THE PUBLISHING HOUSE
OF THE ROMANIAN ACADEMY

BIOLOGY
Review article

BIOMETRIC ESTIMATION OF EMOTIONAL RESPONSE AS A METHOD OF STUDY IN NEUROMARKETING

Livia PETRESCU[1], Andreea BECIU[1], Sarmad Al HADEETHI[1],
Constantin IONESCU-TIRGOVISTE[2], Dan MIHĂILESCU[1] and Cătălin-Dumitru PETRESCU[3]

[1]University of Bucharest, Faculty of Biology, Department of Anatomy, Animal Physiology and Biophysics, 91–95 Splaiul Independentei, Bucharest-050095, Romania
[2]"N C Paulescu" National Institute of Diabetes, Nutrition and Metabolic Diseases, Bucharest, Romania
[3]"Politehnica" University of Bucharest, Faculty of Automatic Control and Computers, Department of Automatic Control and Systems Engineering, 313 Splaiul Independentei, Bucharest-060042 Romania
Corresponding author: Cătalin Dumitru PETRESCU, e-mail: catalin.petrescu@acse.pub.ro

Accepted March 13, 2018

Neuromarketing is an area in which the interpretation of emotions is absolutely necessary. We can provide clues about consumers receptivity, based on multiple analyzes: facial expresions recognition, electrophysiological records (EDA, EKG, EEG, fMRI), pulse measurement, breathing intensity, etc. The purpose of this paper was to study the impact of advertising spots on the emotional status of potential buyers. The working hypothesis is that advertising should not be random; it must be taken into account the sensitive points in consumer psychology.
The study was made on a batch of 30 students of the Faculty of Biology, University of Bucharest, to whom an advertising clip was presented. Several test methods have been used: an impact questionnaire, electrodermal records, and facial expressions analysis. Starting from the skin conductance analysis, 15 key moments in the evolution of the ad clip were identified. In correspondence with these moments, we analyzed the facial expression of the subjects, followed by the identification of the video sequences that generated these reactions. The results showed a close relationship between moments with maximum emotional response and the introduction of promotional sequences. In conclusion neuromarketing has the ability to provide support for increasing the effectiveness of advertising messages.

Keywords: neuromarketing, emotion, electrodermal activity, facial expresions.

INTRODUCTION

Emotion is an important decision-maker[1] in consumer attitudes, a large part of our motivations being, contrary to expectations, determined by the level of the subconscious[2]. The study of consumer emotional reactions started as a theoretical approach[3], and became an important contemporary topic[4] of a still young research field – neuro-marketing, that nowadays is in a growing stage. The study of marketing, consumer behavior and advertising phenomenon created an industry that benefit from neuroscience research findings. In order to understand marketing phenomenon, quantification of emotional reactions was initially carried out by traditional self-report measures[5]. Nowadays a wide variety of modern neurophysiological methods supplement the researches[6] by facial coding, biometrics (electromyography – EMG, electrodermal activity – EDA, heart rate variability – HRV, *etc*.) and new investigative techniques of brain functions (electroencephalography – EEG, fMRI, PET)[7,8].

In order to uncover the emotional responses, the studyes focuses at several predictability marks: understanding of messages (self-report), attention (eye – tracking), arousal, emotional intensity (biometric measurements), valence of emotion (facial coding, EEG, fMRI), *etc*.[9]

The purpose of this paper was to study the impact of advertising clips on the emotional status of potential buyers. The assumed working hypothesis is that advertising should not be random;

it must be taken into account the sensitive points in consumer psychology.

The objectives to achieve this goal were: *(i)* evaluating changes in the *electrodermal activity* when viewing the ad clip*; (ii) analyze the emotions* expressed by the participants while they watching the movie *(iii)* determining the *aspects* that make an ad spot more *convincing* than another and *(iv)* identifying the *key elements* of the advertising clip that can influence the consumer's decision.

The study described in this paper was made on a batch of students of the Faculty of Biology, from University of Bucharest, to whom an advertising clip was presented. Several test methods have been used, including the analysis of an impact questionnaire, electrodermal records, and facial expressions.

MATERIALS AND METHODS

PARTICIPANTS

The study was conducted in two stages. In the first stage, 30 students from Faculty of Biology, University of Bucharest (17 girls and 13 boys, ages between 20 and 26 years, mean age = 23.1 ± 1.398) participated in an impact questionnaire. At this stage, it was selected the video clip of maximum impact from a set of two ad productions related to the same product (a car model).

