How TV commercials affect attention and memory?

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***Abstract*— Neuromarketing is an emerging multidisciplinary field that involves neuroscience methodology to estimate the reaction of consumers to marketing activities and the way they affect their decisions. The most used neurophysiological technique for neuromarketing studies is electroencephalography (EEG). We present a pilot EEG signals-based study on four participants. We investigated the effect of selected seven commercials on memorization and attention. Statistical analysis of extracted attention and memorization indices has shown high inter-subject variability. It has also demonstrated a statistically significant difference (p<0.05) between participant reactions on commercials on the individual level. Novel metric based on normalized total score of attention index, memorization index and self-assessment was proposed and demonstrated through the comparison of commercials.**

***Index Terms* — neuromarketing, EEG, attention, memory.**

I. Introduction

NEUROMARKETING, a new field of marketing research, has greatly benefited from applying neurophysiological methodology in investigating conscious and unconscious consumer behavior, during the past decade [1, 2]. At the same time, it is overcoming challenges that the traditional metrics used to offer and adding value to the traditional marketing research [3]. Some of the neurophysiological technologies that are used in neuromarketing are: functional magnetic resonance imaging (fMRI, for measuring changes in blood oxygenation and flow that occur as a response to brain activity) [4], electroencephalography (EEG, for measuring electrical activity in the cerebral cortex) [1, 5], eye tracking [6] or various sensors for measuring changes in human physiological condition (e.g., heart rate, respiratory rate, skin conductivity) [7,8]. EEG technology is affordable and with an excellent temporal resolution, so it is the most used neurophysiological technique for marketing studies [1].

The growing literature in this field has unequivocally shown that EEG can be successfully used for research in the field of advertising and neuromarketing. For example, Dimpfel et al. recorded EEG and eye-tracking signals of participants who observed 5 advertisements about banks and concluded that the advertisements affected the observer in a way that the distinct brain regions were activated depending on the type of the emotion evoked whilst the person observed the advertisement [9]. In another EEG study, with 34 participants who observed 5 advertisements, Balconi et al. [10] found a strong correlation between what customers liked and the activation of the dorsolateral prefrontal cortex (DLPFC). In participants who watched commercials, Vecchiato et al. found an asymmetric increase in theta and alpha activity related to the observation of pleasant and unpleasant advertisements, in the left and right hemisphere, respectively [11,12]. More precisely, they found de-synchronization of the left alpha frontal activity, as well as the higher theta activation on the left frontal and pre-frontal areas, if the respondents liked the advertisement. Astolfi et. al. [13] assessed cortical activity in healthy subjects whilst watching TV commercials inserted within a film, using a high-resolution EEG technique, and found highly significant brain activity during the observation of TV commercials, which was mainly concentrated in the frontoparietal parts of the cortex (approximately grouped around Broadman fields 8, 9 and 7).

The goal of this research was to, based on the EEG measurements [14], assess attention and memory indices for each of the commercials presented to the participants in order to rate them according to these markers. We expected that some commercials would score high on the index of memory, some on the index of attention, some on neither of the two indices, and some on both. That way, the practical value of this research would be to point out those advertisements which are better suited for attracting attention vs. those who are memorized better. The second goal was to assess individual differences across participants.

In Section II we have presented the performed methodology: experiment description and EEG data analysis. Furthermore, we have illustrated group and individual statistical results of TV commercials impact on attention and memory, in Section III. Finally, we have given conclusion and plans for the further work in Section IV.

II. The Method

A. Experiment description

Four healthy participants (1 female and 3 males, age: 27.7±7.5 years) participated in the experiment. All participants have signed the informed consent.

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During the experiment, participants were asked to comfortably sit in front of the computer screen and watch the prepared video. The video consisted of 7 commercials with a 30 s pause (black screen) between them and at the beginning, as well. Commercials were selected from the list of top 2012 commercials in Serbia [15]. We have considered that the advertisements have been shown on TV long ago and that participants do not remember them in detail, so the initial memory effect was negligible. All commercials had approximately same duration and a similar structure, consisting of three parts: 1) story introduction, 2) action and 3) product logo display. The complete video timeline is presented in Table 1.

EEG data acquisition was performed using a 24-channel Smarting amplifier (mBrainTrain, Belgrade, Serbia) connected to Greentek EEG cap (Wuhan Greentek Pty. Ltd, China). Twenty-two monopolar EEG channels were recorded (10/20 locations: Fp1, Fp2, F3, F4, C3, C4, P3, P4, O1, O2, F7, F8, T7, T8, P7, P8, Fz, Cz, Pz, AFz, CPz, POz). The ground was located at FPz and FCz, and it was used as the reference site. The sampling rate was set to 500Hz. The EEG system sent EEG data via Bluetooth to the computer.

