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Cognitive neuroscience techniques in determining the right time of advertising

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Abstract: Cognitive neuroscience techniques are used in many different domains. Among them is marketing research. The general assumption driving such research is that human brain activity can provide marketers with information that cannot be obtained otherwise. The aim of this article is to show, how cognitive neuroscience techniques and neurometrics can be helpful in determining the appropriate time for advertising a product. The study was conducted with the use of the advertisement for dietary supplement enhancing the cognitive abilities. The experiment presented in the paper consists of two parts. The first one was conducted two months before the exams and the second one - during exams. It was arranged this way to check, if the students would show more interest in the advertisement when they have examinations (in the "right" time) and if the neurometric indexes are able to capture such interest by showing statistically significant difference between these two periods.

Keywords: cognitive neuroscience techniques; neuromarketing; consumer neuroscience; advertising

1. Introduction

Cognitive neuroscience techniques are used in many different domains. One of applications fields is marketing research. Under the name of neuromarketing or consumer neuroscience, scientists utilise neurophysiological signals to gain deeper insight into a consumer brain [1-2]. Such research covers a broad range of topics. However, most of attention is directed to marketing mix and its instruments – product, price, promotion and place, as well as brand research [3].

The general assumption driving this kind of research is that human brain activity can provide marketers with information that cannot be obtained with the use of conventional marketing research methods (e.g., interviews, questionnaires, focus groups) [4]. This is caused by the fact that people are sometimes not able (or do not want to) explain their real preferences when asked; as human behaviour can be driven by processes that are below the level of conscious awareness and subject's feelings are often inaccessible to the interviewer that uses traditional techniques [5-6].

For each aforementioned instrument of marketing mix there is substantial amount of exemplary studies utilising cognitive neuroscience techniques. The product element has been mostly investigated in reference to the optimal design and packaging (e.g. [7]). Pricing policy research concerns typically economic concepts like the "willingness to pay" or experienced utility (e.g. [8-9]). A central aspect of distribution element is the choice of marketing channels adequate for a product and a context optimal for its presentation (e.g. [10-11]).

The field of brand research is concerned with examining the important influence of brand information on decision-making (e.g. [12-13]).

The promotion is the last instrument of marketing mix that was not mentioned above. This element is the main interest in the article, therefore it will be discussed in detail. Although the neuromarketing and consumer neuroscience are present in the scientific discourse for about a decade, neurophysiological measurement methods in the context of consumer research and advertising have been used for a long

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time. Research concerning the reception of TV advertisement and their influence on potential consumers with the use of neuroscience techniques have been carried out since the late 60's of the twentieth century. In 1969, the advertising and public opinion researcher Krugman for the first time used EEG to record a young woman's brainwaves in response to a television commercial [14]. Along with the progress of neurophysiological research, the number of marketing publications using this kind of techniques increased from the 60's to the 80's [15-17]. However, in the 90's, the number of publications that employed neurophysiological measures decreased. An underlying reason for that might be the validity, reliability, and applicability issues of some techniques [18].

The advances of cognitive neuroscience techniques that were achieved in the last few years, have changed this situation. Most of recent research concerning the promotion element of marketing mix is focused on investigating memory [19-20], attention [21-22] and emotional processes [23-24] and to assess predictive value of obtained results in the light of marketing practices and/or theories [25]. Moreover, cognitive neuroscience techniques could allow for determining the right time of presenting the advertising content to the consumers, by giving opportunity to show changes in emotional and perceptual reception of advertisement over time. The best marketing means hitting the right target with the right message at the right time [26] and the possibility to define when the advertisements should be presented would be very valuable.