The second step consists of the actual analysis of the selected clip. The study was attended by other 30 healthy, right-handed respondents volunteers, students of the Faculty of Biology, University of Bucharest, ages between 20 and 25 years, of which 16 girls and 14 boys (mean age = 23.05 ± 1.045). Two different student groups were used because we intended that their emotional response was not affected by the previous video viewing.

In order to obtain optimum results, certain exclusion criteria of volunteers were applied. Were not included in the study those: who wore glasses, which had a beard, who moved exaggeratedly during the films or who had no reactivity to the electrodermal recording.

All records were made under similar conditions, in a quiet room, at about 25ºC, following the same protocol.

Prior to participation, experimental procedure was explained to the subjects, and a written consent indicating voluntary participation was obtained from each participant.

EXPERIMENTAL DESIGN

The study aims to evaluate the emotional impact of advertisements on consumers. For this purpose, two internet advertising clips, which were not broadcast in Romania and which targets a new line of cars, have been chosen. The first lot of subjects was asked to watch both advertising spots (1'33" each). The subjects were not aware of the aim of the recording, they were asked only to pay attention to the material showed on the screen. In order to choose the best one of the two ads, at the end of the movies, volunteers were asked to complete an impact survey questionnaire.

Following the analysis of these questionnaires, the clip used in the second stage of the study was selected.

Two types of tests were applied for analysis of subject's emotional response: *(i) analyzing the electrodermal activity (EDA); (ii) evaluating of facial expression.*

Electrodermal activity was measured using a custom-made skin conductance meter connected to a laptop. This laptop had a built-in webcam and was used to play the ad clip, video-recording of facial expressions, and EDA data storage in the same time.

Five minutes of rest and tranquility were provided prior to the start of the experiment.

IMPACT SURVEY QUESTIONNAIRE

Selection of the ad clip was made using an impact survey questionnaire, containing 5 items designed to provide informations about understanding of the advertising message and ranking of message visual presentation.

The questionnaire was applied to each participant at the end of viewing the ad spot. Students were asked not to decline their identity, complete the questionnaire honestly, and were encouraged to express their personal opinion, provide advice, comments, or recommendations about the ad.

PHYSIOLOGICAL AUTONOMIC NERVOUS SYSTEM (ANS) MEASURES

Galvanic skin response (GSR) or electrodermal activity (EDA) is a technique with a rich history as a handy and relatively noninvasive tool used to study the body reactions to various stimuli, being an

indicator of physiological and psychological arousal. The autonomic control mainly regulates the internal environment, in order to maintain the body homeostasis[10]. It is considered that the skin is an organ that responds preponderantly to the action of the sympathetic nervous system through the eccrine sweat gland[11]. For this reason, the data acquisition made in the skin can get information about the attitude of the body's "fight or flee", and can be a method to measure emotional responses[12].

For electrodermal recording, a custom made device was used. The electrodes of the electrodermal recording device were connected to the left hand of the study participants at the level of the medial phalanx.

All records were performed under similar conditions after a pre-established protocol. The electrodermal recording was performed by the exosomatic method in alternating current, applying a constant voltage of 0.5V at a frequency of 20 Hz. The resulting biological signals were recorded continuously at a frequency of 10 sampled per second, stored in the computer and subsequently processed.

The data obtained from the electrodermal recording were processed using the EDAtool software which is a function developed to pre-process the EDA signal (http://www.musicsensorsemotion.com/2012/06/21/edatool). Pre-processing includes removing electrical noise, as well as detecting and measuring artifacts. The actual signal processing separates the EDA signal into the phase and tonic components.

Experimental data was statistically processed to compare the records of the two experiments. The statistical significance was determined by the $p < 0.05$ index.

FACIAL EXPRESSION (FE) ANALYSIS

Subjects' faces were recorded with the integrated camera in the laptop and VirtualDub version 1.10.4 (http://www.virtualdub.org), in order to evaluate their facial expressions while watching ad spots. This program allows subsequent frame-by-frame recording and viewing (sampling rate of 30 frames per second), so even the smallest changes in volunteer expressions can be noticed.

RESULTS

IMPACT SURVEY QUESTIONNAIRE

The structure of the questionnaire includes questions regarding both the estimation of the visual impact of the advertising spots (the quality of the graphic aspect: questions 1 and 2) and the appreciation of the motivation of the message sent (questions 3 and 4).

STUDENT'S OPINION

Question 1/2 How do you rate graphic design of the ad clip 1/2?

As we can see, the graphic aspect of both films is positively appreciated by the majority of study participants, with a slight advantage recorded by the first commercial ad (Figure 1) – 93.33% (very good and good) *versus* 90% of the second spot (Figure 2).

