Proceedings of the 28th IEEE
EMBS Annual International Conference
New York City, USA, Aug 30-Sept 3, 2006

Neural Basis For The Brain Responses To The Marketing Messages: an High Resolution EEG study

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Abstract— **We investigated the behaviour of the brain during the visualization of commercial videos by tracking the cortical activity and the functional connectivity changes in normal subjects. High resolution EEG recordings were performed in a group of healthy subjects, and the cortical activity during the visualization of standard commercial spots and emotional spots (no profit companies) was estimated by using the solution of the linear inverse problem with the use of realistic head models. The cortical activity was evaluated in several regions of interest (ROIs) coincident with the Brodmann areas. The pattern of cortical connectivity was obtained by using the Partial Directed Coherence (PDC) and investigated in the time and frequency domains, in the principal four frequency bands, namely the theta (4-7 Hz), the alpha (8-12 Hz), the beta (13-30 Hz) and the gamma (above 30 Hz). Results suggest a time-varying engagement of the orbitofrontal circuits that is thought to be involved in the reward value of the stimuli.**

Keywords—**high resolution EEG recordings, Partial Directed Coherence, commercials TV spots**

I. INTRODUCTION

It is well know as the economic models of human decision making have typically minimized or ignored the influence of emotions on people's decision-making behaviour. In this respect, the human decisions are idealized as the results from a totally rational cognitive machine. Recently, this assumption has been challenged by behavioural economists, who have identified additional psychological and emotional factors that influence decision-making [1]. Recently, researchers have begun using neuroimaging tools to examine the behaviour in economic games and in the decision making between different commercial advertisements, a field known as Neuromarketing. The main neuroimaging tool used to track the brain response to the commercial advertisements is the functional Magnetic Resonance Imaging (fMRI) technique, able to return the profile of the brain areas that elicited increased blood flow during the task when compared to a quiet (rest) state. However, there are precise limitations in the actual state of the art approach for the tracking of the brain responses to the commercial advertisements by using fMRI. Essentially, the main limitation is linked to the insufficient temporal resolution of fMRI. In fact, temporal resolution of hundred of milliseconds or less is necessary to track the shifts of the brain activity closely related to the processing of visual and acoustic stimuli provided by the fast moving of visual commercial spots.

Here, we investigated the brain activity by tracking the cortical activity and the functional connectivity changes during the visualization of commercial and emotional video clips in normal subjects. High resolution EEG recordings were performed in a group of healthy subjects, and the cortical activity during the visualization of standard commercials and emotive clips from no-profit companies like Greenpeace, Red Cross, etc, is estimated by using the solution of the linear inverse problem with the use of realistic head models. The aim was to elucidate if the video clips having an emotional contents could be differently recognized and memorized from those having no particular emotional messages.

II. METHODS

Experimental Design. Subjects were exposed to the observation of a documentary of 30 minutes. Intermingled with such documentary, three interruptions have been generated, after 6 minutes, at the center of the documentary and 6 minutes before the end of the documentary. Each interruption was composed by six videoclips of about 30 seconds. Then, a total of 18 videoclips were showed during the documentary. Nine of such videoclips are relative to no-profit organizations, like Greenpeace, the Red Cross, etc, while the other clips are relative to standard international brands of commercial products, like cars, food, etc. In addition, all the videoclips were never broadcasted in the country in which the experiment was performed. Then, the visual material was new to the subject, as well as the documentary observed. The subjects were exposed to the documentary once a day for five consecutive days. Each day the documentary was changed, as well as the order of presentation of the clips, that was randomized between the order of appearance of the emotive and non-emotive clips. The 18 video clips presented along all these five days remained unchanged. After the end of the fifth day of recording, an interview to the subjects aimed to quantify the explicit memory of such spots in the subjects.

High resolution EEG recordings. Ten healthy volunteers was recorded with 64 EEG channels. Informed consent was obtained in each subject after explanation of the study, which was approved by the local institutional ethics committee. For the EEG data acquisition, subjects were comfortably seated on a reclining chair, in an electrically shielded, dimly lit room. A 64-channel EEG system (BrainAmp, Brainproducts GmbH, Germany) was used to record electrical potentials by means of an electrode cap, accordingly to an extension of the 10-20 international system. Structural MRIs of the subject's head were taken with a Siemens 1.5T Vision Magnetom MR system (Germany). The EEG recordings were performed in the days 1, 3 and 5 of the exposition of the documentary. Here we will report the EEG data relative to the day 1, taken during the first exposition to the documentary and to the entire set of the emotional and non emotional spots.

EEG data processing. We estimated the cortical activity from the high resolution EEG recordings, by using realistic head models for the subjects involved and a cortical surface model with an average of 5,000 dipoles, uniformly disposed. In a couple of subjects there were no MRIs available. In such cases the average head model available from the McGill University was employed. Fig. 1 shows the different phases of the generation of the realistic head models from the MRIs images to the electrodes placement on the scalp surface.

