NEUROMARKETING AND APPLICATION OF swLORETA qEEG DURING DECISION MAKING PROCESS

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Abstract: In recent years, interest in studies using electrophysiological methods such as EEG in marketing research has grown. The interest for these methodologies relies in their high-temporal resolution as opposed to the investigation of such a problem with the functional magnetic resonance imaging (fMRI) methodology, also largely used in the marketing research. High resolution EEG technology has greatly improved their spatial resolution in the last decades. By presenting data gathered through swLORETA qEEG we show what kind of information it is possible to gather with these methodologies while the persons are watching marketing relevant stimuli and make a decision. Such information will be related to pleasantness to such stimuli. We noted that temporal and frequency patterns of brain signals are able to provide possible descriptors conveying information about the decision making processes in subjects observing advertisements. This information could be unobtainable through other tools used in standard marketing research.

Key words: Neuromarketing, swLORETA qEEG, decision making process, Brodmann areas, human behavior.

1. INTRODUCTION

The most accepted definition of neuromarketing is a field of study applying neuroscientific methods to analyze and understand human behavior related to markets [1]. Today, neuroscientific methodology includes powerful brain imaging tools, based on gathering of hemodynamic or electromagnetic signals related to the human brain activity during the performance of a relevant task for marketing objectives. The reason why marketing researchers are interested in the use of brain imaging tools, instead of simply asking the people for their preferences in response to marketing stimuli, arises from the assumption that people cannot fully explain their preference when have been asked. Researchers in the field hypothesize that neuroimaging tools can access information within the consumer's brain during the generation of a preference or the observation of an advertisement. The most frequently used brain imaging method in the neuromarketing field is the functional Magnetic Resonance Image (fMRI), a technique that creates a sequence of images of the cerebral activity by means of the measure of the cerebral blood flow. Such images have a high-spatial resolution that no other neuroimaging methods can offer. It is known that the hemodynamic measurements of the brain activity allow a level of localization of the activated brain structures in the order of few cubic mm, being capable to detect activity deep in the brain structures such as amygdala and nucleus accumbens. The lack of time resolution, due to the delay of the cerebral blood flow's increment after the exposition to the stimuli, make the fMRI unsuitable to follow the brain dynamics on the base of its sub seconds activity. However, there are other brain imaging techniques that allow to follow on a millisecond base the brain activity during the exposition to relevant marketing stimuli. Such techniques are the electroencephalography (EEG). The problem with that brain imaging technique however is that the recorded electrical cerebral signals are mainly due to the activity generated on the cortical structures of the brain. In fact, the electromagnetic activity elicited by deep structures (usually advocated for the generation of emotional processing in humans) is almost impossible to gather from usual superficial EEG electrodes [2]. To overcome this problem, high resolution EEG technology (swLORETA qEEG) has been developed to enhance the poor spatial information content of the EEG activity in order to detect the brain activity with a spatial resolution of a squared centimeter and the unsurpassed time resolution of milliseconds [3].

It is worth to say that swLORETA qEEG techniques, while exhibiting a remarkable time resolution and a passable spatial resolution, have drastically different costs for the marketing research.

2. RELATED WORKS

2.1. Neuromarketing and memorizing

The research in the neuromarketing field performed in the recent years by using high-resolution EEG techniques [4] showed results suggesting that the cortical activity of the brain during the observation of TV commercials that were forgotten (FTV) is different from the cortical activity observed in subjects that remembered the same TV commercials (RTV). In fact, the principal areas of statistical differences in the power spectral density (PSD) maps, between such experimental conditions, are located almost bilaterally in the prefrontal Brodmann Areas (BA) 8, 9 as well as in the parietal BA 7.