The objective of this study is to show, how the cognitive neuroscience techniques could be helpful in determining the timing for broadcasting the advertisement. Neurophysiological signals registered for the participants of the experiment can easily show how the memorization, attention, and emotional attitude to the commercial changes when it is watched in a proper time. The study is designed to show that the neurometric indexes could capture the "right" moment to deliver an advertising. It was conducted with the use of the advertisement for dietary supplement enhancing the cognitive abilities. The product is called "Sesja" and it is directed to students and it is advertised as a learning booster for the exam period at the university (called "session" later on in this paper). The experiment consists of two parts. The first one was conducted two months before the exams at the end of the academic term and the second one - during the session. It was arranged this way to check, i) if the students would show more interest in the advertisement of supplement, when they have exams (in the "right" time) and ii) if the neurometric indexes are able to capture such interest by showing statistically significant modification when compared to the previous period. The aim in perspective of such study is to become able "to predict" when the right time for the advertising will be, on the base of period measuring of the target population.

2. Research procedure and methods

To achieve the objective formulated in the paper, research procedure consisting of four main steps was conducted. It is shown in Figure. 1.

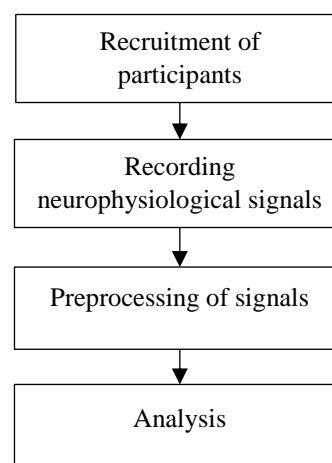


Figure 1: Research procedure

Individuals subject to experiment watched a 20-minutes movie. It was a popular science documentary with three commercial breaks. Each break included three commercial video clips lasting 30''. The commercial that was the target stimuli can be watched at the following link:

<https://www.youtube.com/watch?v=TXhY2SiCmlA>.

During the video the electroencephalographic (EEG), heart rate (HR), and galvanic skin response (GSR) were collected from the subjects. The cerebral activity was recorded with the use of Emotiv Epoc+ device. The HR and GSR were recorded with the Neurobit Optima 4 system. After watching the movie, participants took part in a questionnaire regarding the content they have just seen. At this stage people were asked to recall the advertisements that they remember. Questions concerned the spontaneous and aided recall. Moreover, the subjects were asked to assess their impressions concerning the commercials that they have watched in the scale 1 (negative) -10 (positive).

Participants of the experiment were recruited via word of mouth among the students of University of Szczecin. The experimental sample was formed by 20 subjects (right-handed, 6 women). The mean age of participants was 24 (± 2.5). Informed consent, approved by the local institutional ethics committee, was obtained from each subject after the experiment was explained.

The experiment was conducted in two parts – the first took part two months before the exams at the university (11 participants), the second was during the exam period (9 participants).

The EEG signals have been band pass filtered to remove frequencies below 0.4 Hz and above 50 Hz [27]. Then, artefacts have been removed with the use of wavelet Independent Component Analysis [28]. Comparison of signals with and without artefacts for the exemplary electrode F7 is shown in Figure. 2. By using discrete wavelet transformation function, the signal for each channel has been decomposed into five different frequency bands (alpha, theta, beta, gamma and delta) depending on Daubechies 8 wavelet function [29]. These EEG traces have been then segmented to obtain the cerebral activity during watching TV commercial and that associated with the documentary (baseline period). GSR and HR signals were appropriately filtered after recording [30-31]. Filtering effects for GSR signal are shown in Figure. 3.

