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IMPACT OF SOCIALLY RELEVANT COMMERCIALS ON CONSUMER BEHAVIOR: AN EMOTION RECOGNITION BASED STUDY USING EEG IMAGING

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ABSTRACT

Neuromarketing is a novel domain that tends to combine the diverse fields of psychology, economics and signal processing. The basic motive behind this research is to formulate the most suitable technique for designing an effective advertisement. The secondary motive is to assess the effects of advertisements on human cognition such that the 'Buy Button' in a consumer's mind can be clicked. It traces the subconscious and unconscious mind of a prospective consumer. A wireless EEG recording headset with 14 channels is used to collect the bio signals from participants who are shown a series of pleasant, happy, serious and fearful advertisements. The results from Higuchi's algorithm and the maximum power matched the stated hypothesis. The results also showed that social advertisements with celebrity and commercials with strong content could influence the prospective consumer. The outcomes were also helpful in classifying the different emotions of consumers attached with a particular advertisement.

KEYWORDS: Neuromarketing, EEG, Valence-Arousal model, specific activation, spectral attention.

INTRODUCTION

'Consumer Neuroscience' or 'Neuromarketing' tries to redress the problems faced by management scientists to formulate the best marketing strategy (Wilson, Gaines et al. 2008).

This field converts consumer perception and decision making ability to a marketing problem (Lee, Broderick et al. 2007, Madan 2010). This marketing problem can be solved with neuroscientific methods which has the added advantage that it can increase the effectiveness of the commercial (Lee, Broderick et al. 2007). This becomes possible since it monitors the brain waves and thus takes into account the conscious awareness of the to-be consumers. The neurophysiologic parameters also provides a confirmatory evidence of its ability to influence the purchase behavior of the consumer (Bagdziunaite, Nassiri et al. 2014). Therefore it can be said that the neuroscientific methods of assessing the marketing stimulus is the future of research in commerce domain (Camerer, Loewenstein et al. 2004, Pirouz 2007, Plassmann, Ramsøy et al. 2012). The main reason is that the methods take into account the neuronal activation of the prospective customer. Neuroimaging tools like Electroencephalogram (EEG), functional Magnetic Resonance Imaging (fMRI) or other Event Related Potentials (ERP) like P300 can be used to ascertain and to determine the specific areas of the brain required to execute the decision making for economic perspectives (Astolfi, Fallani et al. 2009, Ohme, Reykowska et al. 2009). Each technique has its own pros and cons in the current study EEG is chosen due to its high temporal resolution and can even detect the smallest neuronal activity (millisecond range). EEG captures the changes in brain waves and also the state of the brain. The brain waves can be classified into beta (widely awake state), alpha (relaxed state), theta (calm state) and delta (deep sleep state) waves. For marketing research, alpha band (8-14 Hz) is of utmost importance as it represents the relaxed state of mind (Vecchiato, Astolfi et al. 2011).

Inner emotion recognition from EEG can be used in a wide variety of applications ranging from medical to marketing research. Human emotion can be thought of as the product of inner thinking process by referring to the brain or any other stimuli. There are different emotion recognition algorithms proposed by researchers but in the current study a two-dimensional arousal-valance model is followed (Sourina and Liu 2011). This model is based on the assumption that emotion has a spatio-temporal location in the brain. The arousal-valance model classifies emotions as happy, pleasant, sad, fear/disgust based on the two parameters viz. arousal and valance. The valance parameter defines the quality of emotion developed and arousal signifies the quantitative activation level.

Spectral attention is obtained from maximum power which in turn is calculated by Welch's method of Power Spectral Density (PSD). It can be used to identify the level of spectral

attention of the prospective consumer towards the audio-visual stimulus (Murugappan 2014). Specific activation is computed using Global Field Power (GFP) (Kong, Zhao et al. 2013). GFP when correlated with Broadman areas can make out the regions involved in the brain while viewing a particular advertisement.