The spectral amplitude in the RTV condition was always higher than the power spectra in the FTV conditions over the BA 8, 9, and 7 [5]. A statistical increase of PSD in the prefrontal and parietal areas for the RMB dataset compared with the FTV one is in agreement with the suggested role of these regions during the transfer of sensory information from short-term memory to long-term memory storage. Although the differences in the cortical power spectra between the RTV and FTV conditions are relatively insensitive to the particular frequency bands and hemispheres, there are experimental evidences showing that there is a stronger engagement of the left frontal areas among all the subjects analyzed during the observation of the TV commercials that were remembered [6]. The analysis of the statistical cortical maps in the condition RTV versus FTV suggested that the left frontal hemisphere was highly active during the RTV condition, especially in the theta and gamma band. Taken together, the results indicated that the cortical activity in the theta band on the left frontal areas was increased during the memorization of commercials. In fact, in such a model the left hemisphere plays a key role during the encoding phase of information from the short-term memory to the long- term memory, whereas the right hemisphere plays a role in the retrieval of such information. It must be noted, that the role of the right cortices in storing images has been also recognized for many years in neuroscience [7]. The pattern of activity, which was elicited during the observation of the TV commercials remembered, suggest an active involvement of the anterior cingulate cortex (ACC) acting as sources of links between cortical areas. Increased activity related to an enhanced outflow of partial directed coherence links from ACC towards other cortical regions could be taken as a sign of increased “emotive” attention to the stories proposed by different TV commercials. The EEG spectral and cortical network analyses performed in several studies also suggest a key role of the parietal areas as targets of the incoming information flow from all the other cortical areas. Functional networks in the frequency domain were also estimated by evaluating the global and local efficiency indexes derived from the graph theory, employed as a measure of the level of communication in the networks. The changes of these indexes could be related both to memory coding activity as well as to increase/decrease of the attentive state of the subjects. In the beta and gamma frequency bands, the respective reduction of global efficiency, as well as the reduction of local efficiency for the alpha band of the cortical network communication could represent a predictive measure for the accurate recall of the commercials that will be remembered.

2.2. Neuromarketing and hedonic evaluation

The research group of Handy and colleagues investigated the rapid emotional evaluation of advertising logos [8]. Their study wanted to evaluate whether the visual cortical processing of everyday images, like logos, can include an implicit hedonic analysis. In particular, they asked participants to identify, within a set of unfamiliar logos, those that were most liked or disliked. By means of an event-related potentials (ERPs) analysis, they found out that visual cortical processing shows an increase of the early positive component (named P1) at central and parietal sites, along with an increase of the later negative component (named N2) at parietal and occipital sites, related to the observation of disliked logos. The idea at the base of this paper is to find electrophysiological signs correlated to the perception of liking or disliking particular advertising logos. Once this correlation was found, as expressed in the paper, it opens the way to the use of such ERPs P1 and N2 waves as markers for the hedonic preferences of the consumer concerning the logos. This procedure could overcome the need to collect verbal preferences of consumers during the evaluation of different kind of logos, by replacing them with an automatic and nonverbal evaluation of such hedonic preferences. The recognition in humans of positive or negative hedonic values during the observation of different logos or advertising could be assessed also by using EEG spectral activity instead the ERPs. In fact, with the use of EEG rhythms indirect variables of emotional processing could be revealed by tracking variations of the activity of specific anatomical structures, such as the pre- and frontal cortex. It is known that the PFC region has a key role in the generation of the emotions. EEG spectral power analyses indicate that the anterior cerebral hemispheres are differentially lateralized for approach and withdrawal motivational tendencies and emotions. Findings suggest that the left PFC is an important brain area that mediates appetitive approach, while the right PFC appears to form a major component of a neural circuit that is responsible for defensive withdrawal.

A contrast of the activity generated by observing pleasant (“like” dataset) and unpleasant (“dislike” dataset) audiovisual content has been performed in a few studies [5, 6]. The result of this experiment shows that the activity of the brain, in terms of PSD, is stronger in the “like” condition than in the “dislike” one, except that in beta band. The results obtained for the “like” condition are also congruent with other observations performed with EEG in a group of 20 subjects during the observation of pictures from the international affective picture system [9]. Such observations indicated an increase of the EEG activity in the theta band for the anterior areas of the left hemisphere. The study highlights the activation of the ACC which is an area involved in reward-based learning and error detection.