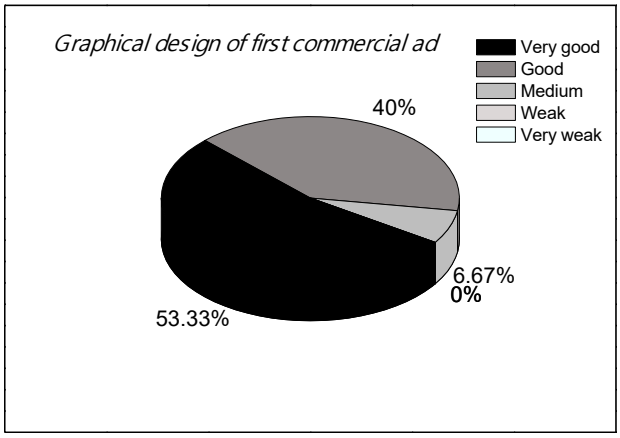


Figure 1. Students' opinion about the graphic aspect of first ad: Question 1.

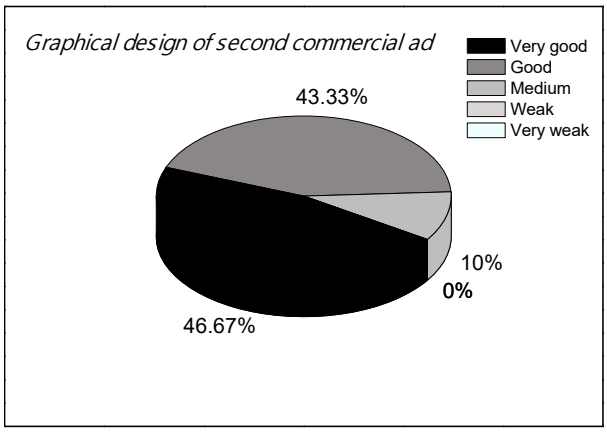


Figure 2. Students' opinion about the graphic aspect of second ad: Question 2.

Question 3/4 How do you evaluate the clip 1/2 message?

The message sent by the first advertising spot (66.67% very motivating and motivating) – Figure 3 – is considered more motivating than the second (56.67%) – Figure 4. This result is endorsed by the higher percentage of the indifferent response of the second film (36.67%) compared to the first (30%).

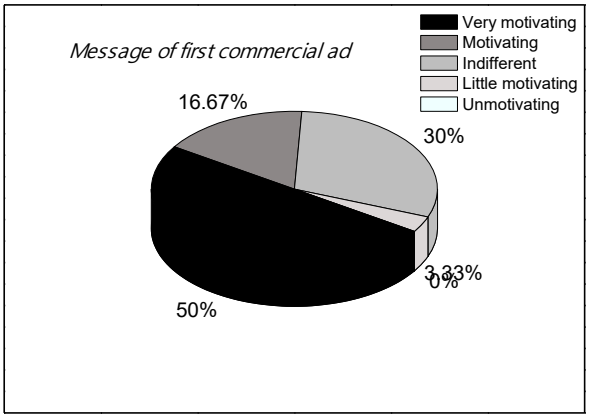


Figure 3. Students' opinion about the message of first ad: Question 3.

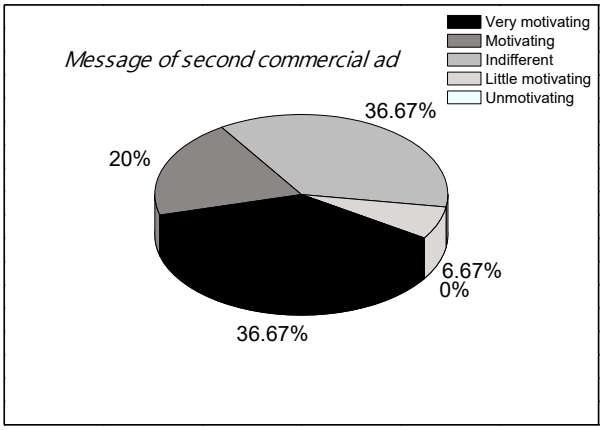


Figure 4. Students' opinion about the message of second ad: Question 4.

To test the understanding of the message sent by each advertisement, the questions 3 and 4 also required a short description of the received message.

Question 3 Message description clip 1

– 22 subjects understood that it was about presenting a car (they said that this presentation is fun, motivating);

– 8 subjects did not understand the message, of wich:

- one person said it was boring and it was not about buying a car;
- one person understood that the message is that a car can influence the social status;
- 5 persons understood that it is about saving the planet or engaging in certain humanitarian cases / rescuing animal species / plant species;
- one person understood that it was about overcoming difficulties / obstacles, which he considered very motivating.

