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Cognitive Neuroscience Techniques in Supporting Decision Making and the Analysis of Social Campaign

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Abstract

The development of Cognitive Neuroscience Techniques application in the recent period and their usage in various areas of knowledge has allowed us to understand cognitive processes related to the human brain functioning. They allow us to better understand human behavior, when they make a decisions. This study refers to the experiment participant's examination during the selection of the product according to their preferences by means of modern neuroscience techniques. In addition, it has been checked how quickly the experiment participants become subject to fatigue in the course the decision-making process and the decision analysis. The individual shots of the advertising spot (saving electricity) were also verified with regard to their impact on remembering the recipient. In the experiment, data required to analyze the experiment participant's preferences where registered by means of electroencephalogram (EEG), the measurement of galvanic skin response (GSR) and heart rate (HR).

Keywords: Cognitive neuroscience • Behavioral aspects • EEG • GSR • HR • Decision making support • Social advertisement

Introduction

Every day, we choose various types of goods and services related to everyday functioning. The number of such choices or related to them decisions is increasing correspondingly to the number of activities conducted by a given person. We perform some of such activities automatically in a routine manner, while some of them require us to conduct certain analysis before we take them. Depending on the level of their complexity, the need to support them occurs. The decision-maker searches for appropriate mechanisms, operating procedures or tools and methods enabling to make the right choice on the basis of many criteria, especially as in majority of cases decision-makers are manipulated by manufacturers and sellers, which hinders rational decision taking. The use of decision-making methods may help decision-make to make a choice in the most rational manner. There are two main areas of supporting

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decision-making processes, i.e. multi-criterion decision analysis and multi-dimensional comparative analysis. Within the scope of the first area, one may distinguish two schools dealing with decision-making methods: the European school (comprising also national schools) as well as the American school. Creators of those schools include B. Roy (French school), J. Brans (Belgium school), T. Saaty (American school). The French school elaborated for instance ELECTRE group of methods (described more fully in works of Duckstein and Gershon 1983, Grolleau and Tergny 1971, Karagiannidis and Moussiopoulos 1997, Mousseau et al. 2001, Roy 1968, Vallée and Zielniewicz 1994). The Belgium school, supported by the French school, is known for PROMETHEE method (Scharlig 1996), whereas, the American school is known for the AHP method (Saaty 1980), and ANP method (Saaty 2005). Representatives of the Polish school include professors: Gubała, Trzaskalik, Słowiński, Kacprzyk, Kaliszewski, Nowak and others. Multidimensional Comparative Analysis – MCA is related mainly to representatives of the Polish school which focuses on taxonomic methods intended mainly for objects arrangement. Those methods are applicable in the situations where there is a necessity for the selection of one variant out of many possibilities.

They are intended for subjective assessment of decision-making variants and informed choice for the best of them according to the adopted criterion, which is preceded by the analysis of potential alternatives. One of the groups of such methods uses pair wise comparison, and such comparison may refer both to qualitative as well as quantitative features (Wątróbski, Ziemba et al. 2016). Variants are compared with each other (each variant is compared with all the others) with the implementation of various scales of assessment depending on the method used (Ziemba et al. 2016). If there are n variants for disposal, then the number of comparisons will be $n(n-1)/2$ (all of them which are compared with each other). In case when the number of variants is n = 3, and there is 1 criterion then we obtain 3(3-1)/2 comparisons 3. A far better solution refers to comparing 2 given decision-making variants with the implementation of one criterion. The number of comparisons may however, considerably increase in such situation. For instance, while considering 100 variants with the implementation of four criteria one needs to conduct 6 for comparison criteria, and while comparing decision-making variants with the implementation of one criterion there will be 4950 comparisons. As above presented, this process is very labor-intensive and it requires extensive concentration from the decision-maker with regard to expressing their preferences while selecting the product. Conducting the comparison the n × n matrix is created. Filling in the matrix, one shall remember that the values are related with each other in the matrix. For instance, in case of the AHP method, a ten-step comparative scale is implemented, whereas in case of the REMBRANDT method a five-step comparative scale is implemented. In the course of research conducted with the implementation of such methods a human factor have a considerable importance (Faizi et al. 2017). This is a participant of the decision-making process that conducting the assessment, exerts the influence on the final result and depending on

