective measures of the human emotional state.

The electrical activity of the facial muscles (facial electromyography EMG) may be used as an indicator of human emotional expressions [6]. Facial EMG provides a way to analyze and observe the emotional state of humans under the influence of external stimuli that might be minimally detected visually.

A number of researchers have attempted to relate various facial EMG activities to specific human emotions [6-20]. Anger expressions produce, for example, an increased EMG activity of corrugator supercilii (frown) muscle, while joyful expressions produce increased zygomaticus major (smile) muscle activity [6]. Dimberg, et al [12], has found certain typical facial activity patterns depending on the type of auditory stimuli. Different kinds of auditory stimuli have evoked different types of emotional reactions. According to their findings, a pleasant auditory stimulus has a tendency to evoke M. zygomaticus major, M. orbicularis oculi, facial muscles near to the lip, while unpleasant auditory stimuli can evoke M. corrugator supercilii muscles, which narrow the eyes [6]. However, they have concluded that it is not possible to differentiate facial reactions in response to different noise level. Similarly, using EMG as an indicator, Ekman et al [21] have introduced a coding system allowing for the registration of changes in facial expressions. The coding method, however, has the drawback that intense training is required to optimize the inter-reliability, which makes the method time consuming [6][21-22].

This work, as a preliminary investigation, is an attempt to observe any change in the facial EMG activity under various noise stimuli. The preliminary experiments were conducted to investigate whether different noises, such as white noise of different sound pressure level, can evoke different facial reaction patterns. The work closely emulates the study that was done by Lutz Jancke et al [6] except that the selected facial muscles and level of noise are different.

Experiment

This experiment was similar to the experimental design of studies in references [6] [18]. In which high and low levels of various noises were presented to test whether there are different reactions of M. *Frontalis laterali* and *M.Zygomaticus major*. These authors used three levels in decreasing order (95, 85 and 75 dB (A)) while recording the facial EMG patterns. In our experiment, the participants were presented with white noise at four different levels 65, 75, 85 and 90 dB (A) in an increasing order. EMG reactions over the three facial muscles (M. *frontalis lateralis*, M. *orbicularis oculi*, and M. *zygomaticus major*) were detected. Throughout the recording procedure, subjects were also asked to perform a cognitive task such as word test (mental fatigue, perception and attention test) or English grammar correction.

Figure 1 Schematic Diagram of Electrode Placement 1. M. Frontalis laterali, 2. M. orbicularis oculi, 3. M. zygomaticus major [6]

Participants

A total of five subjects volunteered and participated in this experiments (3 Males and 2 Females). All subjects were right handed (by means of the writing hand) and didn't suffer from any visual, auditory, or neurological impairment. The participants did not receive any financial benefit for their participation. A strict experimentation procedure was followed which was approved by the ethics research committee. Screening of the participants was carried out for smoking and drugs that may alter electrical muscle activity. The participants were asked not to take any caffeine intake within six hours of the experiment. The participants were also asked to minimize bodily movements and to refrain from conversation and laughter during all of the recording segments.

Experimental Procedure

The subject was always sitting alone on a chair and had no eye contact with the experimenter and was advised that he or she was not being observed. In order to divert their attention, all subjects were also provided with similar cognitive tasks and they were fully aware that noise would be part of the experiment. They were not told, however, that the purpose of the noise is to evoke their facial EMG. At the start of the experiment adaptation time was given to relax. A 30 sec facial EMG signal was recorded as a 'baseline condition'. Noise stimulus was delivered for duration of 1min while Facial EMG was being recorded. After the presentation of stimulus was stopped, recording of the EMG signal continued for 30 sec indicating the 'after exposure state'. At the end of the session, subjects were provided with the questionnaire for ranking the auditory stimuli on a 1 to 5 rank according to the intensity (low, medium and high level).

No.	Stimulus Definition	Level
A1	Silence (baseline condition)	40-52 dB (A)
A2.1	Continuous white noise	65 dB (A)
A2.2	Continuous white noise	75 dB (A)
A2.3	Continuous white noise	85 dB (A)
A2.4	Continuous white noise	90 dB (A)

Table 1Auditory Stimuli

Stimuli

Noise stimuli were selected and tabulated as shown in Table 1. The stimuli were produced based on accepted guidelines [17] [23]. The white noise was created and recorded on an audio CD and was calibrated according to the desired said levels. The stimuli were presented to the subjects through two speakers kept 2.5 meters from the participant. The desired levels of stimuli were measured using an integrated impulse sound level meter of (CEL 383 from Lucas CEL Instrument Ltd England), located close to the subject's head.