Question 4 Message description clip 2

– 14 subjects understood the video message;

– 16 subjects did not correctly understand the video's message, of which:

- 3 subjects understood that this is the impact a car may have on the social status;
- 7 subjects understood that it is about changing physical appearance through sport and increasing self-confidence;
- 3 understood that it was about reaching the goals;
- 1 person understood that it was about the importance of sport;
- 1 person said they did not really understand the message, but because of the graphic layout, it seemed funny;
- 1 subject understood that it was about how to produce a car.

Following the analysis of these first questions, it appears that the first advertising spot is more motivating in terms of targeting consumers to purchase the car.

Question 5 Which of the two advertising spots do you appreciate that is the most motivating to buy the car, and why?

Question 5 asked subjects to choose between the two ad spots and to justify this choice.

– 15 chose the first spot, because they considered it more fun, more creative, more motivating. They also believed that the ad clip motivates the viewer to buy the product because of the theme (saving the planet, a subject of great interest today) and has a much better quality in terms of graphics and soundtrack used.

– 2 did not pick any of the two spots because they considered them the same;

– 13 chose the second spot, because they considered it more fun, but not necessarily more motivating.

Based on the analysis of this questionnaire we concluded that the first advertisment clip was more suggestive and better understood by the test subjects, so our focus was on analyzing its impact on potential consumers.

PHYSIOLOGICAL AUTONOMIC NERVOUS SYSTEM (ANS) MEASURES

Eda response contains two components: a slow and a fast one. The slow component, called the tonic response (skin conductance level – SCL), represents the basic line of skin conductance, depending on the physiological states and autonomic regulation of the subject[13]. The phasic component or skin conductance response (SCR) can be observed when the sudomotor nerve is activated, being a measure of autonomic system activity[14].

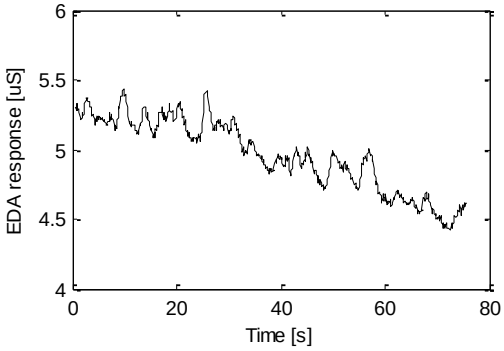


Figure 5

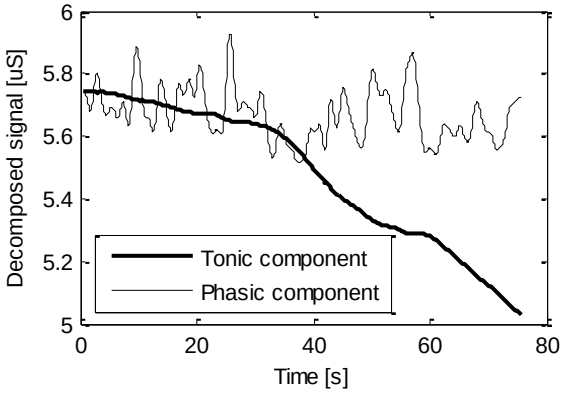


Figure 5 (continued). Sample of signal decomposition in the two components (phasic and tonic).

In Figure 5 we can see an exemple of signal decomposition in the two components (phasic and tonic) for a subject from the study participants group (subject 5).

PHASIC COMPONENT OF SIGNAL

The phasic component, the result of the rapid succession of short-term events, can be characterized both in terms of the number of events and in terms of the characteristics of these events: response latency, initiation response, maximum response, phase slope ascending, etc. (Figure 6).