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his/her actions there is a risk of wrong undertaking of the decision. In order to avoid such situations, the cohesion of criteria and alternatives assessment matrixes are examined, which in case of complex decision-making problems may still be problematic. The more decision-making variants and criteria, the higher number of comparisons occur, which results in bigger engagement of the participant of the study and consequently higher fatigue of such participant (Nermend 2017a, Nermend 2017b).

The decisions making is not just only choosing one variant among many others, But it is dealing with many other situations, for example concerning certain ecological behaviors. Whether we use efficient energy devices, limit water consumption, turn off unused devices (TV, computer, etc.), it is also related to our decision. Various types of social campaigns aimed at raising awareness may influence our decisions. The social campaign is defined as an organized effort of a group of persons focused on convincing recipients to adopt, change or abandon certain conducts, attitudes or perceptions (Kotler et al. 2002). As Prochenko adds (2017), this effort and those activities shall be organized within a given timeframe, and their purpose shall refer to the increase of knowledge, change of perception or conduct with regard to a given social problem which prevents realization of common benefits. Social campaigns promote certain positive attitudes and conducts or negate those inappropriate. Thus, their purpose is often of an informative and educational nature explaining or encouraging to undertake certain determined actions referring to the public interest.

Social advertising is discussed in the context of various information, educational and persuading campaigns whose goals refer to important social issues, which are perceived by majority of the society as proper ones (Scheffs 2015). There are various types of social advertising intended to achieve various goals (Porochenko 2007). Some of them are intended to popularize the activity of social organizations, others to solicit funds, whereas the aim of some others refers to persuading people to adopt certain pro-social conducts or care about safety and health (Scheffs 2015).

The development of good habits in the field of ecology (saving electricity) brings concrete benefits both for household budgets (lower invoices for energy) as well as for the natural environment (our environment and the environment of future generations). Electrical energy saving refers to the protection of our health, saving forest, water, air and the whole nature. Saving methods are not very problematic as it is enough to develop certain habits of proceeding. They are concerned with the appropriate exploitation of household devices such as switching off the light in rooms left by householders, switching off the computer, TV set, and radio when not used, using energy-saving bulbs, filling in the whole washing machine, dish-washer, etc. (Piwowarski 2017). Social campaigns constitute one of the main methods for informing and promoting environmental awareness. Advertisements are broadcasted in TV ensuring a wide group of recipients. It is however, not clearly

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known how people perceive such type of advertisements, whether they evoke any emotions, interest in the subject, what is remembered?

The aim of the publication is to present a possibility to use certain cognitive neuroscience techniques application (EEG, GSR, HR) to study people's behavior (emotions, interest, remembering). The research results are presented in two areas. The first concerns checking, how quickly the experiment participants become subject to fatigue in the course the decision-making process and the decision analysis. The second one is related to the analysis of the effectiveness of social campaign (energy saving).

Materials and Methods

Experiment I

For the purpose of examining fatigue of the decision-making process participants during the selection of a given product, a research experiment has been designed in the form of the selection of one out of six (decision-making variants) vehicles of German production. All the vehicles were Sedans of the same class with regard to the size. Vehicles were compared with regard to six criteria (price, look, fuel consumption, the trunk space, maintenance cost and insurance cost). For the purpose of the research experience execution a web-tracking system has been designed enabling to track all the activities of the decision-making process participant. The system registers all the important events such as pressing the button, mouse clicking, time for each screen changing, etc. as well as the time of their display with the fraction of the second precision (fig. 1).