Facial EMG Recording and Processing

Three Surface Facial EMG (M. *frontalis lateralis*, M. *orbicularis oculi*, M. *zygomaticus major*) were selected for the study. Ag/AgCl electrodes, with 0.5 cm diameter and 1 cm spacing of electrodes, were used in according to accepted recording guidelines [14, 15]. Before electrodes attached, the skin of the participant was cleaned.

The EMG signal was digitized at a sampling rate of 200 Hz. Appropriate digital filters were designed and implemented. Movement artifacts and blink reflexes were removed using a band-pass filter, while the 50 Hz power line noise was filtered out with a notch.

To observe any changes in muscle activity, the recorded raw EMG signal was further processed. Root mean square of the signal is related to the strength of contraction of the muscle and thus was selected and evaluated for this study.

Results and Discussion

Root mean square (RMS) values of the raw signal were used to investigate the effect of noise on facial

EMG. The technique has been tested for a preliminary analysis with five subjects. Table 2 shows the RMS values i.e. magnitude of the EMG signals in milivolts at 75 dB (A). Figure 2 shows the registered raw signals from different facial muscles. Figure 3 is the plot of RMS of different facial muscles and their change in the baseline condition of EMG reaction before, during and after stimulus exposure. The observations from the results are listed below:

- The preliminary results (Table 2) indicate that only the facial muscles in the upper face (M. *orbicularis oculi)* have significant response with respect to the level of the noise. The results indicate a significant rise in the RMS value of the facial muscle M. *orbicularis oculi* at higher levels as compared to the RMS value of EMG registered at lower and medium level noise.
- The RMS values of *Frontalis laterali*, and M. *Zygomaticus major* show little response at the lower and at medium intensity noise level.

The above-mentioned results clearly indicate that facial muscle activity tends to have a linear relationship with respect to the level of the noise and thus with the discomfort of the sound to the human. The results also indicate that facial EMG is an objective measure of the effect of sound on people and thus may be used as an objective measure where the relationship between the sound and effect on human emotions is not known.

To classify all the facial EMG signals with respect to human emotion under the influence of sound or noise, statistically bigger population number as well as more enhanced signal processing techniques have to be implemented. Currently, the authors are investigating the applicability of intelligent system such as neural network for classification and recognition of facial EMG as an indicator of human emotion state.

Further Work

The authors are currently working on the experimentation with the larger population of subject to collect more facial EMG under various noise stimuli. Further work involves the registration and analysis of facial EMG using an intelligent system in conjunction with different levels of natural and environmental noises as stimuli. Future work also involves in developing a system to map out all the emotional states of subjects under different noisy environments and will incorporate analysis of other biosignals alongside facial EMG.

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Sound Pressure Level	RMS (*M. frontalis laterali)*	RMS (M. *orbicularis oculi)*	RMS (*M. zygomaticus major)*
65 dB (A)	0.0008	0.0012	0.0010
75 dB (A)	0.0010	0.0018	0.0007
85 dB (A)	0.0011	0.0018	0.00065
90 dB (A)	0.0009	0.0021	0.0009