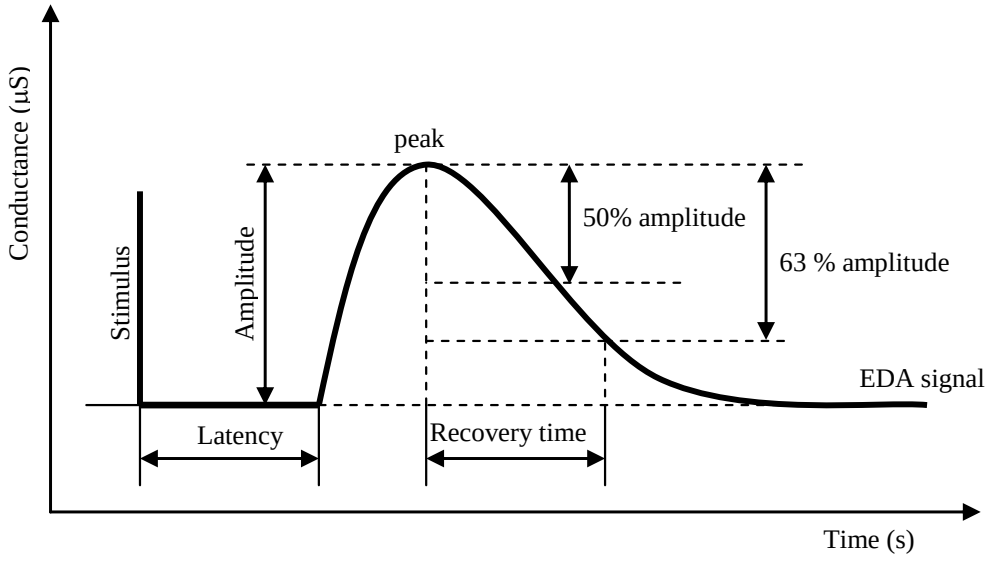


Figure 6. Structure of an event from the phasic component of electrodermal recording.

Thus, we can identify, localize over time and quantify the emotional stimuli that lead to the activation of the sympathetic nervous system.

Analysis of phasic component events

To analyze the events during the ad clip, each of the 30 records was processed individually. For this,

all phasic signals were taken into account, finding the starting points of the response for each spike. Since the manual method is very difficult, time-consuming and can introduce many errors, a MATLAB program has been developed to automatically search for parameters of interest.

In order to better visualize and interpret these events over time, a graphical representation of the key moments recorded during the TV commercial is used. With the help of vertical parallel lines, were identified those moments where most people had a response. Since the representation of all 30 subjects would be difficult to plot, we choosed to represent only 10 subjects, considered representative for this study, as it can be seen in Figure 7.

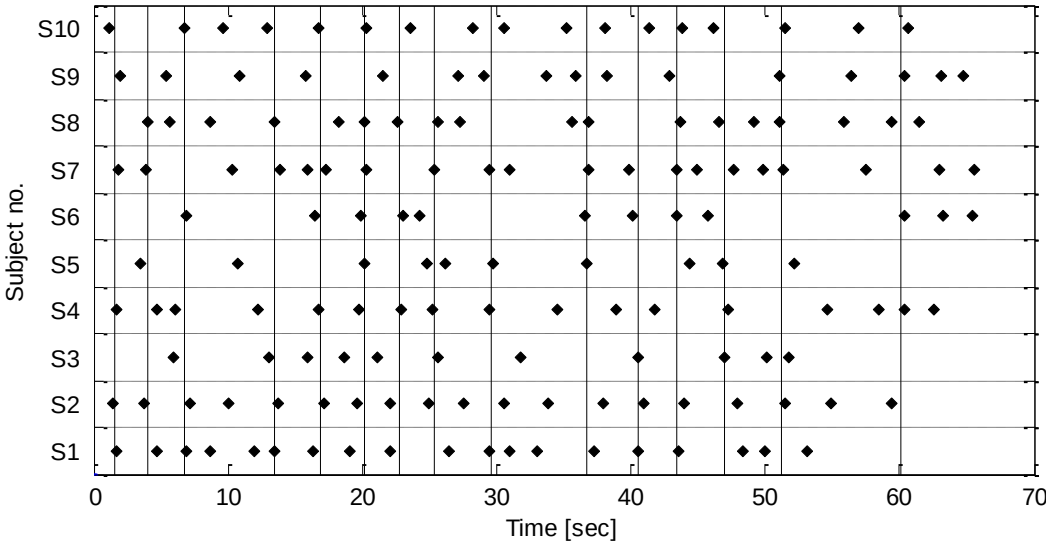


Figure 7. Graphic with scattering of key moments of the clip over time.

As can be seen from the figure, the response of subjects converges around certain moments of the video. Figure 8 shows the moments identified as significant in the evolution of the film.