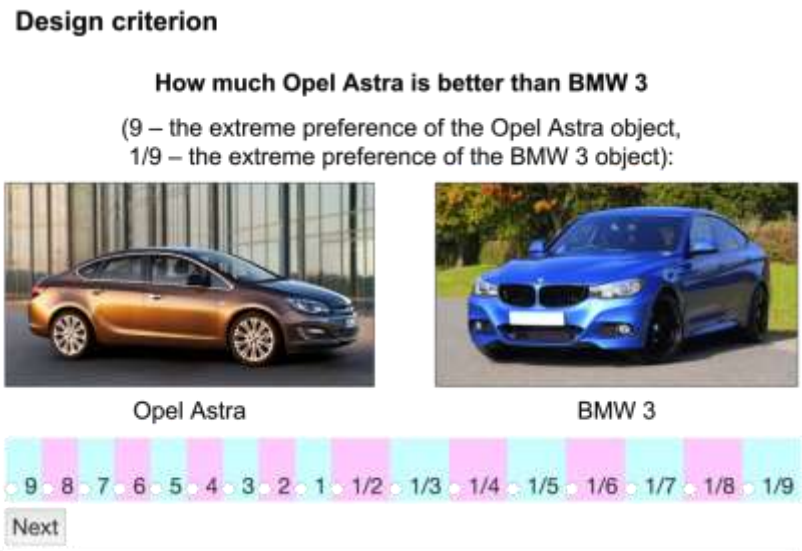

Fig.1. Exemplary screens of the web-tracking system.

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As the figure 1 presents, the majority of screens were assisted by photos of vehicles chosen by participants of the experiment, in order to avoid the situation when a given participant does not know how a given vehicle make looks like, which might affect his/her decision.

For the purpose of data registration by means of electroencephalogram (EEG), electrodes have been installed in compliance with guidelines of the 10-20 system, which determines places for inserting individual electrodes on the scalp.

33 persons from there age groups: 20-24 years of age (students), 30-40 years of age (researchers, administration personnel), and above 40 years of age (administration personnel, researchers) took part in the study. Participants of the experiment included persons having the knowledge of the AHP method.

Experiment II

The advertising spot lasting 30 seconds has been analyzed. The purpose of the advertisement referred to increasing awareness with regard to the need for a rational use of the energy as well as to highlight pro-ecological nature of ENERGA business (energy supplier). The concept was based on engaging unconventional actors – the dog, canary and cat, teaching proper habits, among others, by encouraging to switch off the light, TV set or computer.

The course of the experiment was as follows. A fragment of the film was broadcasted (title: "The birth of a man, the thinking being"), which was divided by 2 advertising breaks. Each break consisted of 6 advertisements. Advertisements referred to various aspects, including among others, various social problems. The total broadcasting time of the film together with advertisements was 32 min. and 2 seconds. The analyzed advertisement (broadcasted 1 time) was broadcasted during 1 advertising breaks (fig. 2).

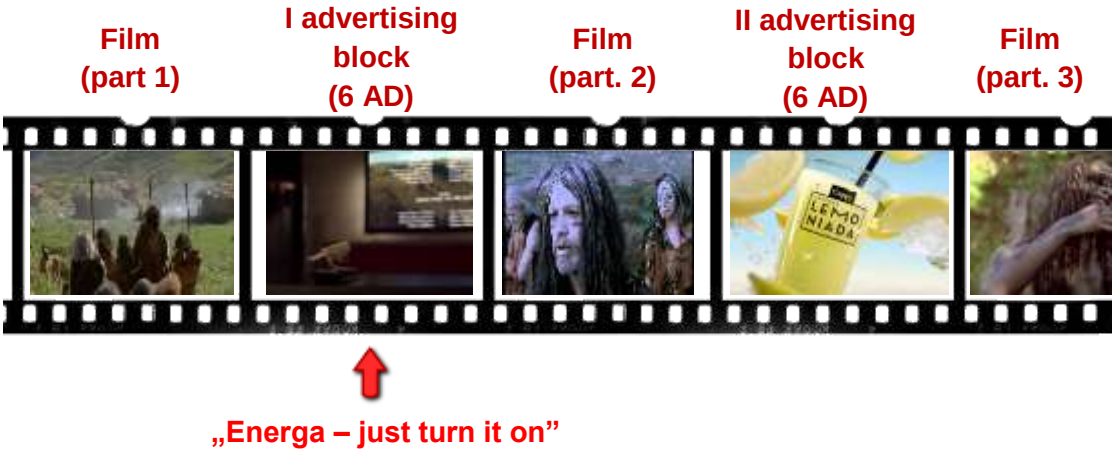

Fig. 2. The experiment - advertisement 'Energa - just turn it on'.

