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The study of brain activity during the observation of commercial advertsing by using high resolution EEG techniques

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Abstract— **In this paper we illustrate the capability of tracking brain activity during the observation of commercial TV spots by using advanced high resolution EEG statistical techniques in time and frequency domains. In particular, we analyzed the statistically significant cortical spectral power activity in different frequency bands during the observation of a commercial videoclip related to the use of a beer in a group of 13 normal subjects. In addition, a TV speech of the prime minister of Italy was analized in two groups of swing and "supporter" voters. Results suggested that the cortical activity during the observation of commercial spots could vary consistently across the spot. This fact suggest the possibility to remove the part of the spot that are not particularly attractive by using those cerebral indexes. The cortical activity during the observation of the political speech indicated a major cortical activity in the supporters group when compared to the swing voters. In this case, it is possible to conclude that the communication proposed has failed to raise attention or interest on swing voters. In conclusions, high resolution EEG have been proved able to generate useful insights about the particular fruition of TV messages, related to both commercial as well as political fields.**

I. Introduction

During these last ten years, the use of the high resolution EEG techniques has returned an increased amount of information related to the brain during activities related to complex cognitive tasks, such as memory, visual attention, short term memory and so forth [1]-[3]. The present work would like to describe how it is possible to track the neuroelectric brain activity in contexts, and for cognitive tasks, more close to the normal day-life of each one instead of particularly laboratory conditions. The example is the observation of a movie intermingled with commercials or even politic advertisements. These two contexts are better known as the fields of Neuromarketing and Neuropolicy.

The aim of the Neuromarketing is to understand mechanisms underlying customer's engagement with brand or company advertised [4]-[6]. In particular, the issue is to explain how the exposure of subsequent film segments are able to trigger in the consumer mind persisting stimuli leading to an interest, preference, purchase and re-purchase of a given product. In the last decades, several Authors have investigated the capability of subjects to memorize and retrieve sensible "commercial" information observed during a TV spot [7]-[12]. From the other side, a growing number of research laboratories are involved in recognizing the cerebral areas activated during the observation of figures and videos showing politicians, a field that the most call Neuropolicy. This intense scientific movement has encouraged some companies and Universities to seriously take an interest about the cerebral activity during fruition of politicians' images and TV commercials [13,14]. The purpose of this paper is to illustrate the potential of the High Resolution EEG techniques, when applied to the analysis of brain activity related to the observation of TV commercials, to individuate cerebral areas mostly emotionally involved. In particular, we would like to describe how, by using appropriate statistical analysis, it is possible to recover significant information about cortical areas engaged by particular scenes inserted within the videoclip analyzed. The brain activity was evaluated in both time and frequency domains by solving the associate inverse problem of EEG with the use of realistic head models. Successively, the data analysed were statistically treated by comparing their actual values to the average values estimated during the observation of the documentary. Statistical estimators were then evaluated and employed in order to generate representations of the cortical areas elicited by the particular commercial considered. An example of the application of these techniques in the field of political communication will be also provided.

II. Materials and Methods

The whole dataset is composed by EEG registrations of 13 healthy subjects (mean age 30±4 years) watching a documentary of 30 minutes intermingled by a TV commercial [15]. Each subject is exposed to the observation of a same documentary. Subjects were informed about the fact that the EEG recordings will be related to the observation of the brain activity during the documentary and TV commercial watching. The entire procedure was authorized by the local ethical committee at the recording site, and informed written consensus to the recording procedures were taken before the EEG recordings. Subjects

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were instructed to pay attention to the material showed on the screen during the entire 30 minutes. The TV commercial was inserted at the middle of the documentary. After the EEG registration each subject was recalled in laboratory where an interview was performed asking if he/she usually drink bier or light alcohol at least one per week. If yes, subjects were considered within the dataset of "drinkers" in opposition to the dataset of "no drinkers". In order to increase the sensitivity of the analysis performed, only the EEG spectral analysis for the "drinkers" were analysed and presented here. In order to enhance the poor spatial content of the EEG activity, we employed the High Resolution EEG technologies [16], [17] to detect cortical areas involved in the task. Basically, these techniques involve the use of a large number (64-256) of scalp electrodes and rely on realistic MRI-constructed head models [18], [19] and spatial de-convolution estimations, which are usually computed by solving a linear-inverse problem based on Boundary-Element Mathematics [20], [21]. 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. In the present work, the cortical activity was estimated from scalp EEG recordings by using realistic head models whose cortical surface consisted of about 5000 triangles uniformly disposed. The current density estimation of each one of the equivalent electrical dipole of the underlying neuronal population, was computed by solving the linear-inverse problem according to the techniques described in previous papers [15], [22], [23]. Thus, a time-varying waveform relative to the estimated current density activity at each single triangle of the modeled cortical surface was obtained. Such waveform was then subjected to the time-varying spectral analysis by computing the spectral power in the different frequency bands usually employed in EEG analysis, i.e. theta (4-7 Hz), alpha (8-12 Hz), beta (13-24 Hz) and gamma (24-45 Hz). In the following we presented only the brain activity related to theta and alpha frequency bands which have been suggested to be maximally responsive during the observation and the memorization tasks when compared to the beta and gamma bands [24]. In each subject recorded, the statistical significance of the spectral values during the observation of the TV commercial or the political speech was then measured against the activity evaluated during the observation of the documentary for the same subject. Hence, a time-varying spectral analysis was then obtained by computing a time-varying z-score variable for each subject and for each dipole placed on the cortical mantle in the analyzed frequency bands. The mean and the standard deviation for such z-score variable was estimated in the documentary period, while the time-varying values of the spectral power in the theta band during the observation of the TV commercial for each dipole was employed. In order to present these results relative to the entire population, we needed a common cortical representation to map the different activated areas of each subject. For this purpose we used the average brain model available from the McGill University website to display the cortical areas that are statistically significant activated during different experimental conditions in all subjects analysed. In this case, we are able to average the single subject result of the z-score test. In fact, we highlighted in yellow a voxel of the average brain model if it was a cortical site in which a statistical significant variation of the spectral power between the experimental conditions was found in all the subjects; if such brain voxel was statistically significant in all but one of the subjects analyzed, we depicted it in red. In all the other cases the voxel was represented with a gray colour. Only the statistical significant variation of such spectral power when compared to the documentary period was highlighted in colour. Statistical significance threshold was set a $p<0.05$ Bonferroni corrected for multiple comparisons.

