European Research Studies Journal
Volume XXII, Issue 4, 2019

pp. 457-471

The Cognitive Neuroscience Methods in the Analysis of the Impact of Advertisements in Shaping People's Health Habits*

Submitted 23/09/19, 1st revision 12/10/19, 2nd revision 27/10/19, accepted 04/11/19

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Abstract:

Purpose: *The aim of the article is to present the use of selected techniques of cognitive neuroscience (EEG, GSR, HR) to study the effectiveness of social advertising in the context of promoting a healthy lifestyle. The respondents' reactions (emotions, remembering, interest) to individual fragments of the advertisement will be analyzed. The results of neural and psychophysiological measurements will be compared with the survey participants' answers provided in the survey (after the study with EEG, GSR, etc.).*
Design/Methodology/Approach: *The cognitive neuroscience methods, allow building knowledge about human and its behavior at the level of internal psychophysiological and cognitive processes before they are integrated and verbalized in the form of an opinion or judgment on a given topic.*
Findings: *The developments of cognitive neuroscience technique have made this discipline applicable to more and more new areas of research. These possibilities are mainly the outcome of the development in techniques for measuring brain activity and their combinations with other technologies, eg biometric measurements. They allow to correlate various mental functions with physiological sensations.*
Practical implications: *One of the applications is to study the impact of social health-promoting advertisements (healthy lifestyle, vaccinations, etc.) on recipients. A well-conducted social campaign with the proper design of an information message (advertisement) can directly transform it into shaping healthy life habits among people.*
Originality/Value: *The research will allow the verification of the idea proposed by the researcher to promote healthy life habits among people.*

Keywords: *Advertisement, health behavior, cognitive neuroscience methods, EEG, GSR*

JEL codes: *D87, M37, I12.*

Paper type : *Research article.*
*******An earlier version of this article has been presented in ICABE 2019 www.icabe.gr*

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Acknowledgements:
The project financed within the Regional Excellence Initiative programme of the Minister of Science and Higher Education of Poland, years 2019-2022, project no. 001/RID/2018/19, financing 10 684 000,00 PLN.

1. Introduction

Shaping pro-social behaviors (giving benefits to others) is associated with the development of abilities and skills through which pro-social behavior can be achieved (Eisenberg, 1986). Shaping pro-social behaviors is never a one-off process, it consists of developing a pro-social motivation for such action (Thompson and Newton, 2013). Modeling specific personality features and moral attitudes is usually a complex process (Stürmer and Snyder, 2010). Forming correct moral attitudes, norms and judgments can take place in various ways. For this purpose, early school education of children and youth is used among volunteering, support groups and identifying authorities to follow having the information on introductory restrictions about disturbing social phenomena (eg alcohol, cigarettes, drugs), etc. (Einolf and Chambré, 2008; Mareš, 2017; Schneider, 2018). An important factor in shaping pro-social behavior is social campaign using the most popular media: Internet, TV, radio, and the press (Hogan, 2012). The goal of social campaigns is to convince the audience to change specific attitudes. It may depend on takeover certain behaviors, views or rejecting them (Kotler *et al.,* 2002). Various information activities and educational campaigns are used to explain and at the same time encourage specific pro-social activities. These type of activities use various advertising techniques and tools, and one of them is social advertising.

Therefore, social advertising serves to support important social issues through its informative and educational character depending on the purposes to be fulfilled by social advertising, it can be distinguished by different ways (Aiwars, 2015). Some social advertisements are focused on acquiring financial resources, others on promoting social organizations, and others such as shaping attitudes and pro-health behaviors. In order to achieve the goals set in the advertisement, different ways of influencing people are used. It affects human emotions, the subconscious, or for example, social engineering is used. The advertisement should attract attention, stick in the memory, and trigger specific associations, so some level of expression means should be reached (Chudzian, 2014; Piwowarski, 2017). When designing an advertising message, you should pay attention to these factors. For example, the proper saturation of the advertisement with emotions can cause the recipient to behave in certain ways, like the desire to have or make changes.