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Figure 3 presents 30 shots of that advertisement selected over 1 second periods.

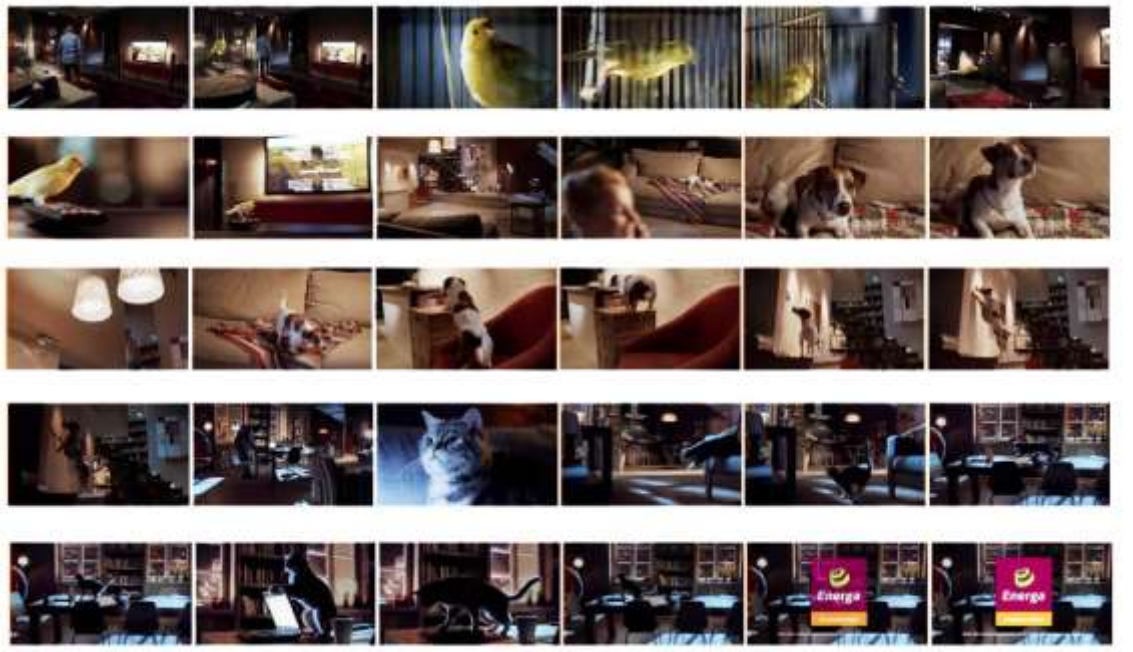

Fig. 3. Film frames of the analyzed advertisement ‘Energa - just turn it on’.

Having seen the film, persons fulfilled the questionnaire based on questions about their preferences, approaches to various aspects of life and the content remembered by them from the advertisements watched. Results of the questionnaire were later on compiled with results obtained from measurements. Such measurements included the examination of the brain activity by means of electroencephalography (EEG). Tests were conducted in 2017 for a group of 20 persons of different ages, from 20 to 50 years old.

Results

Experiment I

On the basis of the registered time of the event occurrence from the web-tracking system, the average time for the selecting the alternative for individual criteria was calculated for each participant of the decision-making process (fig. 4). At the beginning the time for the criterion of the price was about 11 second. The average time decreased for the criterion of the look dropped down to (6,9 s.), and increased for the criterion of fuel consumption to (7,3 s.). For the trunk space criterion was dropped down to (5,95 s.) and for other criteria it was more or less similar. The above mentioned could stem from higher skills with regard to filling in the questionnaire by the person examined as well as from decreased interest of the person examined which might lead to random responses.