The use of z-score will allow us to have a variable that can be averaged and can be used to synthesize the results of the entire population investigated

III. Results

Of the 13 subjects recorded, only seven are "drinkers". Hence, the successive analysis and results are presented for seven of such subjects. We summarized all results for the "drinkers" group in a series of figures showing the statistically significant differences of cortical activation concerning this dataset in the theta frequency band (4-7 Hz),

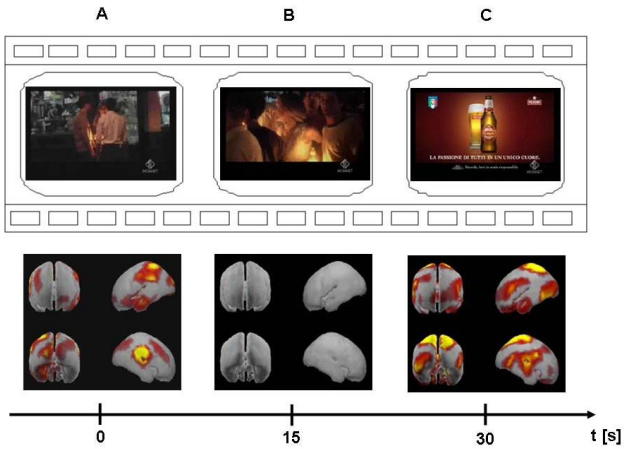

Fig. 1 The track of the mean cortical activity of the group of "drinkers" in the theta frequency band spot. The statistical significant activity in this population is shown in 3 panels (A-C), each representing subsequent film segments of a TV spot with corresponding brain activity. Temporal axes beats the spot in correspondence of the beginning (A), the middle (B) and the end (C) of the entire film sequence. Time in seconds.

being the data regarding the alpha frequency band equivalent to the theta band. For the sake of simplicity and in order to illustrate the capabilities of methods we used in this analysis, in Figure 1 we present three panels

corresponding to the first (panel A), the middle (panel B) and the last (panel C) frame of the commercial along with the related brain activity. The Figure 1 is formed by a series of subsequent panels (A, B and C) each containing two images: the upper one represents a sequence of three frames of the TV commercial while the lower one displays the corresponding statistically significant brain activity in the theta frequency band. In particular, each image at the bottom of the panel shows four different views of the average brain model organized in two rows: the upper row comprises the front and left perspective while the lower one the rear and right brain perspective. The temporal axes beat the time of the commercial in seconds.

By examining this strip, it results evident how the temporal evolution of the mean cortical activity changes according to the images viewed by the subjects. In particular, an enhancement of cerebral activity is suggested by the result of the application of the statistic tests at the beginning and at the end of the commercial presented. In fact, from the lower row of the figures, it is possible to observe how in the middle film segments no cortical areas provide statistically significant differences when compared to the ones watched at the beginning and at the end of the commercial. The final part of the commercial spot attracts the interest in all the population analyzed, as the large cortical areas depicted in yellow and red suggested. It could hypothesized that the central part of the TV spot presented fails in the attract the attention of the experimental group, as the brain activity resulted similar to that generated during the observation of the documentary. This could be used in a future to better tailor the TV spots by removing the parts of them that were unable to attract the attention from the audience. The applications of the above mentioned technology to the evaluation of a TV speech of the Italian's Prime Minister is shown in Fig. 2.