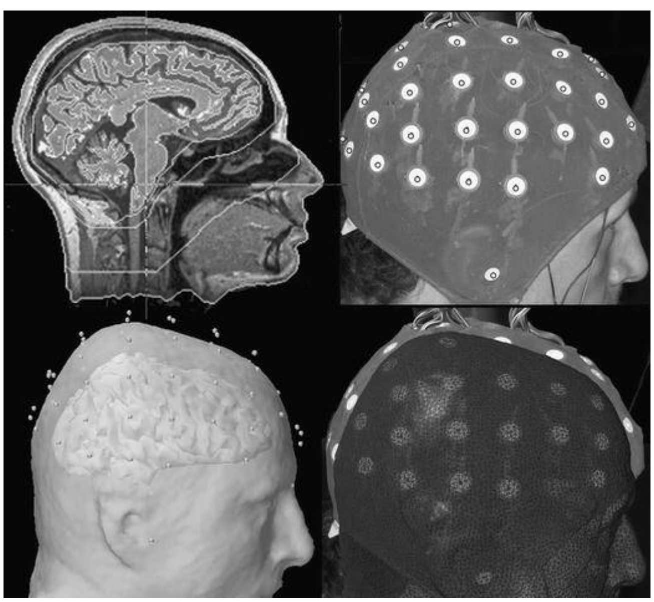

Fig.1. *Images shows the different phases of the generation of the realistic head model for each subject involved in the analysis. Upper left: the segmentation of the MRIs of the subject. Upper right; the electrode mountage used. Lower left: the generation of the realistic head model for the subject. Lower right: coregistration of the electrode position and the realistic head model for the generation of the electrical model for the potential propagation from the cortical envelope to the scalp leads.*

The estimation was obtained by the application of the linear inverse procedure already depicted in the previous publication of the same research group. Cortical activity were then estimated in ROIs generated by the segmentation of the Brodmann areas (B.A.) on the accurate cortical model used. Bilateral ROIs considered in this analysis were the primary orbitofrontal and prefrontal areas, including the B.A. 8, 9/46, 10, 6, as well as the cingulated motor area (CMA), the anterior cyngulate cortex (ACC) and the parietal areas (BA, 5, 7). The labels of the cortical areas have also a postfix characterizing the considered hemisphere (R, right, L, left). Such ROIs were segmented on the basis of Talairach coordinates and anatomical landmarks available. For each time point of the recorded EEG we solved the linear inverse problem and we estimated the magnitude for each one of the thousand dipoles used for cortical modelling. Then, we computed the average of the magnitude of such dipoles in each ROI considered and for each time point. The resulting cortical waveforms, one for each predefined ROI, were then processed for the estimation of the cortical connectivity by using the Partial Directed Coherence (PDC) [2].

III. RESULTS

The cortical activity estimates for all the ROIs considered in each one of the subject analyzed were then subjected to the functional connectivity analysis via PDC algorithm. The results were then summarized as total outflow of functional links from a specified cortical areas toward all the others (of the same subject). This measure of the particular ROI considered is called outdegree. It is also possible observe the total amount of the functional links from all the other cortical areas toward the considered ROI. Such measure is called indegree. Fig. 2 presents the connectivity values originated during the visualization of the videoclips related to the commercial products with no emotive content in the gamma band (16-40Hz), in a representative subject. Arrows moving from one circle to another depicts the existence of a functional connection between the cortical areas due to visual observation of the commercial spots. In Fig. 3 is presented the similar connectivity graphs for the gamma band during the visualization of clips with emotional or neutral contents. It is possible to observe a change in the network depicted between the different experimental conditions. In particular, the role of the right Brodmann area 8, located in a prefrontal regions, is different during the commercial spots when compared to the behaviour of the same area during the observation of the different kind of clips. The situation for the particular subject examined is presented in Fig. 4, where it is possible to observe a graphical representation of the functional connections entering in each cortical area analyzed in this study in the gamma frequency band. In particular, three lines are depicted to represent the values of the number of connections entering in each one of the cortical areas during the visualization of the tree different kind of video clips.