At the end of the experiment, participants were asked to subjectively evaluate each advertisement (scale 1 to 5, 5 was the highest mark).

TABLE I
THE VIDEO TIMELINE

No.	Advertisement's name	Duration
	Pause	30 s
1.	"Forever", Carnex	33 s
	Pause	30 s
2.	"Meeting with happiness", State Lottery of Serbia	30 s
	Pause	30 s
3.	"Infostud jobs"	20 s
	Pause	30 s
4.	"LAV beer"	30 s
	Pause	30 s
5.	"Schweeps"	35 s
	Pause	30 s
6.	"JAFFA cakes"	30 s
	Pause	30 s
7.	"Sportingbet"	28 s

B. EEG data analysis

EEG data analysis consisted of 1) EEG preprocessing, 2) extraction of attention and memory indices and 3) statistical data analysis.

EEG preprocessing included FIR filtering in range 2-30 Hz, removing eye-blink artifacts using *Individual component analysis* (*ICA*) method and bandpass extraction of alpha activity (8-12 Hz) in the right frontal (Fp2, F4, F8) and the left frontal lobe (Fp1, F3, F7) and theta activity (4-8 Hz) in the left frontal lobe (Fp1, F3, F7) by a fifth-order Butterworth filter. The flowchart of the EEG preprocessing is presented in Fig. 1.

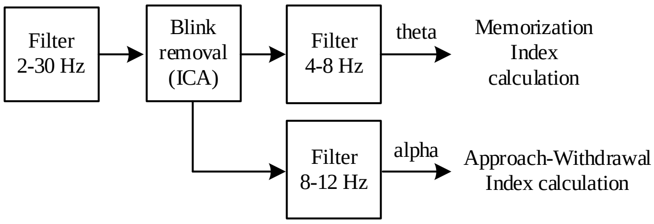

Fig. 1. Flowchart of the EEG preprocessing

Approach-Withdrawal index [7, 8, 16] for attention (*AW*) was calculated on preprocessed alpha activity in the right and left frontal lobes, on time windows of 3 seconds as in

$$AW = P_{\alpha\ right\ frontal} - P_{\alpha\ left\ frontal}$$

$$AW = \frac{1}{N_R}\sum_{i \in R} EEG^2_{r\ \alpha_i}(t) - \frac{1}{N_L}\sum_{i \in L} EEG^2_{l\ \alpha_i}(t) \quad (1)$$

where $P_{\alpha\ right\ frontal}$ and $P_{\alpha\ left\ frontal}$ are the averaged powers of alpha activity in the right and left frontal lobes, respectively; $EEG_{r\ \alpha_i}$ and $EEG_{l\ \alpha_i}$ are the *i*-th preprocessed alpha band EEG channels in the right (R) and left (L) frontal lobes, respectively; N_R and N_L are numbers of $EEG_{r\ \alpha_i}$ and $EEG_{l\ \alpha_i}$ channels (N_R=N_L=3).

Memorization index (*MI*) [17] was calculated on preprocessed theta activity in the left frontal lobe, on time windows of 3 seconds as in

$$MI = P_{\theta\ left\ frontal} = \frac{1}{N_L}\sum_{i \in L} EEG^2_{l\ \theta_i}(t) \quad (2)$$

where $P_{\theta\ left\ frontal}$ is the averaged power of theta activity in the left frontal lobe. $EEG_{l\ \theta_i}$ are the *i*-th preprocessed theta band EEG channels, in the left (L) frontal lobe and N_L is the number of $EEG_{l\ \theta_i}$ channels (N_L=3).

EEG signal preprocessing and indices extraction was done in Matlab R2014b (Mathworks, USA). EEGLAB Toolbox was used for filtering and for *ICA* application [18].

The ANOVA analysis was performed on extracted *AW* and *MI* indices to investigate the statistical differences (the significance values of $p<0.05$) in the reactions of the participants on different commercials. We have analyzed changes in *AW* and *MI* indices on the group level (all participants for each advertisement) and on the individual (participant) level for each advertisement. Statistical analysis was done in RStudio [19]. A novel metric defined as a total score for *AW* index, *MI* index and self-assessment was also calculated (as a sum of participant mean values for each advertisement) and normalized to the range [0,1].