The emotional process is directly related to three feature that affect the appearance of appropriate emotions. The first of them is the sign of emotions: positive or negative. Positive is associated with pleasant stimuli for people (happiness, love, etc.), negative with unpleasant stimuli (fear, anger, etc.). The next feature concerns the intensity of emotions resulting from the appearance of a stimulus. The last

feature is related to the content of emotions (Gilchrist *et al.*, 2007; Izard, 2009; Armenta *et al.*, 2017). Advertising, including social one can influence the subconscious of a human to varying degrees evoking various emotional behaviors. The advertising message passed below the awareness thresholds is referred to as subliminal advertising. A hidden message can include both auditory stimuli and visual stimuli, which are too short to be recorded consciously by the memory (Suresh and Tandon, 2018). This form of advertising is legally prohibited in many countries. On the other hand, less-invasive ways of advertising influence on the recipient's subconscious are commonly used. This can be, for example, frequent reproduction of an advertising message, which is fixing in the memory, even despite the lack of attention of the recipient (Williams *et al.*, 2006).

The effectiveness of the advertising message was noticed long time ago by the initiators of social campaigns, including promoting appropriate pro-health attitudes. Health-related attitudes can be understood broadly, namely in the field of healthy eating habits, physical activity, avoidance of stimulants (cigarettes, alcohol, drugs, etc.), systematic health check, or performing recommended preventive vaccinations. World research in this area confirms the impact of advertising on stimulating pro-health of human behaviors (Young *et al.*, 1996; Utter *et al.*, 2006; Daubresse *et al.*, 2015; McAfee *et al.*, 2017). It follows that social advertising can have a certain health effect, is able to change behaviors and attitudes in the context of human health. The concept of health effect is related to the initiative called Health Impact Assessment (HIA). It is understood as a combination of methods, tools and procedures in assessing the potential health effects of policies, plans and various projects. HIA develops recommendations that will help to prevent disease and promote a healthy lifestyle (World Health Organization, 2019). One of the areas in which the HIA initiative develops is the impact of social advertising on promoting pro-health attitudes (health care). Existing state institutions, such as the Ministry of Health or the Advertising Ethics Council, have a real impact (legislative, control and opinion-forming powers) on published advertisements, thanks to which they can advise, emit and even prevent advertisements about negative health effects.

Study of the effectiveness of the advertising message (including social advertising) is a difficult task. The people like some ads, others are not. Some advertisements evoke interest, some advertisement scenes are remembered, and evoke specific emotions, others on the contrary. In addition, people often deliberately avoid advertising because of the high saturation of ads. Therefore, it is important to design advertisements in such a way that the advertising message influences the audience as much as possible. Traditional, declarative research techniques for advertising audiences (surveys and interviews) do not bring the expected results.

The interviewed people do not necessarily have to convey the truth, but they are also unable to reproduce what the subconsciously registered. Therefore, other methods should be used in the study of the impact of the advertising message on the recipient. Methods that will allow you to register and then analyze the reactions in the human

body to a given advertising message. Therefore necessary to use modern measuring techniques that allow for the registration of brain signals, registration of skin-galvanic reactions, or the measurement of heart rhythm. On the basis of such measurements you can examine the emotions appearing in a person, as well as set other metrics, such as interest or remembering. The aim of the article is to present the use of selected methods of cognitive neuroscience (EEG, GSR, HR) to study the effectiveness of social advertising in the context of promoting a healthy lifestyle.

2. Methodology

Cognitive neuroscience deals with the study of the neural basis of cognition (based on the physical and chemical activity of neurons in the brain), including attention, perception, memory, reasoning, problem solving, or decision making (McClelland and Ralph, 2015) which finds more and more practical applications. New interdisciplinary research areas are emerging that exploit neuroscience gains, such as neuroeconomics, neuromarketing, neurolinguistics or even decision-making (McClelland, 2001). Within the field of cognitive neuroscience, there are different research methods that can be grouped into brain neuroimaging methods, psychophysiological methods, neuropsychological methods and methods related to the study of individual nerve cells (Newman, 2019). Not all methods of cognitive neuroscience find practical applications, this is due inter alia to from the valuables of their use or invasiveness.