3. NEUROMARKETING ELECTROPSYCHOLOGICAL swLORETA qEEG RESEARCH

The idea of our neuromarketing neuropsychological experiment is to trace the impact of 5 different types of logo:

No. 1

No. 2

No. 3

No. 4

No. 5

The five participants in the survey, saw each logo for the first time. During the observation, 1 minute swLORETA qEEG recording was performed on each participant. Previously, qEEGs were recorded in normal condition without visual impacts and incentives. Five swLORETA qQEEG records were made for each logo. After the experiment, participants were asked to share which of the logos they liked most. Their responses were compared to the electrophysiological characteristics of the recording. For the purpose of the study, EEG hardware of Cognionics Quick 20 was used. Software processing of qEEG records was carried out through Neuroguide, Applied Neuroscience. Through the Fast Fourier Transformation (FFT), the following frequency ranges were defined: delta (1-4Hz), theta (4-8X), low alpha (8-10X), high alpha (10-12K), CMP (12-15K) beta (15-18X), high beta (18-25 Hz) and gamma (30-35 Hz).

For all these frequencies in order to monitor the flow of information Z-score, absolute and relative power, coherence, spatial asymmetry, Phase lag, Phase shift, Phase lock and Phase slope index (PSI) were calculated for each Brodman area.

The following figures present the results of the swLORETA qEEG test for each participant. The chart on the left, above, depicts the functional state of the brain before the visual marketing logo stimulation. The charts track the brain response in the sequential representation of the 5 types of logo in the order defined above.

Participant №1 (fig. 1): The most significant changes in the observed electro-psychological parameters occurred with the logo №1 и №5, subjectively identical choice.

Participant №2 (fig. 2): The most significant changes in the observed electro-psychological parameters occurred with the logo №2 и №5, subjectively identical choice.

Participant №3 (fig. 3): The most significant changes in the observed electro-psychological parameters occurred with the logo №1 и №5, subjectively identical choice

Participant №4 (fig. 4): The most significant changes in the observed electro-psychological parameters occurred with the logo №1 и №5, subjectively identical choice.

Participant №5 (fig. 5P): The most significant changes in the observed electro-psychological parameters occurred with the logo №5, subjectively identical choice.

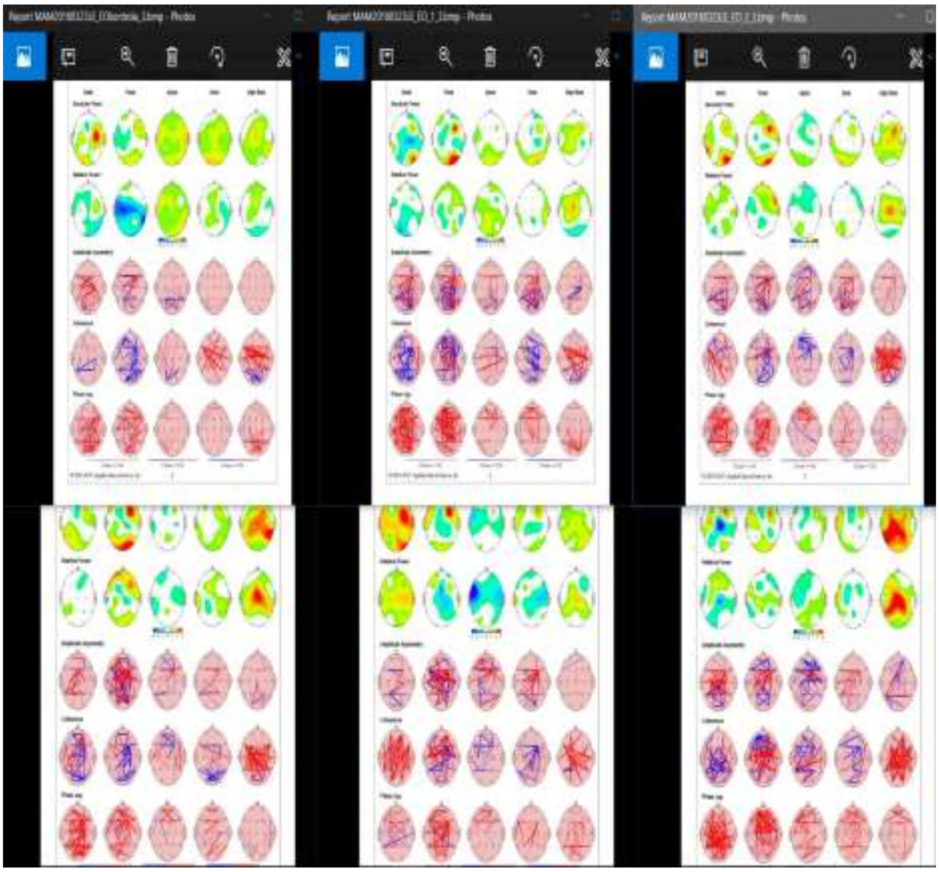

Fig. 1. Participant №1 (MM)

