Mathematical Modelling Of Human Fear And Disgust Emotional Reactions Based On Skin Surface Electric Potential Changes

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Abstract

The paper deals with skin surface electric potential data registration of a human while he/she is watching specially selected videos that are supposed to activate basic emotions of fear and disgust. We describe the selected video materials and data logging process and present human emotional reactions model, which was implemented by numerical methods. We demonstrate these experimental results of fear and disgust psycho-emotional states that were obtained from 100 respondents.

Keywords: Mathematical model of emotions, skin surface electrical potential, emotion model, numerical indicator of emotional level.

1. Introduction

The classification of human emotional reactions is normally based on the analysis of video data, psychological tests, electroencephalography data, galvanic skin response and other non-invasive methods. We propose developing a numerical model of human emotional reactions as the way to measure the level of experienced emotions, not to classify them. The main objectives of this study were to develop a hypothesis of numerical model to evaluate a person's emotional state and to compare the data obtained in the experiment with the subjective ones received from the interviews.

2. Material and Methods

During the experiment two basic emotions were analyzed, i.e. disgust and fear. We selected them because of the eight basic emotions these two are considered to be the most prominent, easily reproducible and recorded ones. 100 respondents were interviewed. As a basis we took the existing developments to register the skin surface electric potential and adapted them for the investigation. We used the SuTest Pro project source code [1] and Biopulse-TC device for the skin surface electric potential registration. The Biopulse-TC device is characterized by the maximum electric current of 40 μA, the output values are from 0 to 200 standard units, which corresponds to 0 - 50 mV with 0.01 Hz sampling frequency. During the experiment we recorded the electrical skin response in three stages: before, during and after watching a video. The rate of data logging was approximately from 8 to 10 records per second. At the same time we had a psychological polling. For that purpose we developed a psychological test to represent
subjective emotional state in numerical form, that consisted of 41 questions: 10 neutral questions, 10 questions related to one of the basic emotions according to Tomkins [2] and remaining 3 questions for the rest basic emotions. The sequence of questions was generated randomly. The answer to the question was marked on a scale from -3 to +3, where the value of -3 meant that the emotion was not expressed and the value of +3 meant that the emotion was completely expressed at the highest rate. 100 respondents took part in the experiment. To select the most appropriate video material (the most terrible one for fear and the most "disgusting", "hideous" one for disgust), we demonstrated each of the options to 30 respondents. We took into account personal opinions of the respondents and external reactions to the video (mimic, facial expression).

3. Results and Discussion

To analyse the data obtained, all the results were presented in graphical form. In case of disgust we noticed that all the graphs had a descending tendency. Moreover, if there was any development of action in a storyline of the video, we could find insignificant increase in indices during the most emotive parts of the video (Fig. 1).

Fear expression, a peak emotional state (caused by video material), was represented by jumps in the graphs of all respondents (Fig. 2). In our research we supposed that fear and disgust dominate over all human emotions [3].

Our hypothesis regarding each indicator of numerical model (for the state of disgust) is as follows.

The graph tendency is characterized by:

\[ \bar{x}_1 - \bar{x}_2 \]  

(1)

where \( \bar{x}_1 \) is arithmetic mean of initial sample (before watching the video), \( \bar{x}_2 \) is arithmetic mean of final sample (last seconds of watching the video). The value characterizes a common level of the experienced emotion (disgust). It is assumed that the greater the value is, the higher the level of experienced disgust. The indicator that characterizes fluctuations intensity of the graph is:

\[ \sum_{i=1}^{n} |x_i - x_{i-k}| \]  

(2)

where \( n \) is total number of values, \( x_i \) – value, \( x_{i-k} \) – value with the step of \( k \) size. This value characterizes variability of the emotional state. It is assumed that the greater the value, the more stable the emotional state is.

The standard deviation is:

\[ s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2} \]  

(3)

where \( n \) is total number of values, \( x_i \) – value, \( \bar{x} \) – arithmetic mean. This value represents the total change of the emotional state. It is assumed that the greater the value, the higher the level of experienced disgust is.

Our hypothesis regarding each indicator of numerical model (for the state of disgust) is as follows.

The biggest (maximal) fluctuation:
\[ \max |x_i - x_{i-k}|, \ i = \frac{1}{n} \]  

This value represents a peak emotional state, maximal emotion expression (the state of fear). It is assumed that the greater the value, the higher the level of experienced fear.

The maximal standard deviation of fluctuations:

\[ \max s(|x_i - x_{i-k}|), \ i = \frac{1}{n} \]  

It is assumed that this value represents a peak emotional state (the maximal emotion expression (fear)) regarding its own generalized emotional state.

The numerical model presented in our study makes it possible to distribute respondents according to the level of the experienced emotion. Thus, we built distribution for each emotional state separately for all the respondents. We made similar distribution in accordance with numerical polling data.

After comparing psychological polling data and skin electric response indicators for the same video we came to the conclusion that experienced emotional intensity distributions did not match.

The method used for subjective estimation of the emotional state cannot be used for numerical model validation.

4. Conclusions

Mismatch between psychological polling results and final indicators data needs to be investigated further.

For that purpose we suggest to take a Lövheim Cube as a basis [4]. The Lövheim Cube represents 8 basic emotions according to Tomkins, which levels depend on serotonin, dopamine and noradrenaline neuromediator values.

The validation of the proposed numerical indicators for experienced emotion intensity evaluation is possible only after measuring neuromediator levels in the brain during video watching.

We do not consider invasive ways of measurement. The only non-invasive and the most precise way to measure serotonin, dopamine and noradrenaline levels is to study subcortical systems of the brain with FMRT [5].

In case of successful validation, the resulting model will allow us to compare the level of the analysed basic emotions of fear and disgust in number. The results of the research can be used to estimate the strength of the external influence on the emotional state of a person.

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References