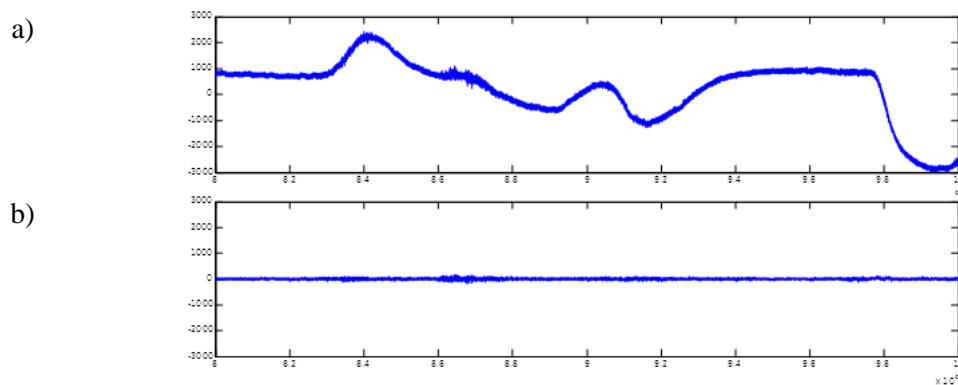


Figure 2: Signal for F7 electrode a) with artefacts b) without artefacts

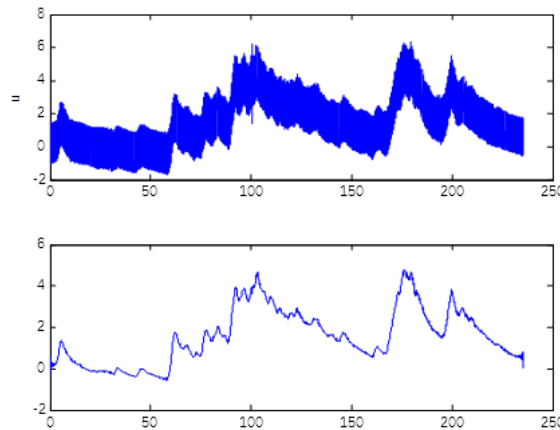


Figure 3: Galvanic skin response before and after filtering

Then EEG, HR and GSR signals were standardized using the Z-score. The standardized EEG values were then used to compute two different indices: Memorization Index (MI) and Approach-Withdrawal Index (AW) [32].

For MI EEG signal in theta band was taken into account and only the left frontal channels have been selected as it is proved that trace for successful encoding of novel information can be detected by measuring an increase of EEG theta power from the left frontal cerebral regions [33-34]. The spatial average of these signals was computed through the following formula:

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

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.

Approach-Withdrawal Index was calculated as difference between the average EEG power of right and left channels in alpha band [35-36]. The formula used to compute AW is as follows:

$$\begin{aligned} AW &= \frac{1}{N_P} \sum_{i \in P} x_{\alpha_i}^2(t) - \frac{1}{N_Q} \sum_{i \in Q} y_{\alpha_i}^2(t) = \\ &= \text{Average Power}_{\alpha_{\text{right, frontal}}} - \text{Average Power}_{\alpha_{\text{left, frontal}}}, \end{aligned} \quad (2)$$

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.

Galvanic skin response and heart rate signal were used individually as the autonomic measures of emotions [37].

3. Results

From the calculations of MI and AW indices, data recorded for one person during the session was excluded as registered signal was incorrect, because of the technical fault of the EEG device.

Results for MI are shown in Figure. 4a. The commercial achieved higher values of memorization index (MI), during the session. In fact, average MI (calculated for all subjects) for the whole advertisement before the session was 2.51 (± 1.04), and during the session 4.15 (± 1.36). With the use of Student's t-test it was possible to state that the difference between the two mean values is statistically significant (at $p < 0.05$).