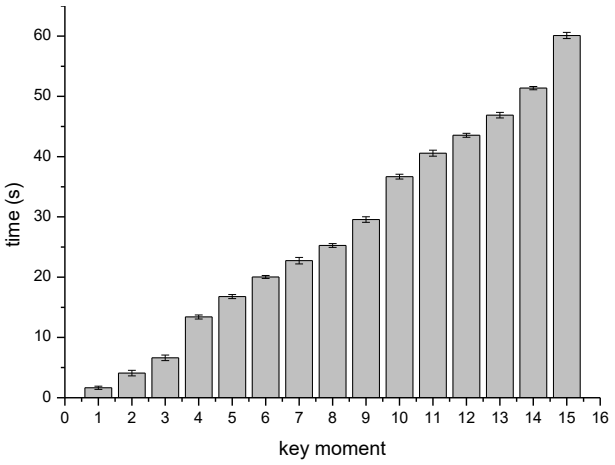


Figure 8. Key moments in the ad clip.

In Table 1 is presented the time and standard deviation of each of the 15 key moments identified.

Table 1

Time and standard deviation of each of the 15 key moments identified

Key moments	Time (s)	Standard deviation
1	1.65	0.2754
2	4.0833	0.4634
3	6.6167	0.4634
4	13.4	0.3367
5	16.7833	0.3387
6	20.0286	0.2491
7	22.7333	0.5375
8	25.2667	0.3145
9	29.5667	0.4643
10	36.6833	0.3976
11	40.5667	0.4955
12	43.5429	0.3289
13	46.8833	0.4561
14	51.3667	0.2687
15	60.1	0.5099

FACIAL EXPRESSION (FE) ANALYSIS

The next step was to analyze the video sequences obtained from the video recordings of the participants, followed by correlating these data with the EDA records.

The VirtualDub program has been used to visualize frame-by-frame the film events, in order to capture the various facial expressions displayed by the study participants.

Every time a change of expression was observed on the face of the subject, these actions were noted and a screen capture was performed to be immortalized facial mimics.

The screenshots of the volunteers' faces were further processed, keeping only those parts with eyes, eyebrows and lips, important markers of facial expressions interpretation (Figure 9). In this way the significant elements of the expressions attempted by the participants were emphasized, while at the same time their identity was protected.

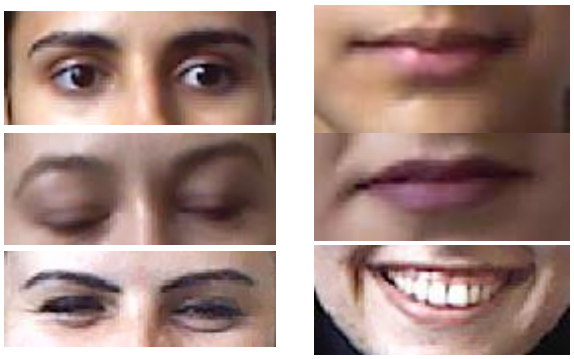


Figure 9. Screenshot processing.

Both electrodermal event initiation times and moments when subject's facial expressions changed were monitored simultaneously.

At the same time, the appropriate moments in the ad clip was identified, followed by a snapshot of the corresponding video sequence.

In Table 2 are presented some example of key moments of the ad clip and the data gathered from the study participants.

Table 2

Examples of key moments of the ad clip
and the data gathered from the study participants