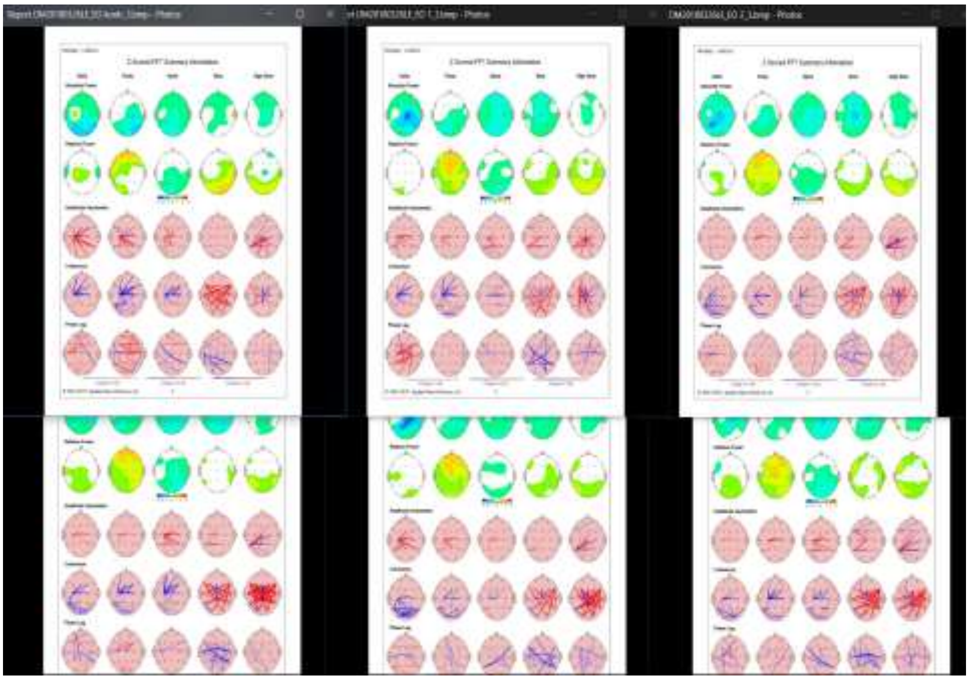

Fig. 2. Participant №2 (DM)