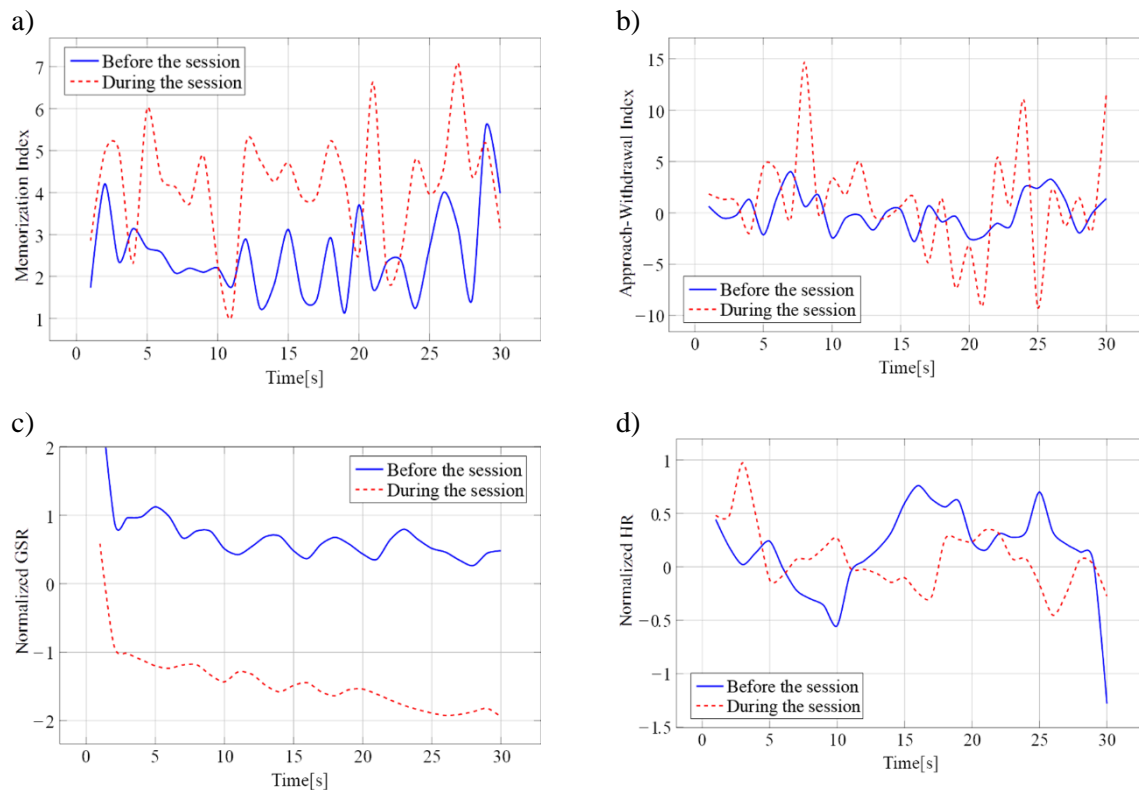


Figure 4: a) Memorization Index b) Approach-Withdrawal Index c) normalized GSR signal d) normalized HR signal; before and during session

Before and during the session, students memorized the elements of advertisement differently. During the session they memorized especially elements that are connected directly with the exams and associated relative emotions. The presence of the supplement (e.g. the appearance of the name of the supplement) in the advertising was associated with the lowest values of the MI.

In the next step of research, AW was calculated (Figure. 4b). Average AW during the entire duration of the ad before the session was $0.04 (\pm 1.77)$ and during the session $1.14 (\pm 5.3)$. The difference between the averages, according to the Student's t-test is statistically significant at $p < 0.05$. During the session, the average interest of students has increased, so has the variability of this interest. Before and during the session, students were interested in similar elements (the scene with falling box, party). The intensity of interest during the session was much larger, but its duration shorter than before.

A clear difference in the GSR values before and during the session can be observed (Figure. 4c). Subjects reacted with stronger emotions before the session than during the exam period. The average value of normalised GSR during the entire duration of advertising before the session was $0.74 (\pm 0.63)$, and during the session $-1.44 (\pm 0.48)$. The Student's t-test has shown that difference between averages is significant at $p < 0.05$.

While participants watched the advertising before the session a steady decline in the value of GSR could be seen. This could be due to fatigue connected with watching the ad. Interestingly, the beginning of a new scene often causes an increase in the value of GSR, followed by a decreasing trend. Scenes in the commercial are changing very quickly, and if they are too similar to each other, they may cause only a slight increase of GSR (if any).

The values of HR have been standardized and then the average values for each second of ad, separately for experiment before the session and during the session, were calculated. The values that differed more than two standard deviations from the mean were not taken into account when calculating

the average. The result is shown in Figure. 4d. A minor difference between the data gathered during and before the session can be observed. The average value of normalised HR during the entire duration of the ad before the session was $0.16 (\pm 0.41)$ and $0.08 (\pm 0.3)$ during the session. Student's t-test has shown that the difference between the averages was statistically insignificant.

