

# EMOTION ASSESSMENT TOOL FOR HUMAN-MACHINE INTERFACES

## *Using EEG Data and Multimedia Stimuli Towards Emotion Classification*

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**Abstract:** The identification and assessment of human being emotional states belongs to one of the primordial objectives of the scientific research in disparate areas such as artificial intelligence, medicine or psychology. The main objective of this project is related to automatic assessment of a subject's basic emotional states by using electroencephalography as a source for biometric data acquisition. This evaluation is based on predefined mechanisms of emotional induction, as well as specific methods and tools capable of data analysis and processing. From the experimental results attained in several experimental sessions and through the support tools developed, the most pertinent conclusion extracted from this work refers to the capability of effectively performing automatic classification of the subject's predominant emotional state. The emotional conditions were induced through the presentation of specific visual multimedia contents. The success rate of this tool, compared against the self assessment interviews carried out immediately after the experimental session, was approximately 75%. It was also experimentally concluded that female subjects are emotionally more demonstrative than the male ones.

## 1 INTRODUCTION

Emotions play an important role in all human activities, from the trivial to the most complex ones. This significance is translated both in terms of reality perception and even in the cognitive decision process. Meanwhile, computers have gained such a relevant presence in the modern society that they have been introduced in almost every aspect of it, enhancing the magnitude of ubiquitous computing.

Having these two realities in mind – the importance of emotional states and the necessity of daily interaction with multiple devices – merging them would be a great improvement. By providing the distributed computer systems with the perception of their users' emotions, the applications would be able to adjust their interface, promote and suggest functionalities accordingly. It is believed that this approach would increase the global system's transparency and efficiency as its dynamism would follow in the encounter to user's intentions and temper.

Alongside the ubiquitous computing, multimedia contents are becoming constantly more complex and seemlier to reality, enabling a greater action

immersion sensation, the primitive absolute need of achieving a perfect match between audiovisual contents and the audience desires is still present and constitutes the main key to the industry success.

The alliance between the multimedia contents choice possibility that enables the audience to individually presence what desires and accurate emotional states detection systems leads to subconscious individual interaction between the audience and the multimedia control system, potentiating the perfect match between content and individual audience desires.

This study illustrates an application that enables automatic emotional state assessment using minimal invasive solutions.

## 2 METHODOLOGIES

The emotional induction approach defines the number and main characteristics of the emotional states that will be reproduced in the subject and it can be developed through two main different paths. In order to guarantee the control of the induced emotions and optimize the biometric device (EEG)

used, the emotions' induction through image stimuli is the most suitable method for this study since its quality is greater and more realistic than using other kinds of approaches as audio and video stimuli (Chanel, 2005). The IAPS library is an indicated emotional induction method, as it has been widely used through the research community with similar intentions (Aftanas, 2002) (Chanel, 2005) (Müller, 1999). All the pictures are classified according to their valence, arousal and dominance. The picture selection was based on the concept that the detection, post-analysis and interpretation of the biosignals became more accessible as the pictures are stratified accordingly to its valence value (Aftanas, 2006) (Takahashi K., 2004). For these experimental sessions two discrete emotional states were studied: joy and sadness. It was added a neutral state for control purposes.

The demanding task of finding a specific area of the skull where the brain activity is sufficiently high to detect oscillations, according to the emotional state of the subject, undertook significant improvements with recent studies developed during the last decade (Chanel et al, 2005)(Aftanas et al, 2006) (Aftanas et al, 2004) (Rusalova et al, 2003) (Ebrahimi et al, 2003). The emotional induction produces, in parallel with physiological responses, individual patterns along brain wave amplitude. These patterns have been studied and interpreted in order to locate a suitable position on the human skull where there are strong evidences between specific brain waves oscillations and emotional induction. Accordingly to Aftanas (Aftanas ET AL., 2006), Frontal and Central areas of the brain are the ones where is most likely to occur slight changes of the amplitudes' brain waves due to emotional states.

In Figure 1 it is depicted the amplitude variations along all the brain areas for Joy and Anger. By observing it, it is denoted a higher variation of the waves' amplitude in the Frontal-Central and Central areas for the Anger case. For the Joy case, both Frontal-Central and Central brain areas have a high value for the amplitudes' brain waves variation.