Table 2.RMS Magnitude Values in milivolts extracted from Subject 2 at 75 dBA

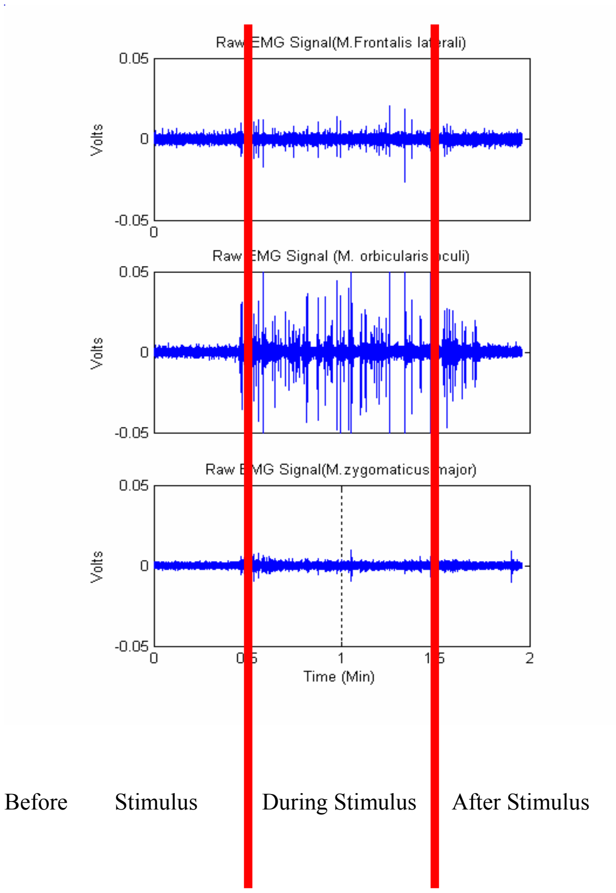

Figure 2.Raw Biosignals extracted (in milivolts) from Subject No 2 at 75 dBA

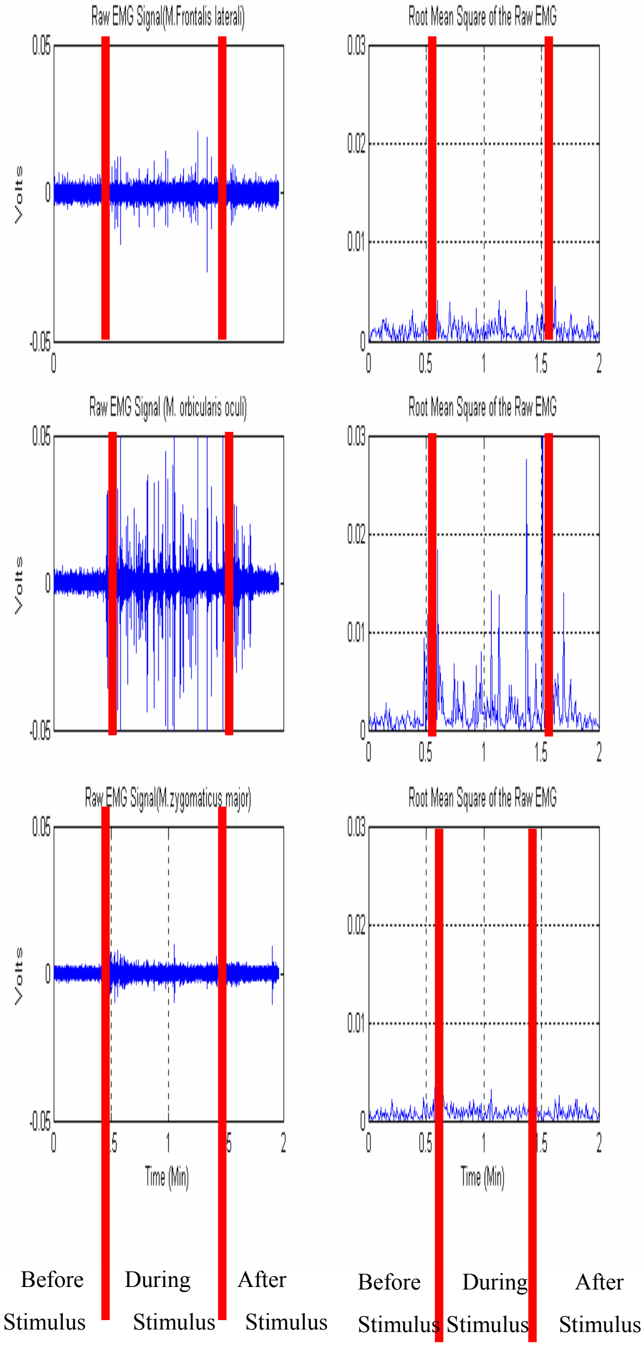

Figure 3.Plot of RMS values in milivolts of Biosignal Examples From Subject No 2 at 75 dBA