The sole objective of research in consumer neuroscience domain is that it provides an opportunity to understand the neural level processes of the consumer. They, in turn offer valuable insights into cognitive decision making process which are otherwise not captured through traditional methods of management research (Plassmann, Ramsøy et al. 2012). Following the objective mentioned, this study inculcates cognitive strategy for switching attention towards a certain type of advertisement. It further incorporates emotion as a deciding factor to design an effective commercial.

MATERIALS AND METHODS

Data Collection

EEG signals were collected from Emotiv Epoc Research Edition, which is a 14 channel wireless, portable, and easy to use data acquisition system. The physiological signals were collected from AF3, F7, F3, FC5, T7, P7, O1, O2, P8, T8, FC6, F4, F8 and AF4 channels which are aligned according to the international 10-20 system of electrode placement. A total of 18 subjects, in the age group 21-26 (mean age 23.6), participated in the study with equal gender ratio. Out of the 18 participants 15 were non-alcoholics and non-smokers and 9 wore glasses. A protocol was formulated which contained a series of sad, pleasant, happy and fearful advertisements. The audio-visual stimuli have a one-minute blank screen at the beginning and the end to check the baseline and a 5 second blank in between the commercials in order to avoid the mood carry over (Fig 1). The documentary was chosen to be a cartoon film so that the subject remains interested throughout the video. The advertisements were precisely selected to evoke significant different emotions for the age group 21-26. The commercials were such that there were four of them featuring celebrities from the Indian film industry and the remaining four with non-celebrity ones placed alternatively. Out of the four advertisements in each of cases, i.e. celebrity and non-celebrity ones, three of them were containing happy, pleasant and fearful emotion, one each, and one with a social cause (Table.1).

Table 1: Details of the included advertisements.

	Celebrity	Non-Celebrity
Social	Polio ad featuring Amitabh Bachan	Respect of National Anthem ad
Happy	Coca Cola ad featuring Amir Khan	Naukri.com ad
Pleasant	Oreo biscuit ad featuring Ranbir Kapoor	Camlin Markers ad
Fear	1920 movie clip featuring Zayed Khan	Fearflies serial promo ad

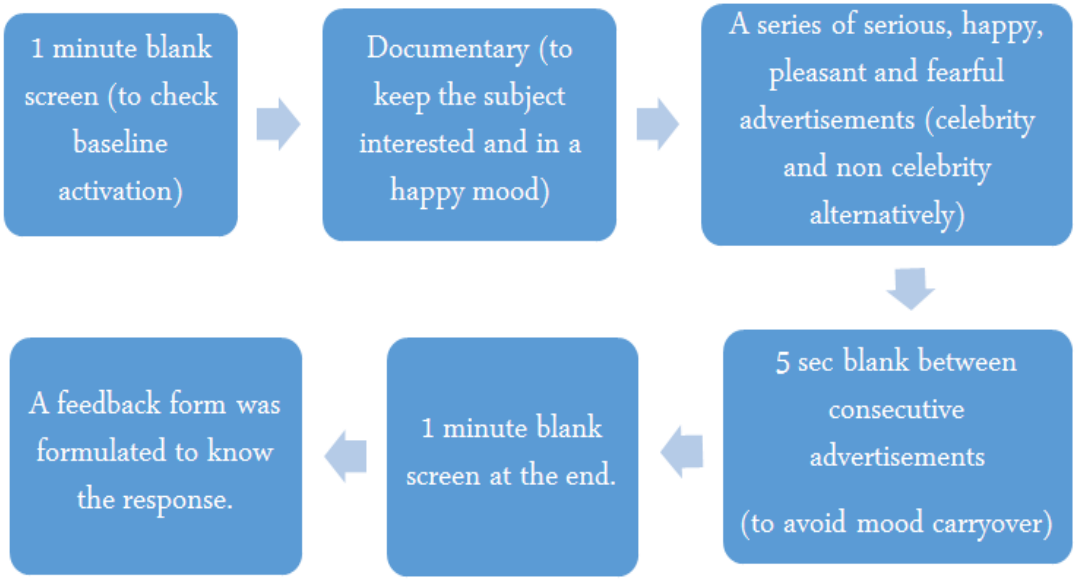

Fig 1: Flow chart of the Experimental Methodology.