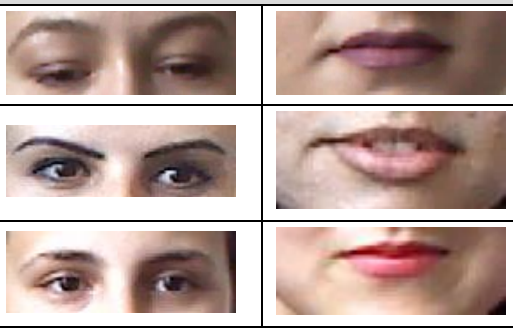
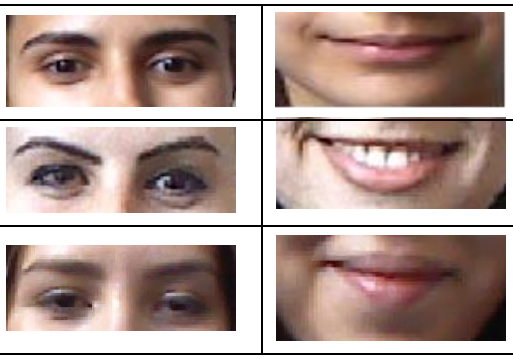
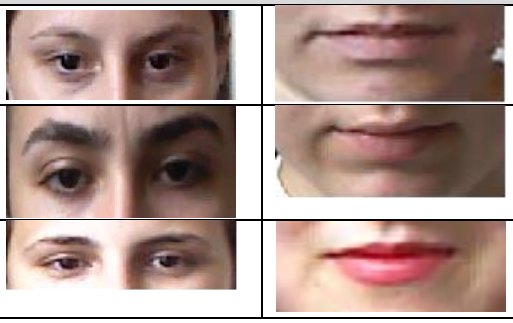
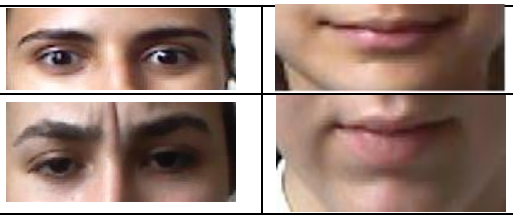
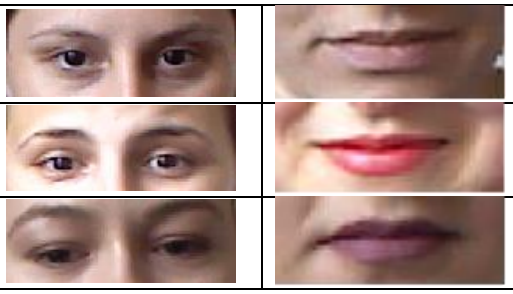
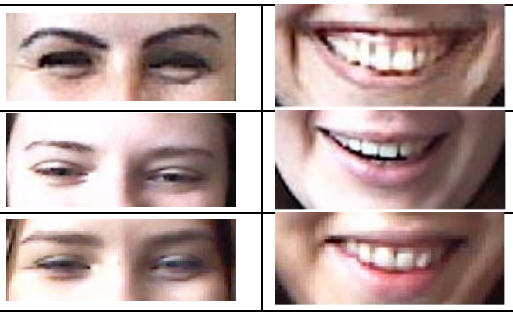
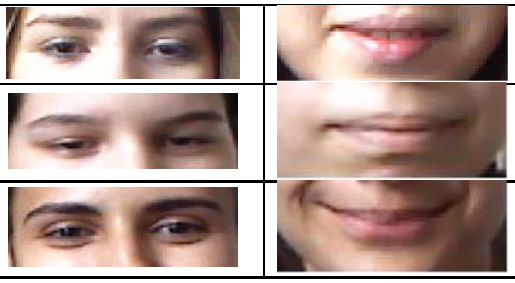
Key moment	EDA time (s)	Ad clip description	Facial expresion	Observations
1	1.65	The car is making its appearance for the first time, being viewed from above, among the trees of a forest in the winter.		Neutral state
2	4.0833	The main character agrees to participate in a whale rescue operation, and starting at sea in the fight to save whales, raises his hand with encouragement, as a sign of motivation.		The enthusiasm of the main character generates the goodwill of the test subjects, which smile with sympathy.

Table 2

(continued)

Key moment	EDA time (s)	Ad clip description	Facial expresion	Observations
5	16.7833	Right in front of the main character, a frightening whale arises vertically from the water.		Tension at the sight of the animal.
7	22.7333	Balena collapses on main character's boat.		State of concern for the fate of main character.
8	25.3667	The main character is thrown into the air through a hilarious acrobatics		The subjects sketch a smile of amusement.
9	29.5667	With a last shout, the main character is projected and crushed by the ship he descended to save the whale.		Although the situation is tense, the subjects start to laugh (a reaction similar to one in which people slip on ice and fall)
10	36.6833	A frame with a car suddenly appears. The car logo appears.		The promotional sequence is carried out while the subjects preserve the status of the previous scene.
Another episode begins. The main staff is involved in saving trees, fighting melting glaciers and saving endangered rhinos. After each of these tense situations, short promotional images are introduced.				

DISCUSSIONS

In the watched ad clip there are some attempts of the main character to save the planet, acting in some hot points. There are presented four important scenes: saving whales, stopping trees cutting, fighting glaciers melting and rescuing endangered rhinos.

At every desperate attempt to save the planet, the main character fails in a seemingly hilarious way, suffering especially physical damage that impresses the viewer.

Thus, it is projected on the ship's hull by the whale, falls into the abyss with the illegally cut tree, falls (and strikes) into the crack in the glacier or is taken in the horn by the rhinoceros for whose salvation it fights.

Apparently unrelated to the events, after each of these tense situations, the advertiser introduces a short sequence in which the image of the car is presented, without explanatory comment.

The design of the ad clip confirms our initial hypothesis that advertising should not be random; it must be taken into account the sensitive points in consumer psychology.

When the body is in a state of sympathetic excitement it is more receptive to surrounding signals and has a greater ability to retain certain information that would not normally have been of particular interest.