Neuropeconomics, neuromarketing, and decision-making studies mostly use the EEG (Electroencephalography), NIRS (Near Infrared Spectroscopy), GSR (Galvanic Skin Response), measurement HR (Heart Rate) and EMG (Electromyography). Examples of practical use of such methods in the context of social advertising analysis include work (Vecchiato *et al.*, 2014; Maison and Oleksy, 2017; Piwowarski, 2017, 2018a; 2018b). These methods are often supported by other measurement methods, such as eye tracking or face reading. EEG (Electroencephalography) records the bioelectric activity record of the brain using a device called electroencephalograph. The electrical potential from a given part of the brain is obtained by means of electrodes placed on the head. The electrodes are arranged in accordance with the international standard 10-20 or its extensions. In its simpler version, 21 electrodes are used, of which 19 are placed in the right places of the head, and the other two are the reference electrodes (around the ears) (Oostenveld and Praamstra, 2001).

The human brain is distinguished by certain rhythms of signals, the so-called EEG waves. These waves are characterized by different frequency and amplitude. The most popular and most frequently analyzed are: alpha waves (frequency 8–13 Hz, amplitude approx. 30–100 μV), beta waves (12–30 Hz, do 30 μV), theta waves (4–8 Hz), delta waves (0,5–4 Hz) and gamma waves (32–100 Hz). Each of the wave types is associated with some activity. For example, theta waves are associated with cognitive activity (memory processes) and alpha waves with relaxation state (Tatum,

2014). The EEG signal undergoes specific changes based on external stimuli, e.g. triggered when watching an advertisement. GSR (skin-galvanic reaction) is a phenomenon related to the formation of electrical conductivity of the skin, resulting from the activation of the sympathetic nervous system. It is the result of physiological arousal associated with experiencing emotions, created on the basis of external stimuli. Skin resistance changes are measured using a galvanometer (Dawson *et al.*, 2007; Boucsein *et al.*, 2012). The heart rate (HR) measurement allows you to acquire physiological data that can be used to study emotions. The rhythm measurement is performed on the chest or wrist of the hand, so the frequency of heart beats is recorded (Dulleck *et al.*, 2014). The EEG, GSR and HR methods were used for this study. Based on recorded measurement data, metrics (indexes) of emotions, interests and memorization were determined.

Study of remembering - Memorization Index:
Scientific research in the area of neuroscience confirms that information can be detected by means of EEG measurements. The increase in the theta signal strength in the left part of the frontal lobe of the brain indicates an increased level of information storage (Davidson, 2004). By calculating the mean theta signal strength from this area of the brain, an index can be determined, informing about the level of memorization (Summerfield and Mangels, 2005; Werkle-Bergner *et al.*, 2006):

$$MI = \frac{1}{N_Q}\sum_{i\in Q} x_{\theta_i}^2(t) = Average\ Power_{\theta_{left,\,frontal}} \tag{1}$$

where: x_{θ_i} - the i-th EEG channel in the theta band (from the left frontal lobe), Q - set of left channels, N_Q represents its cardinality. The increase of the MI value is related to enhanced memorization.

Study of interest - Approach-Withdrawal Index:
Study on approach-withdrawal is based on the research of many other researchers for years which has the observation on positive and negative emotions are differently produced by brain in the two different hemispheres namely frontal and anterior temporal. The approach behavior stated as related with the left hemisphere where the anterior cortical regions are being lateral with the fundamental continuum is considered approach-withdrawal, when the left anterior region is acting as an approach system and the right hemisphere is acting as a withdrawal system (Davidson *et al.*, 1990; Borghini *et al.*, 2015; Maglione *et al.*, 2015). In order to determine Approach-Withdrawal (AW) Index (according to the theory of leading EEG asymmetry), calculate the difference between the average of EEG signal power of left and right channels, according to the formula (2):

$$AW = \frac{1}{N_P}\sum_{i\in P} x_{\alpha_i}^2(t) - \frac{1}{N_Q}\sum_{i\in Q} y_{\alpha_i}^2(t) = Average\ Power_{\alpha_{right,\,frontal}} - Average\ Power_{\alpha_{left,\,frontal}} \tag{2}$$

where: x_{α_i} and y_{α_i} - the i-th EEG channel in the alpha band (from the right and left frontal lobes), P and Q - the sets of right channels and left channels, N_P

and N_Q represent their cardinality. The value of the AW index is related to the increase of interest, its drop together with the decrease of interest (Davidson, 2004).