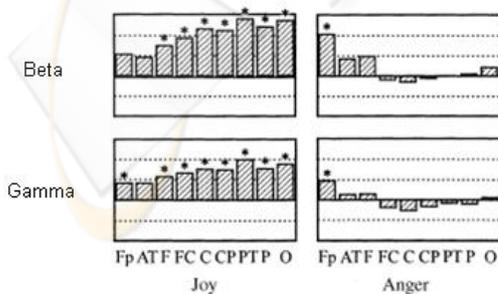


Figure 1: Electrical Brain Activity Variation (Aftanas, 2006).

Before Aftanas's studies, Damásio concluded that patients with the ventromedial areas damaged have significant changes on their emotional behaviour (Damásio, 1994). In Figure 2, it is represented the location of the ventromedial areas, which are integrated in the Frontal-Central and Central areas of the brain.

Taking in account the two opposite emotional states, joy and sadness, as well as the physical limitation of the EEG (one active electrode plus two references), and based on the studies previously developed, the most appropriate area of the skull to locate the active electrode is the middle line, between the Central and the Frontal area, in the ventromedial areas.

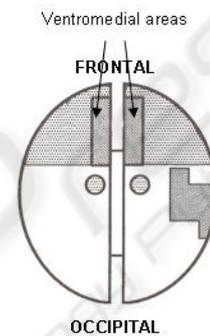


Figure 2: Ventromedial areas. Adapted (Damásio, 1994).

Apart from the electrode location, special attention was given to samples choice and these procedures were carefully followed during the experimental sessions. For this reason, a subject exclusion principle was created. Before each experimental session, a survey had to be filled by the subject in order to discard eccentric subjects – epilepsy, alcohol, caffeine, etc. A total of twenty eight subjects, seventeen males and eleven females, all right-handed, aged eighteen-thirty years old took part in this study.

### 3 RESULTS

The experimental results are presented here, starting with the achieved results and the proof of the initial hypothesis.

#### 3.1 Results Achieved

From the experimental sessions conducted two different kind of results were achieved: the first belongs to the visual analysis performed and is based on the pattern-behaviour defined for the high frequency brain waves; the other concerns to the results obtained from the application of the EAT to

the biometric data captured during the experimental sessions.

The gathered biometric data showed a high degree of similarity between the behaviour of the high frequency brain waves and the hypothesis previously stated when the predominant emotional state of the subject is coincident.

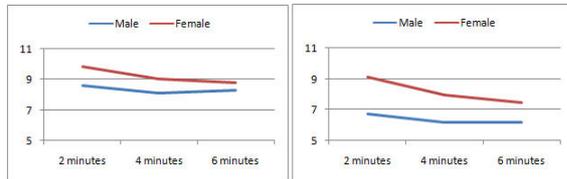


Figure 3: Beta wave (a) and Gamma wave (b) comparison for men and women.

Apart from these results, the comparison of men and women brain wave behaviour, presented in Figure 4, indicates differences in amplitude directly related with the sex of the subject. The presented charts were based on the average amplitude of all subjects, male and female separately, for the three distinct session stages. Through this illustration, it is shown a slightly decreasing variation of the average amplitude along the entire experimental session, which proves the pattern-behaviour previously described.

Together with these results, also an amplitude difference between male and female waves is presented during the session, with a higher amplitude for the female behaviour. Based on the previously described results, as well as the statistical analysis, the EAT was able to follow the initial hypothesis. The emotional state decision taken by the application is based on the clusters' length, centroides' value and the respective high frequency brain wave. Figure 5 represents the cluster analysis of one experimental session for the Gamma wave.

These results indicate a clear majority of data associated with the lowest centroide value, and a small density of data near the high value centroide. Based on this approach, the emotional state classification is based on the clusters' length and its degree of correlation between each others.

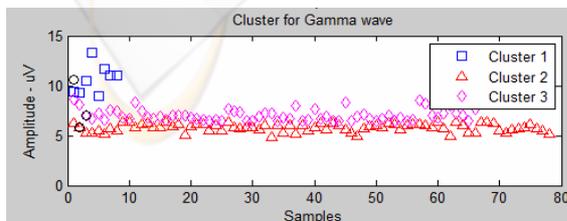


Figure 4: Cluster analysis for the Gamma wave.