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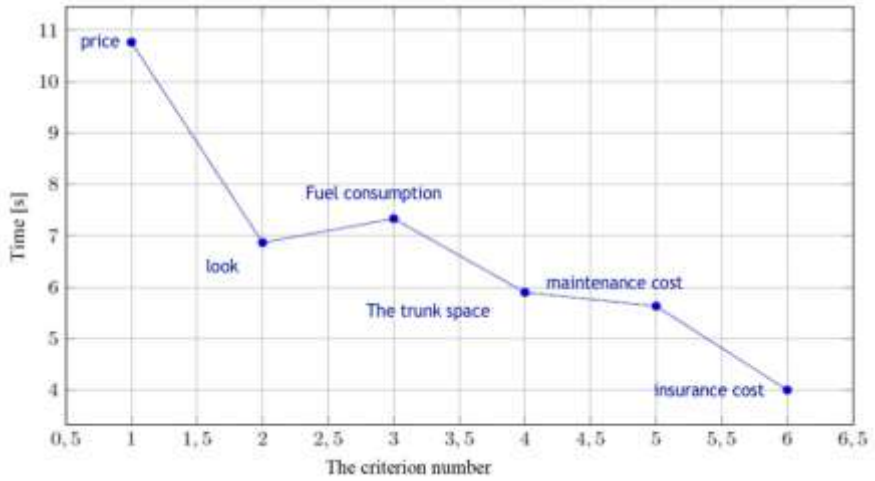

Fig. 4. Data from the web-tracking system: the average time of the first action together with the question reading.

The above mentioned fact confirms that there was no interest in the study commencing from the half of the experiment, that is, after forty five comparisons. After such number of pair wise comparisons with the AHP method, participants started to select responses automatically without thinking. A greater interest in the answers provided (after the price criterion) was related to the fuel consumption criterion. The above mentioned may be related to the fact these criteria directly affect the consumer's finances.

Fig 5 presents charts of GSR signals for the criterion of the fuel consumption for the experiment participant. The events of mouse-clicking at the radio-button referring to the selection of one of two alternatives according to the Saaty scale are marked as points.

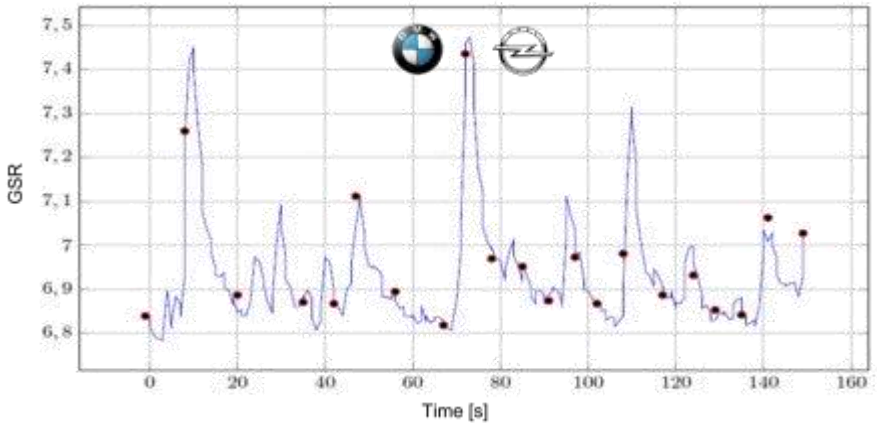

Fig. 5. GSR signal for the criterion of the fuel consumption for participant of the experiment.

The galvanic skin response occurs with a delay ranging within 2-6 seconds depending on the participant of the experiment. The signal registered presents the levels of emotions of the person examined in the course of the experiment. Fig. 5 presents that in experiment participant the biggest emotions were raised at the moment of comparing the decision-making variant of Opel Astra to BMW

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3 with regard to the criterion of the fuel consumption. The time for the selection of the decision-making variant was very long which reveals that the participant of the experiment hesitated for long before undertaking the decision.