This ad clip has the potential to be very efficient, because we found a very close relationship between moments with maximum emotional response and the introduction of sequences with a promotional message.

CONCLUSIONS

While viewing an ad, the person goes through several states, characterized by varying degrees of receptivity to the received stimuli.

In this paper we started from the hypothesis that advertising must not be done randomly.

We verified this hypothesis based on the analysis of the existing relationship between the advertising clips structure and the psychophysiological response of the tested subjects.

For this purpose, two online advertising spots have been chosen, targeting the same product: a line of cars.

Several tests were applied for analysis:

– completing an impact questionnaire for selecting the most representative clip;

– skin conductance study (EDA);

– assessment of facial expression for emotional impact assessment.

After analyzing the impact questionnaire, we concluded that not all ad clips manage to correctly send the desired message.

Of the two viewed videos, the first one is more suggestive, because the message was better understood by the test subjects.

Consequently, our attention turned to analyzing the chosen clip impact on potential consumers.

The next step was to analyze the resulting biometric parameters following electrodermal recording and facial expression analysis.

The results confirm the initial work hypothesis, demonstrating a close relationship between moments with subject maximum emotional response and the introduction of promotional sequences.

In conclusion neuromarketing has the ability to provide support for increasing the effectiveness of advertising messages. A combined application of several techniques increases the predictability of the consumer's emotional response.

DECLARATION OF INTERESTS

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

REFERENCES

1. Damasio, A. R., "Descartes' Error: Emotion, Reason, and the Human Brain", New York: Grosset/Putnam., 1994.
2. Ohme, R., Matukin, M., Pacula-Lesniak, B., *Biometric Measures for Interactive Advertising Research*, *Journal of Interactive Advertising*, **2011**, *11 (2)*, 60-72.
3. Zajonc, R. B., *Feeling and thinking: Preferences need no inferences*, *American Psychologist*, **1980**, *35 (2)*, 151-175.
4. Lajante, M., Droulers, O., Dondaine, T., & Amarantini, D., *Opening the «black box» of electrodermal activity in consumer neuroscience research*, *Journal of Neuroscience, Psychology, and Economics*, **2012**, *5 (4)*, 238-249.
5. Varan, D., Lang, A., Barwise, P., Weber, R., Bellman, S., *How Reliable Are Neuromarketers' Measures of Advertising Effectiveness?, Data from Ongoing Research Holds No Common Truth among Vendors*, **2015**, *55 (2)*, 176-191.
6. Venkatraman, V., Dimoka, A., Pavlou, P. A., Vo, K., Hampton, W., Bollinger, B., Hershfield, H. E., Ishihara, M., Winer, R. S., *Predicting Advertising Success Beyond Traditional Measures: New Insights from Neurophysiological Methods and Market Response*

Modeling, *Journal of Marketing Research*, **2015**, *52 (4)*, 436-452.
7. Ohme, R., Reykowska, D., Wiener, D., Choromanska, A., *Analysis of neurophysiological reactions to advertising stimuli by means of EEG and galvanic skin response measures*, *Journal of Neuroscience, Psychology, and Economics*, **2009**, *2 (1)*, 21-31.
8. Samant, S. S., Chapko, M. J., Seo, H. S., *Predicting consumer liking and preference based on emotional responses and sensory perception: A study with basic taste solutions*, *Food Res Int*, **2017**, *100 (Pt 1)*, 325-334.
9. Horst, S., Woodard, R. P., *Uncovering Emotion: Using Neuromarketing to Increase Ad Effectiveness*, **2011**.
10. Sequeira, H., Hot, P., Silvert, L., Delplanque, S., *Electrical autonomic correlates of emotion*, *Int J Psychophysiol*, **2009**, *71 (1)*, 50-6.
11. Shibasaki, M., Crandall, C. G., *Mechanisms and controllers of eccrine sweating in humans*, *Front Biosci (Schol Ed)*, **2010**, *2* 685-96.
12. Kreibig, S. D., *Autonomic nervous system activity in emotion: a review*, *Biol Psychol*, **2010**, *84 (3)*, 394-421.
13. G. Valenza, G., Lanata, A., Scilingo, E. P. , *The Role of Nonlinear Dynamics in Affective Valence and Arousal Recognition*, *IEEE Transactions on Affective Computing*, **2012**, *3 (2)*, 237-249.
14. Zangroniz, R., Martinez-Rodrigo, A., Pastor, J. M., Lopez, M. T., Fernandez-Caballero, A., *Electrodermal Activity Sensor for Classification of Calm/Distress Condition*, *Sensors (Basel)*, 2017, 17 (10).