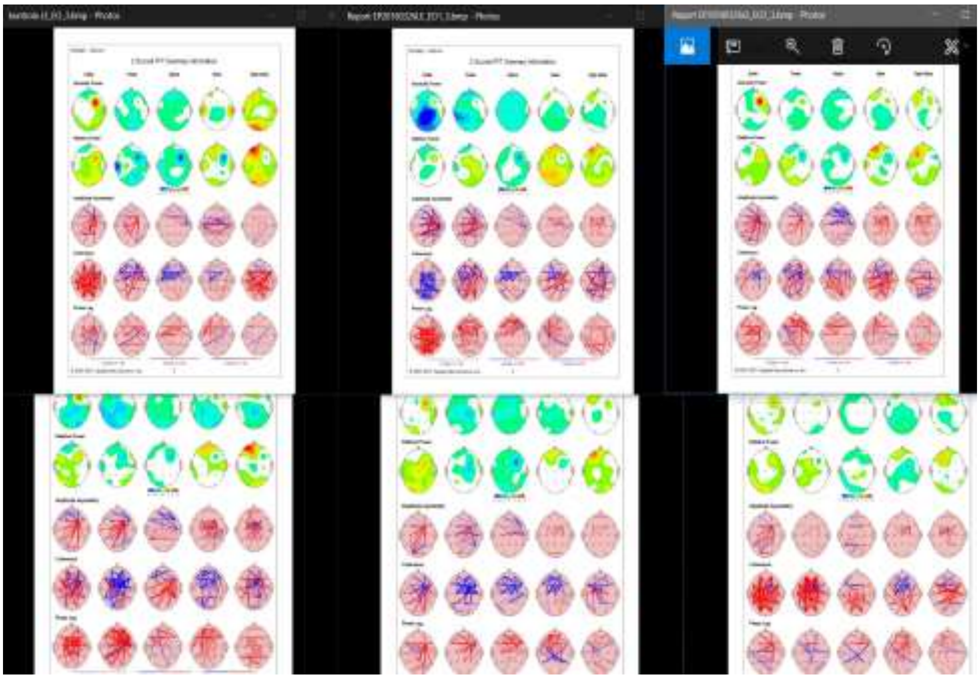

Fig. 3. Participant №3 (EP)

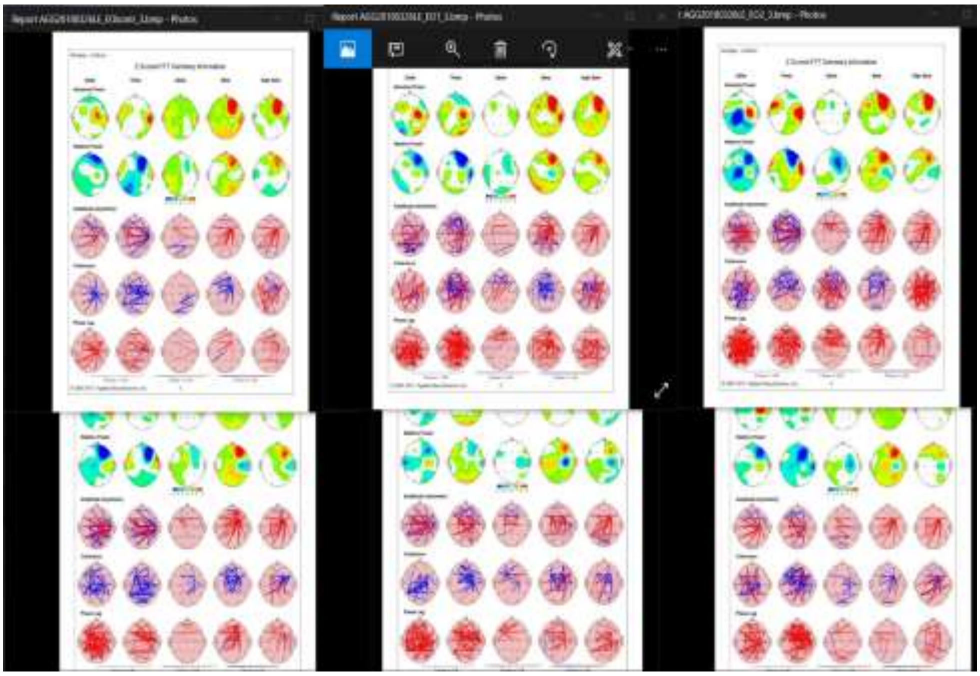

Fig. 4. Participant №4 (AG)