Study of emotions - Emotional Index:
Emotional assessment of an individual is a tricky activity. Response to a specific stimuli of behavior is an experiential mode of observation conceptualizes as a consensual model. Different study conducted on analyzing different type of emotions to check whether they response same or differently to different stimuli. Most of the assessment suggests to measure the emotional dimension rather the discrete states. As per the study there is no specific standard to measure emotions, though experiential, physiological, and behavioral are most relevant measurement (Critchley, 2002; Mauss and Robinson, 2009). Emotion is measured using Electrodermal activity (EDA) and galvanic skin responses (GSR) which represents neuronal activity. EDA is assessment of emotional and cognitive states which considered as a very sensitive index of psychophysiological activity.

GSR and HR signals are accounted for defining the emotional index. These variables are constructed by affect circumplex where HR is on horizontal axis and the GSR on vertical axis coordinated together and correlated with valence and arousal. Though for mono dimensional variable emotional state of the subject is assed using the formula of emotional index (3) (Vecchiato *et al.*, 2012):

$$EI = 1 - \frac{\beta}{\pi} \tag{3}$$

where:

$$\beta = \begin{cases} \frac{\frac{3}{2}\pi + \pi - \vartheta}{\frac{\pi}{2} - \vartheta} & if\ GSR_Z \geq 0, HR_Z \leq 0, \\ & otherwise. \end{cases} \tag{4}$$

and where: GSR_Z, HR_Z - Z-score variables of GSR and HR, ϑ - $arctan\ g(GSR_Z, HR_Z)$ in radians.

EI varying between [−1,1]. Higher EI values imply more positive emotion experienced by the participant, lower EI values mean more negative emotions (Astolfi *et al.*, 2008; Mauss and Robinson, 2009).

3. Methods and Materials

Subjects:
Thirty healthy volunteers participated in the study. Before starting the study, the participants were informed about its course and which devices (non-invasive) will be connected. However, they were not informed about the details of the experiment (what it will concern). The procedure was carried out in accordance with guidelines approved by the appropriate Research Ethics Committees. Prior to the start of the study, the participant of the experiment signed a document certifying about

conscious participation in the research and agreed to participate. The study was conducted in accordance with the principles published in the Helsinki declaration of 1975 ("World Medical Association Declaration of Helsinki," 2013).

Procedure for the preparation and conduct of the study:
The procedure for preparation and implementation of the study included the following stages:

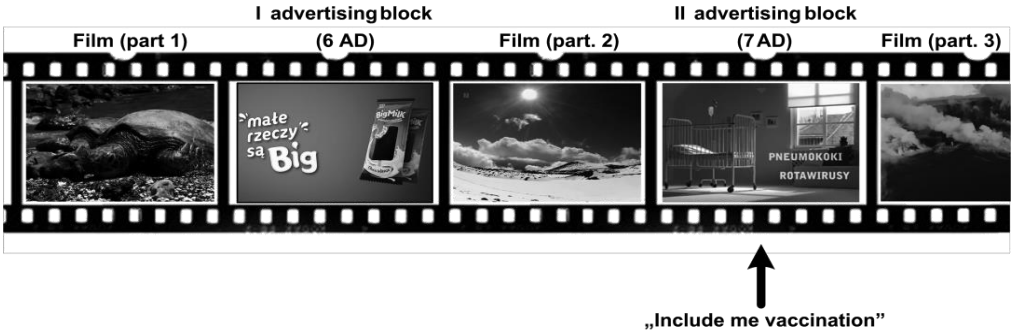
- The participants should have cleansed disinfectant on the scalp, ear lobes and fingers.
- The participants sit comfortably in a chair in front of the computer screen.
- The device g.Nautilus by the company g.tec was used for EEG study. According to system 10-20, eight electrodes placed on positions were mounted on the patient's head: Cz, Fp1, Fp2, F3, F7, Fz, F4, F8. The ground electrode was placed on the ear and the head (GND-AFz).
- The impedance measurement for the EEG signal has been checked in the signal recording software. For all electrodes, it had values below 30 kΩ. The sampling frequency of the EEG signal was 500 Hz.
- Neurobit Optima 4 was used to measure GSR and HR. One heart rate electrode was mounted on the left wrist, two others on the second and third fingers of the non-dominant hand.
- The right course of EEG and GSR signals has been verified in the EEG and GSR registration software.
- Before running a research experiment on a computer (a movie divided by two ad blocks), the participant was asked to limit any movement and remain relaxed throughout the duration of the recording.
- The EEG recording procedure was started from the level of the EEG recording software, and the GSR signal from the GSR recording software (by pressing the START buttons).
- In order to obtain a silent (relaxation) state, the participant examined for one minute the rotating solid on a white background. A reference image was then displayed for determining the GSR reaction delay time.
- After completing the presentation of the presentation on the computer, the EEG and GSR signal registration procedure has been stopped (from the software level). The measuring devices have been removed.

The collected measurement data (EEG, GSR, HR) were used to individually assess the reception of stimuli emitted during the displayed experimental task. While watching the video and ads, the participants were not aware that a few hours after the end of the measurements the survey will be carried out with them. The questionnaire appeared on what they remembered (advertisements, scenes from commercials), whether advertisements appeared specific brands, products, services, and how they relate to selected issues (the need to carry out vaccinations, the effectiveness of vaccines, etc.). Participants of the study once again looked at the ads and evaluated each of them (whether it is understandable, whether it is convincing, if

they like it, etc.). Due to the volume restrictions of this publication, the results of the statistical analysis of the conducted surveys will be published in another article.

Stimuli:
The experimental task (displayed on the computer) consisted in the observation by the subjects of the natural film titled Hawaii (19min.), which was interrupted by two advertising blocks (Figure 1):

Figure 1. *The course of the experimental task*



Source*: Authors' elaboration.*

The first advertising block lasted 3 minutes, and contained 6 ads. The second advertising block lasted 4 minutes, and included 7 ads. The ads concerned social issues, finance and consumption. The advertisement "Include me vaccination" concerned the promotion of prophylactic vaccinations. Lasted 30 seconds and was in the second advertising block.

The plot of the advertisement includes such scenes as: shows a cozy children's room, carrying out a child's bed from the room and turn off the lamp, a room that looks like a hospital space (hall), information about recommended vaccinations, again a small children's room with parents (Figure 2). The pharmaceutical company responsible for the advertising is assuming that this advertising is campaigned for social awareness (information and education) and encouraging the children vaccination.

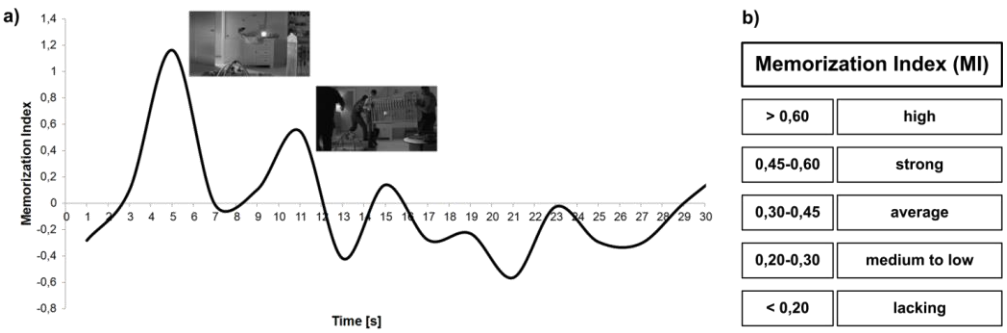
4. Results and Discussion

The indexes MI, AW and EI were determined from the registered EEG, GSR and HR signals. The values of these indices allowed for the assessment of the degree of interest in particular fragments of the analyzed advertising (Include me vaccination), the degree of remembering and the level of triggered emotions. The first of these indexes Memorization Index (MI) was calculated based on formula (1), and its values represent the level of memorization in individual time segments. The values of this index for the whole advertisement (30 sec.) Are depicted in Figure 3a, and the scale describing the degree of remembering in Figure 3b.