Fig. 6 presents chart of the Approach-Withdrawal Index for the participant experiment, during the pair wise comparison of the decision-making variants with the AHP method with regard to the trunk space and fuel consumption.

Index of interests - Approach-Withdrawal (AW) Index is calculated on the basis of the formula:

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

where: x_{α_i} and y_{α_i} represent the *i*-th EEG channel in the alpha band that have been recorded from the right and left frontal lobes, respectively, P and Q are 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. The AW signal measured has been transformed and averaged in such a manner so as to obtain the averaged course (Davidson 2004, Vecchiato et al. 2014).

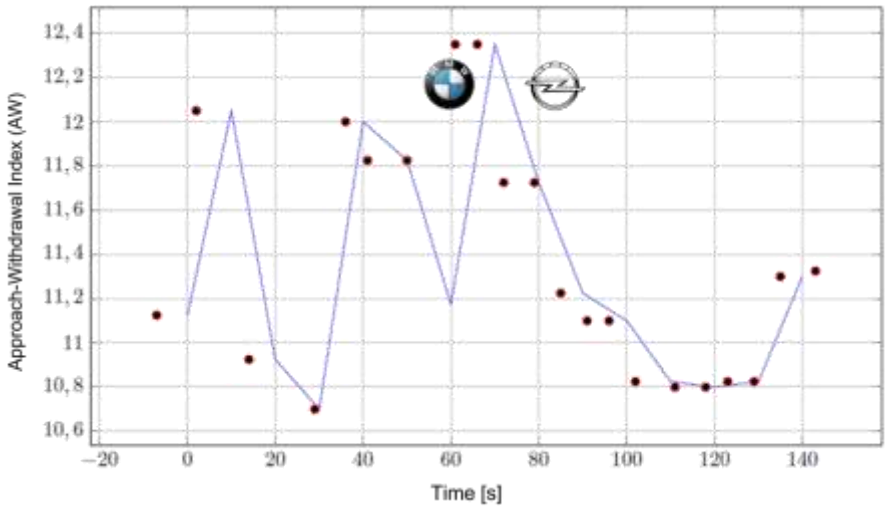

Fig. 6. Values of Approach-Withdrawal Index for the criterion of the fuel consumption for the participant of the experiment.

For the criterion of the fuel consumption (fig. 6), the highest activity of the signal occurred while comparing the decision-making variant of BMW 3 to Opel Astra. That means, the participant of the

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experiment showed the greatest interest in the serial comparison of the decision-making BMW car with opel astra.

Experiment II

In the course of the experiment, signals of EEG have been registered. Such signals were subjected to processing, including filtration and extraction of features. The Memorization Index (MI) were established on the basis of the registered signal of EEG. Memorization Index is established in compliance with the formula:

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

where: x_{θ_i} represents the *i*-th EEG channel in the theta band that has been recorded from the left frontal lobe, Q is the set of left channels, N_Q represents its cardinality.

The increase of the MI value is related to enhanced memorization (Werkle-Bergner 2006, Summerfield 2005, Vecchiato et al. 2014).

Memorization index was established for each second of the broadcasted advertising spot, for each of the participants of the experiment. Subsequently, the averaged values for all the persons examined have been calculated. Figure 7 presents the chart of the averaged values of memorization index for all the persons examined.