### 3.2 EAT

The Emotion Assessment Tool was developed with the main intention of evaluating and assessing the predominant emotional state of the subject that has been previously induced by some type of multimedia content. For this specific project, there were studied two different emotional states plus the neutral one, so that three clusters were adopted for the statistical analysis. The integration of this tool in a project with a bigger scope is suitable and advantageous, since the number of clusters is dependent on the number of emotional states to analyse and the specific multimedia content used for the emotional induction.

Besides the emotion assessment functionality, this tool also integrates some important features for data analysis as: plotting the original biometric data gathered from the EEG; calculate the weighted means directly from the original signal in intervals of 5, 10 and 20 seconds, defined by the user; activate or deactivate the spikes removal technique, affecting and improving the assessment results for more unstable experimental sessions. Figure 6 represents an EAT running screenshot, where the final conclusion led to a predominant emotional state of sadness after a decimation of 20 seconds of the load of raw session data file.

### 3.3 Success Rate

The performance attained through the application of the EAT is directly related with the success rate of the emotional assessment and is a determinant factor for the verification and validation of this tool for future work.

Accordingly to Table 1, where the confusion table is presented, the final rate of success is 74% and all the failures of the EAT are related with the sadness emotional state, with low values for the brain waves amplitude. The application of the EAT for the automatic assessment was, for one of the experimental sessions, able to determine the correct predominant emotional state, which wasn't possible through the empirical visual inspection analysis of the biometric data after processing it.

Due to the processes inherent to the emotional classification, the decision algorithm needs to check if both Beta and Gamma brain waves achieve a similar emotional state. This indicates that the 16% of failure of the EAT are related to a discrepancy between the analysis of the Beta and Gamma brain waves' behaviour.

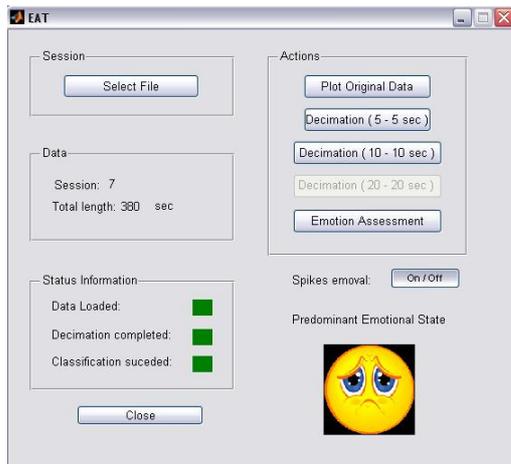


Figure 5: EAT running screenshot.

Table 1: Confusion Table.

		EAT		
		Joy	Neutral	Sadness
Subject	Joy	<b>11%</b>	0%	11%
	Neutral	0%	<b>0%</b>	0%
	Sadness	0%	16%	<b>63%</b>

## 4 CONCLUSIONS

The initial enunciated hypothesis was validated and the majority of the subjects included in this project have reacted in a similar way to the multimedia content presented. Starting with light, enjoyable contents and finishing with sad ones, it was able to conclude that the average amplitude of the high frequency brain waves decreased along the entire session based on the emotional state induced on the subject. Secondly, and from the comparison of the high frequency brain waves average amplitude between male and female subjects, the females' one have a higher amplitude which indicates that they are more sensible to sad multimedia contents.

In what concerns to the statistical analysis, two different emotional states – joy and sadness – plus a neutral one led to the use of three clusters, characterized by its centroides' value, the number of samples included and the degree of correlation between them. With this approach, the emotion assessment tool was able to classify the predominant emotional state, out of three, with an accuracy of almost 75%. Multiple application domains have been identified as some interesting applications.. In this category, one shall consider system adaptations in order to accommodate psychiatric diagnosis and treatment procedures, either by simple emotional

state assessment or by complementing this feature with audiovisual adequate contents. Videogame related entertainment industry is also a potential target with the introduction of emotional state information as an extra variable for game play enhancement. Another expected adaptation consists in studying different human activities from the emotional point of view, and it is believable to be an important contribute to diverse social sciences.

As a final remark, one shall state that the presented study achieved to develop an automatic tool for basic emotional states detection with high rates of success based on stable methodologies of emotion induction and data processing and validation. The used hardware solutions are believed to be minimal invasive and are not costly which enables its vast application at a larger scale.

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