Figure 2. *The division of advertising into frames (1 second) with marking of major scenes.*

Source*: Authors' elaboration.*

Figure 3. *(a) MI index averaged values for all participants of the experiment; (b) MI index interpreted as the scale*

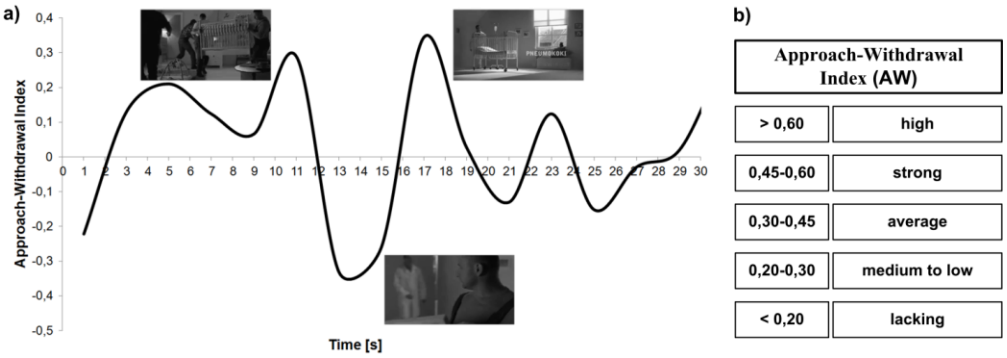


Source*: Authors' elaboration.*

Interpreting the obtained results, it can be seen that the advertisement except two fragments did not activate the functions of the brain responsible for memorizing. A clear jump in MI value (up to 1.16), corresponding to a high degree of remembering was recorded for shots showing a nice, lighted and equipped children's room (4-6 seconds). The second fragment of the advertisement (10-11 sec.) remembered at the strong level (value 0.55) concerns lifting the empty bed from the children's room. The remaining parts of the commercial spot did not trigger the memorizing function (below 0.2).

Figure 4a contains the average values of the Approach-Withdrawal (AW) index of all persons subjected to the study, for individual time segments of this advertisement (determined on the basis of formula 2). The AW values are translated into the degree of interest according to the scale shown in Figure 4b.

Figure 4. *(a) AW index averaged values for all participants of the experiment; (b) AW index interpreted as the scale*



Source*: Authors' elaboration.*

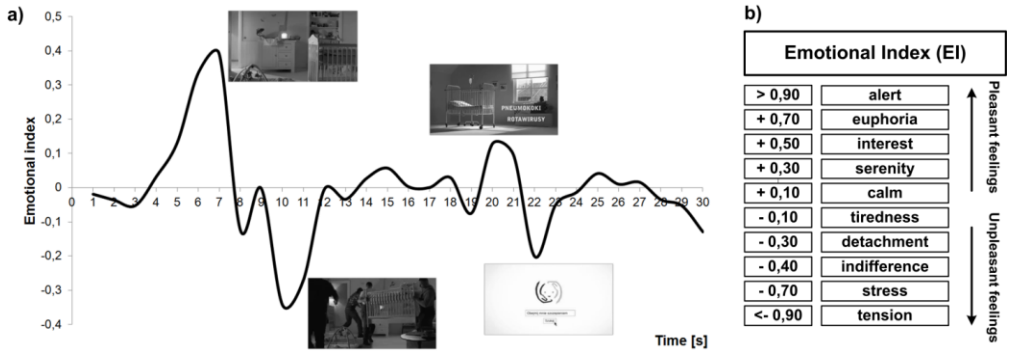
Analyzing the values of the AW index (the approach-withdrawal phenomenon) it can be concluded that in general advertising does not arouse high interest. At most the average level (range: medium to low) is visible in the case of two takes, i.e. around 10-11 sec. (value 0.29) and 17 sec. (value 0.34).