In the questionnaire every participant evaluated the commercial of "Sesja". On Figure. 5a and 5b standardized answers of all subjects are combined with the average Memorization Index. Standardization was done using the mean and standard deviation of all answers given by the certain person. The charts show that the declared assessment is not connected with the value of Memorization Index. With the use of Student's t-test it was also checked if the difference between average assessment during the session (-0.01) and before it (0.02) is statistically significant. The result of the test was negative.

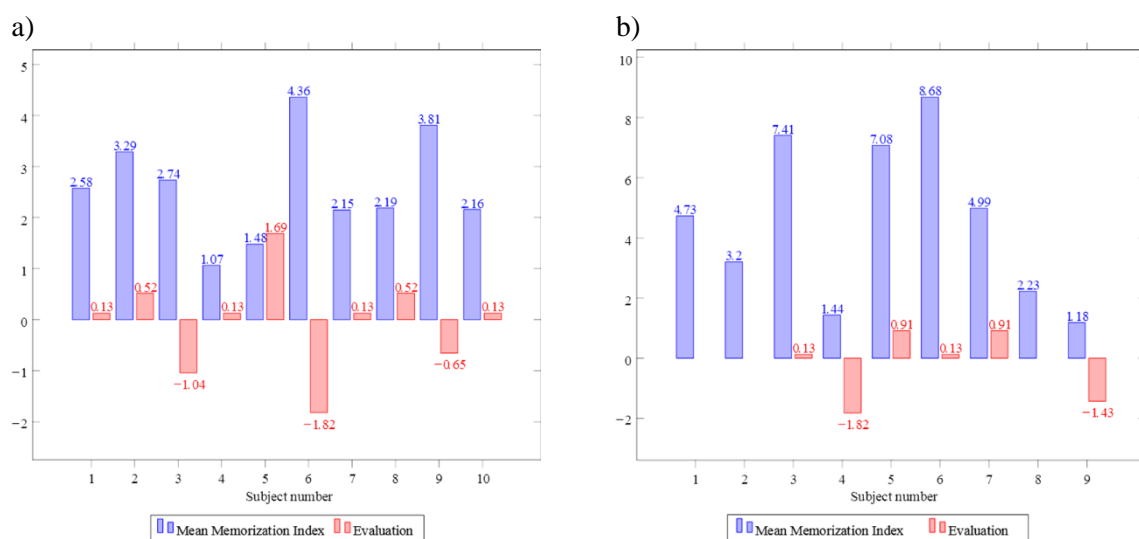


Figure 5: a) Mean MI and assessment of the commercial before the session b) Mean MI and assessment of the commercial during the session

In questionnaire, participants were also asked what commercials of these shown during the experiment they could recall. During the session, spontaneous recall of "Sesja" ad was 33%. Before session it was slightly bigger and equal to 36.36%. When the recall was aided by the experimenter, the results during the session and before were 55.56% and 36.36% respectively. Using the analysis of variance (ANOVA), the influence of watching the commercial during the session on the MI, AW and GSR/HR values, was studied.

Every second of the advertisement has been treated as separate group. Registrations before and during the session were also treated as separate groups. It resulted in 60 groups. The recorded results for different subjects were treated as observations. For the surveyed groups Fisher statistics with right-critical area ($F_{\alpha, u, v} = 0.74$) were set. Value of α was assumed to be 0.05. Degrees of freedom are: $u = 9$ and $v = 8$ accordingly. Based on the obtained results it can be concluded, that for Memorization Index ($F = 1.44$), Approach-Withdrawal Index ($F = 0.79$) and GSR ($F = 1.63$) analysed groups differ significantly, while for HR ($F = 0.61$) there are no significant differences. HR values cannot therefore be used to determine whether the reception of advertising before and during the session was similar.

In order to determine which of the analyzed groups contributed to the determining of differences, LSD (least significant differences) test was used. Test was performed for every pair of groups. It allowed determining which fragments of the commercial differ from one another significantly. Figure 6 presents the obtained results. With °symbol, parts of advertisement resulting in reactions that differ significantly from others were marked. Symbol of • shows the fragments where reactions were different before and during the session.