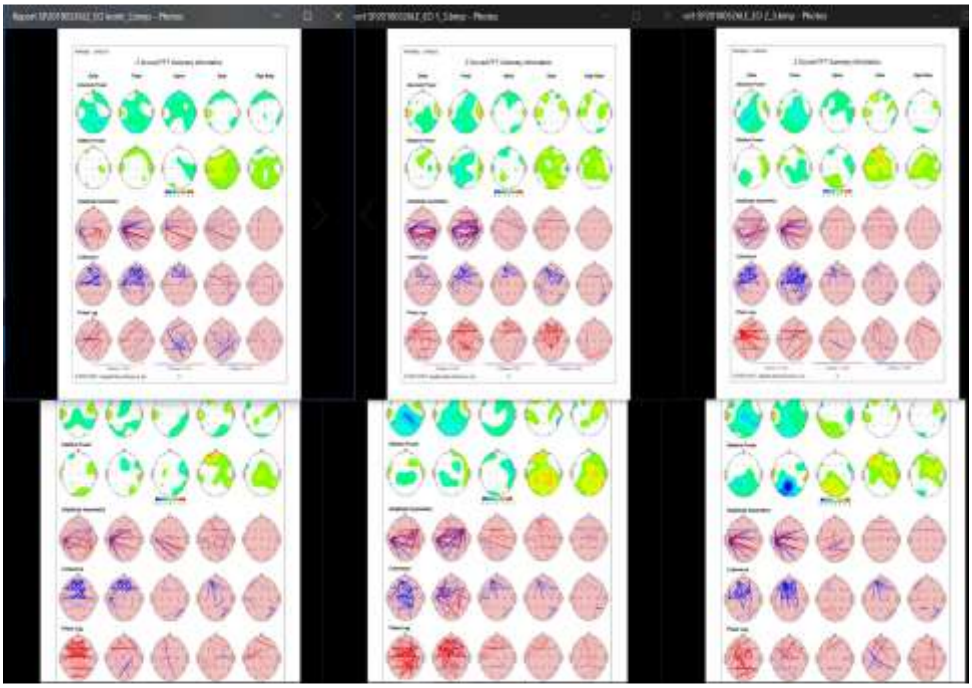

Fig. 5. Participant №5 (SP)

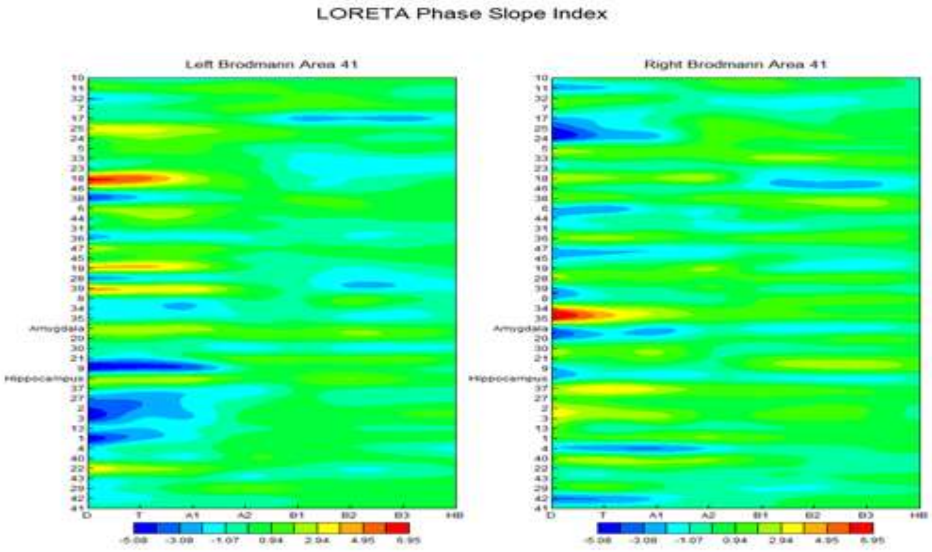

Fig. 6. Network information transfer between BA 41 and rest of the Brodmann areas

4. CONCLUSION

Our pilot neuromarketing study showed that a spectral imbalance at frontal lobe is related to logos the subjects judged pleasant or unpleasant. We observed that such "like" and "dislike" datasets are characterized by different EEG power spectral maps in theta and low alpha bands. This imbalance in the activations was linearly correlated with the degree of pleasure expressed by the subjects and has an influence over decision making process.

In the neural network information transfer, we observed a change in amplitude power for the different frequency bands, a change in coherence in the 5 frequency bands, and the magnitude of the Phase Slope Index (PSI), an electrophysiological marker for the transmission of information in neural networks. The transfer of information was mainly between the visual cortex and the structures of the Salience network (a neural network dealing with the decimation of value from non-value). The most important were the functional changes in the left 10, 12, 41, 42 and 45 Brodman fields (areas of the cortex that are related to the evaluation of language visual stimuli). In the assessment of the visual impact of different language visual stimuli cross frequency coupling was also taken into account. Cross frequency coupling between theta and gamma frequencies occurs when processing cognitive information. These changes were most pronounced in the occipital and frontal divisions of the brain.

Results presented in this paper highlight that the left prefrontal cortex is activated while subjects are observing stimuli that will later be remembered and by the ones, which will be judged pleasant. In this way, the prefrontal cortex plays a key role in decision making processes since the neural activity in these areas seems to participate in encoding a new complex stimuli (logos) and reflecting the emotional state of the subject.

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Manuscript received on 14 January 2019