III. RESULTS

Box plots for *AW* and *MI* indices on the participant group level for each commercial is presented in Fig. 2. ANOVA analysis has shown statistically significant difference ($p<0.05$)

between commercials only for *AW* index, Fig. 2A. There was no significant difference between commercials on the participant group level in terms of memory, Fig. 2B.

Individual differences between participants concerning their reaction for each commercial were investigated as well. Fig. 3 shows box plots for *AW* (Fig. 3A) and *MI* (Fig. 3A) indices on the participant level for each advertisement. ANOVA analysis has shown statistically significant difference ($p<0.05$) between commercials for both indices, *AW* and *MI*.

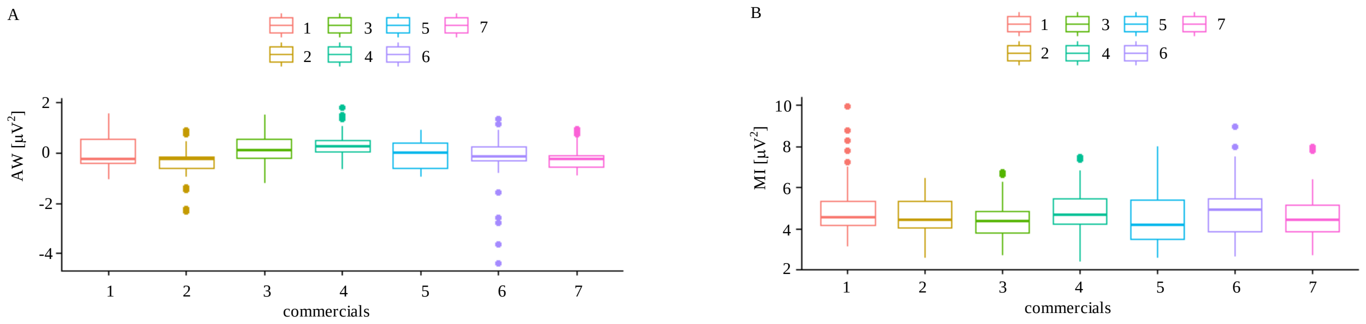

Fig. 2. A) Approach-Withdrawal index (*AW*) and B) Memorization index (*MI*) for each commercial on the participant group level (commercial order 1-7 is shown in Table 1).