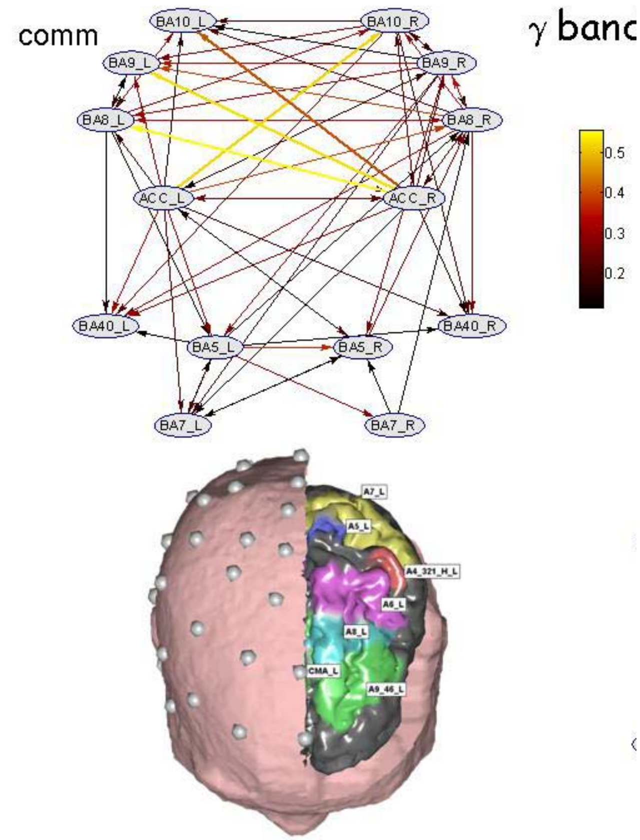

Figure.2. Upper part: *Graph of the functional connectivity between the cortical areas during the observation of the emotional clips in the gamma band in a representative subject. The arrow exiting from a source area and pointing toward a target cortical areas depicts the existence of a functional link between these two areas during the observation of the emotional clip.* Bottom part: *Realistic representation of the Brodmann Areas (BAs) depicted on the realistic model of the cortex of a subject employed in this study. The coloured areas refers to the BA employed in the present study. The labels on the BAs return the information about their names with the postfix L or R for describing right or left. The head is seen from above, nose at the bottom. The bumps on the scalp surface are the electrodes used for the EEG recordings in the particular subject investigated.*

IV. DISCUSSION

The use of electroencephalogram (EEG) measurements in order to describe the electrical activity of the brain while a viewer watches television was already investigated by several authors [3-5]. A particular focus of attention in the past has been on hemispheric variations in how the right brain processes information differently than the left brain. Differences in brain activity as a function of the type of wave measured, for example alpha waves versus beta waves, have been previously pointed out [3]. Several authors have underlined the existence of precise moments during the vision of commercials in which the attention increase or decrease relatively to the simultaneous engage of both the emotional and cognitive context [6]. These moments comprise rather short periods within the advertisement, but are assumed to do much of the ‘work’ in actuating advertising performance measures. Young derives a rudimentary measure of (mental) engagement from fundamental rhythms present in the EEG. He has found a high correlation between moments identified by brain waves and moments identified using a behavioural, attention-sensitive method of picture sorting. This may suggest that there are indeed moments of ‘special’ importance within a given TV commercial.

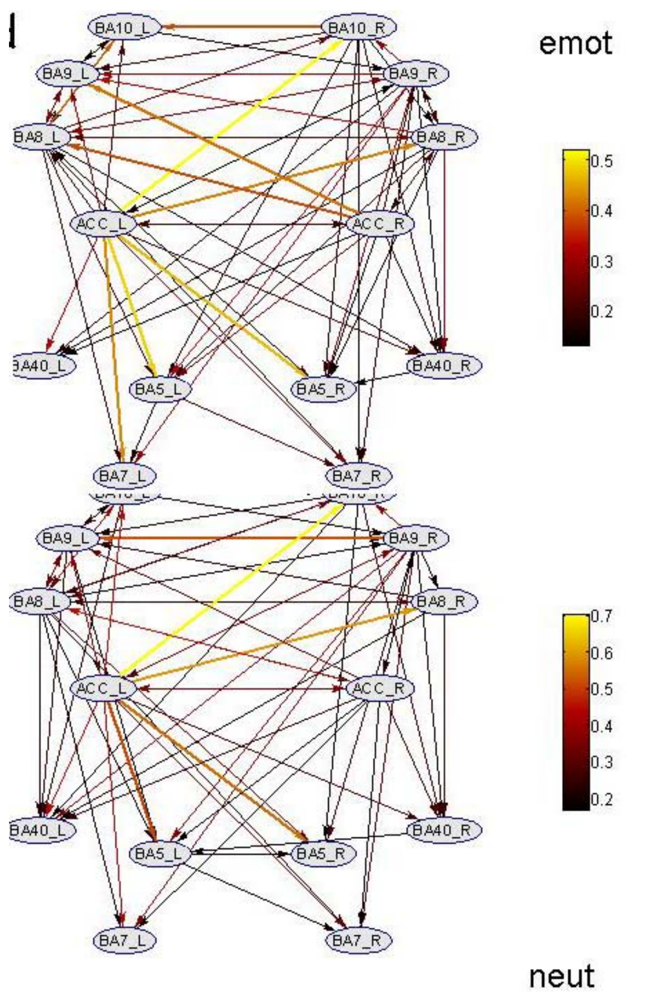

Figure.3. *Networks of functional connectivity during the visualization of the emotive (upper graph) and neutral clips (lower graph). Same conventions of the Fig. 2.*