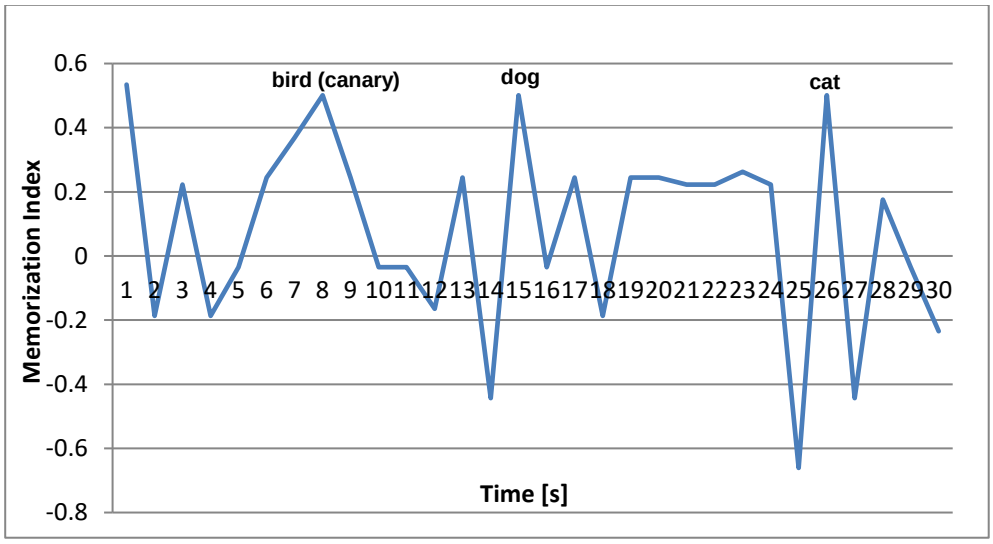

Fig. 7. Averaged values of the memorization index (MI) for all the participants of the experiment.

The curve of the signal reflecting the MI values visibly presents that three shots, in which the animals switch off electrical receivers (the bird and cat) or intend to do so (the dog) were memorized in

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particular. The first considerable increase of the signal refers to frame 8 (the bird's switching off the TV set by a remote control), frame 15 (the dog's climbing up the cabinet) and frame 26 (the cat's closing of the laptop). They are very characteristic shots, in which household animals conduct certain not typical for them activities. As it is presented on the chart, the memorization index value for frames with the logo of the electricity supplier is low about which the advertiser may be concerned as its intention is to promote the brand.

Conclusions

Cognitive neuroscience techniques in the field of undertaking decisions (not only management decisions) demonstrate a tremendous research potential. In part it has been already utilized; however, still there are many possibilities which have not been verified yet. The main difficulty in preparation of the appropriate study refers to the necessity of having knowledge in various fields – neuroscience, psychology, economy and IT.

The research which were shown in the article is intended first of all to present the potential of neuroscience and its techniques with regard to taking decisions. In the first experiment the most important decision criteria for choosing one of the five cars was the price and fuel consumption criterion. The conducted studies reveal that the longer the study lasts the more fatigue is experienced by participants of the experiment as presented on fig. 4. Such effect was visible approximately after 45 responses. In such situations one shall consider whether it would not be better to apply other methods, as for instance the PVM (Preference Vector Method) method, for a high number of decision-making variants. This method will limit the participation for the experiment participant in the decision-making process to the minimum, which may help avoiding the phenomenon of fatigue in the experiment participants. The application of cognitive neuroscience techniques for the registration of the brain activity in the experiment participants may be very helpful for monitoring their real preferences as participants not always undertake decisions in compliance with declared by them preferences.

The second experiment concerned the study of factors which affect the effectiveness of advertising in terms of memorizing the scenes there. The examined advertisement with the social message on energy saving (ENERGA supplier) turned out (according to the potential assumptions of the advertiser) to be a good production. The engagement of animals for promoting proper conducts of humans turned out to be effective. The above mentioned is confirmed by results of the examinations which were conducted with the use of cognitive neuroscience technique, such as EEG. Registered and processed signals allowed for the final designation of index MI reflecting the state of man, namely remembering ability. The scene with the dog (switching off the light), where achieved high values, are turned out to be highly effective of the examined index. In case of the scene with the cat (closing of

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the laptop), just as in the scene with the canary (switching off the TV set with a remote control) they also achieved high MI index values. The analysis of the advertising spot, conducted with the implementation of cognitive science techniques, considerably (however, not fully) covers the results of the questionnaire conducted among examined persons (after the completion of the examination). The persons remembered scenes with the animals, in particular with the dog, other scenes were less remembered. It may seem interesting that at the moment of broadcasting the logo of the energy supplier, MI index was characterized low values (declining tendency).

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