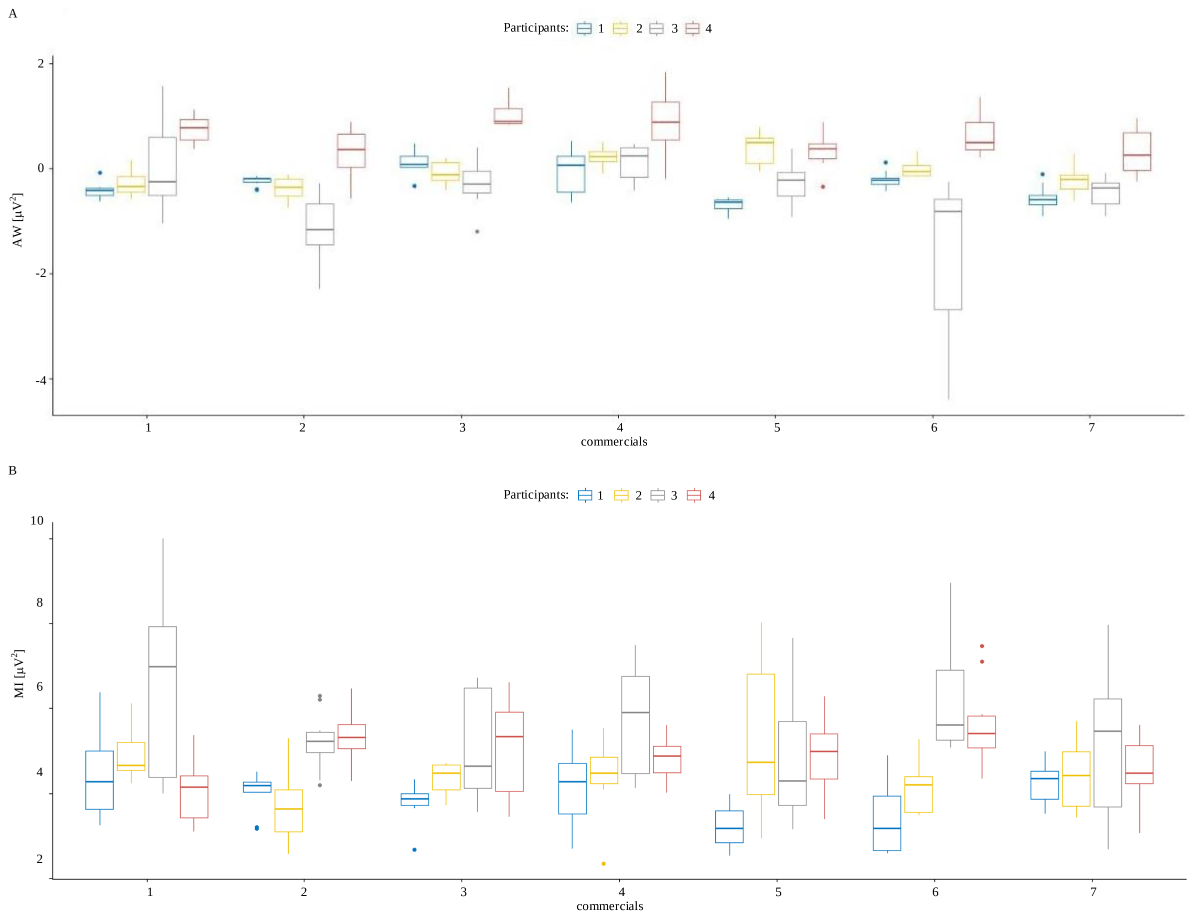

Fig. 3. A) Approach-Withdrawal index (*AW*) and B) Memorization index (*MI*) for each commercial on the individual (participant) level (commercial order 1-7 is shown in Table 1).

From Fig. 3, it can be noticed that there is a high inter-subject variability for each commercial that caused no statistically significant difference for *MI* index on the group level as well as a low statistically significant difference for *AW* index.

Finally, Fig. 4 shows the comparison between normalized total scores of *AW*, *MI* and self-assessment (*SA*) for each commercial. It was found that there is no correlation between *SA* and indices. This means that the objective and subconscious criteria concerning attention and memory is necessary for the detailed observation of the advertisement impact on participants. From Fig. 4, it could be noticed that commercials 1 and 4 have high (attention and memory) impact on participants, commercials 3 and 5 are better suited to attract attention while commercial 6 was memorized better. It is important to mention that commercial 3 lasts shorter than others (20 s vs 28-35 s) which may be the reason for low memory. Commercials 2 and 7 have low induction of attention and low induction of memory as well. Regarding results presented in Fig. 4, normalized total scoring seems to be a promising tool for comparison and visualization of the effects of advertisements on participants. Potential benefit from this type of analysis is obvious: for the investor, it is important to have objective and detailed feedback from customers regarding their attention and memory engagement whilst watching commercials.

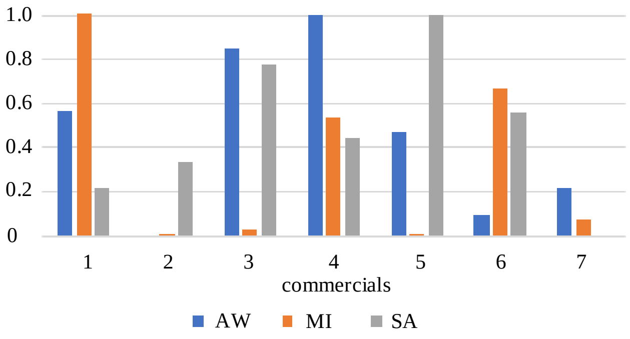

Fig. 4. Comparison of normalized total score for Approach-Withdrawal index (*AW*), Memorization index (*MI*) and Self-assessment (*SA*) for each commercial (commercial order 1-7 is shown in Table 1).

IV. Conclusion

In this paper, we have demonstrated a novel approach for the comparison of commercials in the pilot EEG signals based study. Large individual differences in attention and memory involvement were ascertained between participants whilst watching the video content. For that reason, differences in reactions on commercials for each participant were also considered. Individual approach showed the existence of statistically significant differences for attention and memory indices between commercials. All individual scores for *AW*, *MI* and *SA* were summed and normalized giving an effective way for presenting and comparison of different impacts of commercials on participants. However, this type of neuromarketing study can be expanded by simultaneous recordings of heart rate, electrodermal activity and eye tracking activity (along with EEG signals), enabling the assessment of the emotional index and eye tracking features as well. Also, the longer duration of commercials could enable analyzing and comparing individual parts of advertisement, and not just analyzing advertisements as a whole. Future work will be focused on designing a longer experimental paradigm, applying a multimodal approach for data acquisition and advertising differentiation, using multiparametric analysis.

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