Several studies have investigated the impact of TV advertising on the memory, using behavioural measures to assess the performance in tasks of image recognition and recall [7]. The results obtained from such studies suggest that under normal conditions, recognition and recall of affective TV material (using e.g. suspense, drama, humour) is superior to cognitive material (based on plain facts). It has also been observed that when a drug able to lower the level of affect recognition was delivered to the person who viewed the TV spots, it was noticed a decrease of the recognition of TV spots with affective material, but an increase of the capability to recall the TV spots that contains mainly the cognitive material (phrases, sentences over pictures).

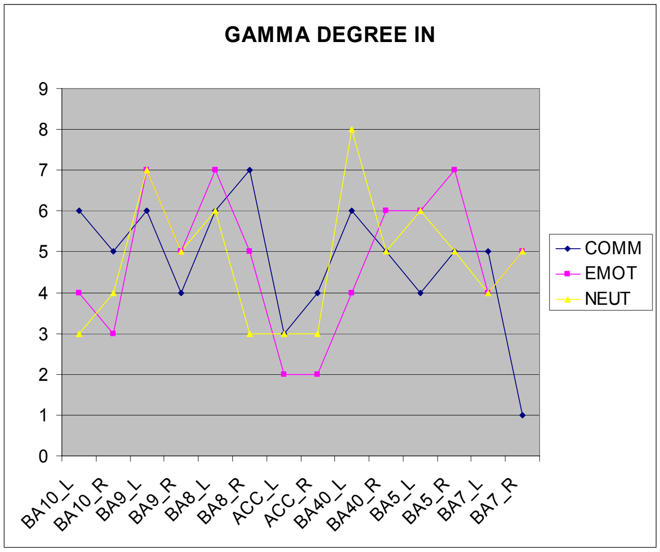

Figure.4. *Graph representing the number of connections entering in each one of the cortical areas investigated in the gamma band. The three lines depict the functional graphs obtained during the visualization of the commercial clips (blu line), the emotional (cyan line) and the neutral (yellow line). The axis present the name of the cortical areas considered.*

Assuming that memory processes are strongly involved in the connection between advertising inputs and behaviour, the findings obtained by [7] can be placed somewhat between 'persuasive hierarchy' and (affective) 'reinforcement' models of advertising. The former see advertisements as providing information and reasons to buy and/or to prefer the products advertised, assuming sequential mental processing according to learn first then feel and finally do. In contrast, reinforcement models view advertising as part of a continuing process where (initial) preferences are shaped, altered or reinforced by experience as well as rational and emotional aspects of marketing stimuli. The latter is in line with recent developments in neuroscience where emotion is considered to play an integral part in cognitive processes [8]. Brain activity with the same ads proposed by [7] where then monitored by using magnetoencephalography (MEG; [9]) that is a technique able to detect the rapidly changes of the neural activity on a temporal scale of milliseconds and on a spatial scale of centimetres. Those MEG data suggest that cognitive advertisements activate predominately posterior parietal and superior prefrontal cortices, whereas affective material modulates activity in orbitofrontal cortices, the amygdala and the brainstem. The results seem to imply that cognitive rather than affective advertisements activate cortical centres associated with the executive control of working memory and maintenance of higher-order representations of complex visual material. Interestingly, neuronal responses to affective visual material seem to exhibit a greater inter-subject variability than responses to cognitive material.

By using not the EEG rhythms but rather measures derived from EEG others authors [10] demonstrated that the activity of the steady state visual evoked potentials (SSVEP), in particular changes of latency of them, in the left frontal hemisphere correlates well with the capability of the subjects to memorize short segments of TV commercial spots previously unseen, after a week of delay from their exposure. They argue that SSVEP was able to monitor and indicate the efficient recognition of memory remarkable moments in the spots into the long term memory (LTM). It is now that this is encoding process for visual and auditory material is largely mediated by the left prefrontal hemisphere, according to the so-called HERA model.

In the present study we depicted the possibility to study the cortical processes occurring during the visualization of videoclips related to the emotive, commercial and neutral materials with the techniques of high resolution EEG and the estimation of the functional connectivity between the cortical areas. This body of techniques produced images of the activity of the brain areas related to the memory encoding and retrieval of such videoclips. Differences between the behaviour of the cortical areas during these events have been observed in the gamma frequency band. The technology presented here is then suitable to track the rapidly time-varying shifts of the cortical activity occurring during the visualization of such videoclips.

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