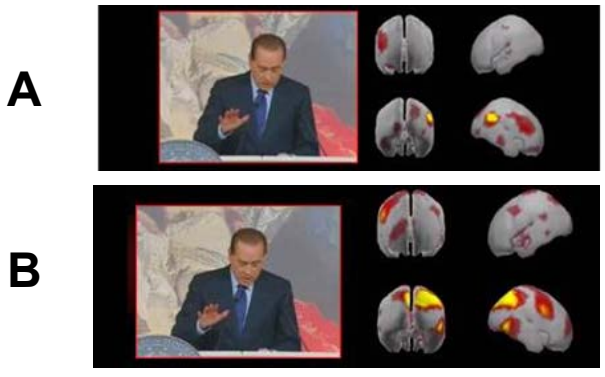

Fig 2. Analysis of a talk by the Italian's Prime Minister: panel A presents the cerebral activity related to the population of swing voters in the theta frequency bands. Panel B shows the cortical activity in the same frequency band for the supporters of the Prime Minister. Cortical areas depicted in red and yellow highlight those zones in which there is an enhance of cerebral activity, when compared to a resting state.

Such figure shows the cerebral activity observed in two groups of people divided between swing voters (panel A) and the "supporters" of the Italian Prime Minister (panel B). The figure presents the statistically significant activity in the analyzed groups in the theta frequency band for a particular moment of the speech. The brain activity observed for the supporters (panel B) was characterized during all the speech by power spectral activity significantly larger than those obtained in the documentary. On the contrary, swing voters are relatively less attracted by the speech, since they had the brain activity not different from the documentary for the major part of the speech.

Hence, the results would suggest an overall efficacy of the communication generated by the video for the second group of subjects (panel B) with respect to the "perceived" communication offered by the prime minister's speech by the first one (panel A). A possible interpretation of this results is that analysed talk could only intensify the supporters' idea leaving neutral the swing voters.

IV. Discussions

Thanks to the high resolution EEG techniques we tracked subjects' brain activity during visualization of a commercial: in such manner it has been possible to obtain a global measure of the reconstructed cortical signals by means of a simple graphic tool which allow us to distinguish the activity of different cortical areas. The above mentioned results allow us to comment temporal and spatial events observed. In fact, it is worth noticing that the principal areas of statistical differences in power spectra in the "drinkers" condition are located almost bilaterally in the prefrontal BAs 8 and 9 as well as in the parietal BA 7. As presented in previous works performed both with EEG analysis [15] and MEG recordings [8], the observed phenomena suggest an active role of the prefrontal and parietal areas in coding of the information that will be retained by users from the TV commercials. In particular, activations of these cortical areas can be associated with attentional and memorization processes. The present work intends to stress the useful properties of the High Resolution EEG technologies: this tool is able to help us in observing and analysing the temporal trend of the cortical activities thanks to a high temporal and spatial resolution allowing us to distinguish changes of activation of ROIs corresponding to different cortical areas. The reconstruction of the cortical activity by means of the high resolution EEG technique and by combining the above statistic treatment of our data, allowed us to track subjects' brain activity during visualization of the commercial. In such a way for each film segment of the clip it was possible to distinguish cortical areas that were differently activated when compared to the observation of the documentary. This could be useful in the evaluation of the cortical responses to particular types of visual solicitations, performed by film, commercial clips or faces of politicians, that at the moment is a field largely unexplored by the neuroscience. In fact, the big attention paid on political scenes originates from the experimental

result that decisions based on "superficial" observation could predict the elections' results, linearly correlated with the candidate's margin of victory with a precision of 68.8% [25]. The consequence of this observation is that the recognition and liking of the politician's face is a principal factor for the choice of the citizen, more than "rational" considerations don't suggest. Such phenomenon has been also confirmed by subsequent studies published in the international scientific literature [26] and newspapers [27] suggesting that the scenic presence by itself mostly influences the decision of vote besides the fact that men and women can elicit a different kind of engagement according to the figure they saw. These results are surprising if we think about the USA midterm elections of 2006 when candidates and their supporting groups spent about 1 billion dollar in advertisements in order to inform electors about their political affiliation, qualities and ideas. After predicting the electoral results [25], [26], the subsequent pass of this research has been to understand whether in this immediate decision the positive effects were prevailing (i.e., face pleasantness as well as his/her adaptation to particular a priori requirements demanded to the candidate) when compared to the negative ones (i.e., negative judgement about pleasantness of person who was implicitly extended to a hypothetical work of the same). This was then studied in literature [26] and its result was that the effect of a emotionally "negative" judgement towards a candidate is an prevailing reason in his defeat (even in a contest of simulated elections) with respect to the fact of simply being "less attractive" then the other candidate. These data could also suggest that the cerebral activity, generated from an emotional state of "rejection" of the candidate, is completely different from the one generated from an emotional state of acceptation or satisfaction of the same one. Another interesting aspect is that results obtained by means of analyses performed on behavioural data reveals how decision-makers sometimes have already made up their mind at an unconscious level, even when they consciously indicate that they are still undecided. From the traditional political research, i.e. performed without using cerebral measurements techniques, it was already known that the negative vote carries also out an important role in the final vote decision. In this contest, having a measure of the emotional state of people observing a candidate's face assumes always more importance.

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