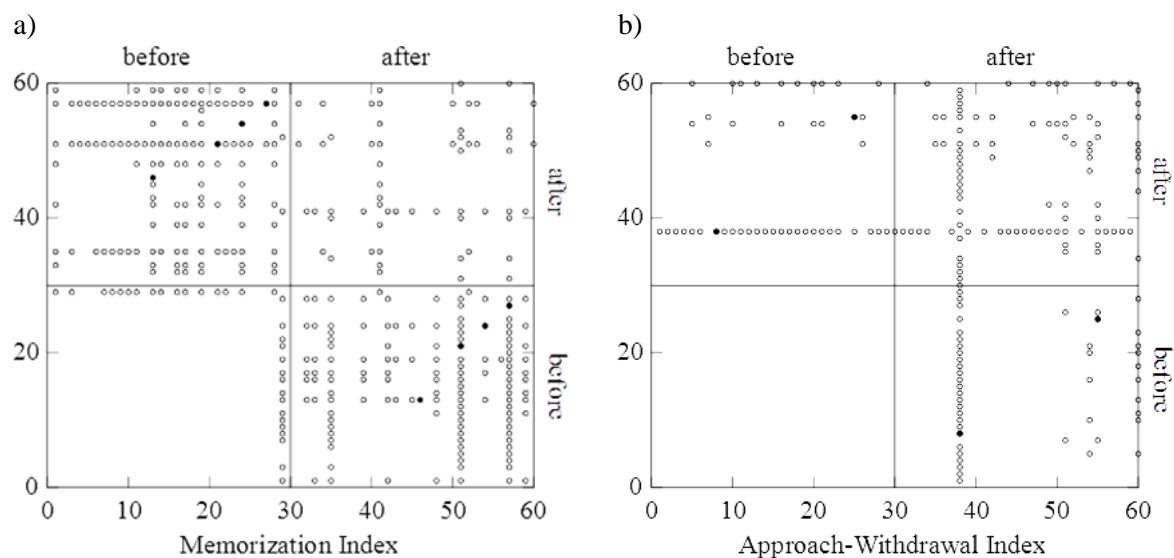


Figure 6: LSD test for a) Memorization Index and b) Approach-Withdrawal Index

4. Discussion and Conclusions

The methodology shown in the article could be used for any product that is designed to be used in specific periods of time. In the case study presented, the commercial was tested two months before and during the examination period. The results have shown the differences in commercial reception. Especially Memorization and Approach-Withdrawal Indexes calculated for the participants during two experimental sessions have proven that when the commercial is broadcasted when the product is needed, the response of the viewers is better. Both indexes achieved higher values during the exam period and the differences are statistically significant at $p < 0.05$. The pattern of memorization during the session shows, that students remembered better the images directly connected with exams and emotions associated with them. However, the presentation of the supplement itself and its name was associated with the lowest values of MI. The Approach-Withdrawal Index values, on the other hand, have shown that the first occurrence of “Sesja” supplement in the advertisement aroused interest of experiment participants. It may be assumed that the increase of AW was caused by the way in which the product was presented. Its appearance was sudden and unexpected, so it could surprise the viewers and generate their interest. The GSR measurements conducted during the experiments have demonstrated that also emotions aroused in participants on average are more intense, when they watch “Sesja” advertisement during the session than before. The difference is statistically significant.

The questionnaires conducted along with the experiment also haven't demonstrate any statistically significant differences between participants watching the commercial before and during the session. It could confirm the hypothesis that neuroscientific tools are able to reveal more than the traditional methods of marketing research.

Preliminary results do not allow to state, when exactly the campaign should start to achieve the best outcomes. However, the neurometrics have proven to be useful in this field. The problem could be studied in following experiments involving recording the neurophysiological signals in different time intervals before the examination period, to observe the changes in subjects' response and draw appropriate conclusions on this basis.

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