The first one is a fragment in which the empty cot of a child from the room is carried out. The second one is an empty cot in the hospital setting. After taking the cot, we can see a significant drop in interest (to -0.33) next part of the advertisement (about 12-15 s.). This part of the ad is the overlapping images of people who are equipping a children's room with pictures of a hospital bed. The remaining fragments of this advertising spot fall within the limits defined as the lack of interest.

The level of emotions triggered by the ad was estimated based on the Emotional Index (EI) index, calculated from equation (3). The value of emotions index is presented in Figure 5a. The scale values of emotions level is shown in Figure 5b.

Figure 5a, shows the highest level of positive emotions (max. Value 0.39) triggered the shots associated with showing a nicely prepared children's room (6-7 sec.). This is not a very high level of emotion, only corresponding to Interest. In other parts of the advertisement, we cannot talk about any pleasant emotions. Negative emotions (detachment / indifference) appeared for a moment (about 10 seconds) when the bed was taken out of the room (max value -0.34). The next light jump (value -0.20) appeared when the vaccination information was displayed (about 22 seconds).

Figure 5. *(a) EI index averaged values for all participants of the experiment; (b) MI index interpreted as the scale*



Source*: Authors' elaboration.*

Summarizing up the results of social advertising research (Include me vaccination) made using the methods of cognitive neuroscience (EEG, GSR, HR), it should be stated that its effectiveness is not too high. Effectiveness is here understood as the achievement of a certain threshold of expression agents. Neither the level of remembering, the level of interest nor the emotions evoked bode the expected reception by the viewers. Only the first part of this ad (the decor of the children's room and taking the bed out of the room) triggered specific brain neural responses and physiological arousal. These fragments of the message should be considered as hit. The rest of the spot would have to be redesigned. Acquiring such information is not possible using declarative techniques. It is required to use such research methods as those proposed here (EEG, GSR, HR). In the context of social advertising referring to the promotion of health habits, the use of such methods in the design of a message seems to be justified.

5. Conclusions

Cognitive neuroscience methods have a huge research potential not only in the field of neuromarketing, but also in other areas of economics (decision making, risk aversion, etc.). The popularity of these methods come from the possibility of observing psychophysiological functions of the human being and accurate objective measurement of the body's response to specific external stimuli. Such methods allow to build knowledge about a human behavior already at the level of internal psychophysiological and cognitive processes before they are integrated and verbalized in the form of an opinion expressed on a given topic. In the context of study the advertising message, they can bring specific benefits related to the evaluation of a given spot including the assessment of the effectiveness of the message's specific content, e.g. pro-health. With their help, we can analyze individual parts of advertising spots, explore how they affect people. One can study

emotional reactions, levels of remembering or interest. One can also set other metrics, for example involvement or fatigue.

Having such detailed knowledge about the human response to a given advertising message can effectively increase the quality of this message. Inefficient scenes with low impact on the recipient can be redesigned. Longer advertising spots can be shortened by removing relevant parts of it. This can have a direct impact on the reduction of advertising costs (shorter advertising - lower emission costs). The specificity of social advertising, especially aimed at promoting health habits often means that it contains scenes with a high emotional basis. In this context, selected methods of cognitive neuroscience (such as EEG, GSR, HR) work well. The advertisement analyzed in this article encouraging to carry out preventive vaccination did not reach a sufficiently high threshold of expression agents.

However, having the results of such analyzes, it would be tempting to redesign the spot so that this threshold of expression would be higher. Further research in this area will consist of combining the obtained results of neuronal and psychophysiological measurements with the respondents' answers (questionnaire). Survey questions relate to the remembrance of the advertising message, the assessment of the reliability of advertisements or their relation to the content being promoted.

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