After the experiment, each participant was given a feedback form to be filled which contained the following question:

1) What emotions were developed while watching ads?
2) Were you more concentrated over the celebrity or the story line?
3) Did you focus on the advertisements environment?
4) If celebrities in the ads were replaced with non-celebrities, will it still be convincing?
5) If non-celebrities in the ads were replaced with celebrities, will it still be convincing?
6) How was the background music for the advertisement?
7) Were you inquisitive during the ads?
8) Which ad did you like the most?

This feedback form also helped to know about the purchase tendency of the products and also helped in covering the traditional method of management research in addition to 'Neuromarketing'.

Signal Analysis

The raw signal acquired from the instrument is subjected to a Notch filter of 50 Hz in order to remove the power line interference. Eye blink artefacts were removed by normalization i.e. removing the mean from all the values and thres-holding (rejecting all values above 100μV). Independent Component Analysis method of artefact removal was not used since it considers the jaw and head movements as artefacts. These movements are a part of the emotions and rejecting those components will remove the emotion content from the signal.

Alpha band is extracted through wavelets (Bhagawat and Jain 2013). Wavelets perform the operation of 'reverse, shift, multiply and integrate' technique of convolution, with portions of a known signal to extract information from an unknown signal. Haar wavelet is considered due to its efficiency in both speed and memory requirement. The technical disadvantage of Haar wavelet is that it is not continuous and therefore not differentiable. This property can, however, be of advantage for the analysis of signals with sudden transitions. This is followed by feature extraction which includes the fractal dimension computed through Higuchi's algorithm and the linear features of Global Field Power and Power Spectral Density.

Higuchi's Fractal dimension (Esteller, Vachtsevanos et al. 2001) is computed through the following method: Given a one dimensional time series $x(1), x(2) \dots x(n)$, construct k new time series x_m^k as

$$x_m^k = \left\{x(m) + x(m+k) + x(m+2k) \dots x\left(m + \left\lfloor\frac{N-m}{k}\right\rfloor k\right)\right\}, \quad - (1)$$

For m = 1, 2, 3 … k

Where m is the initial time and k denotes the delay between the time intervals. For each of the time series the average length is computed as

$$L_m(k) = \frac{\sum_{i=1}^{\lfloor N-m/k \rfloor} |x(m+ik) - x(m+(i-1)k|(n-1)}{\left\lfloor\frac{N-m}{k}\right\rfloor k} \quad - (2)$$

Where N is the total length of the sequence x and $(N-1)/\lfloor N-m)/k \rfloor k$ is a normalization factor. For series having the same delay, average length is computed as the mean of k lengths as $L_m(k)$ for $m = 1, 2 \dots k$. The method is repeated for each k varying from 1 to k_{max}, resulting in the sum of the average lengths $L(k)$ for each k as

$$L(k) = \sum_{m=1}^{k} L_m(k) \quad - (3)$$

And the data should fall on a straight line, with a slope equal to the Fractal Dimension of the time series $x(1), x(2) \ldots x(n)$.

Thus Higuchi fractal dimension is defined as the slope of the line that fits the pairs $\{\ln(L(k)), \ln(1/k)\}$ in a least squares sense. In order to choose an optimal value for the parameter k_{max}, fractal dimension values are plotted against a range of k_{max}. The value of k_{max} was chosen such that it corresponds to the point where the fractal dimension plateaus are saturated (Raghavendra and Dutt 2010).

Power spectral density for a discrete signal is calculated using the relation

$$P_{xx}(f) = \sum_n r_{xx}(m) e^{-i2\pi fmT} \quad - (4)$$

P_{xx} Was calculated with the above formulae for the entire data range, from which the maximum values were used for deriving the inferences.

The global field power is the standard deviation of the potentials at all electrodes of an average-reference map and was computed using the relation

$$GMFP(t) = \sqrt{\frac{\sum_i^k (V_i(t) - V_{mean}(t))^2}{K}} \quad - (5)$$

where V_i is the voltage of the map V at the electrode i, V_{mean} is the average voltage of all the electrodes of the map V and K is the number of electrodes of the map V (Gärtner, Brodbeck et al. 2015).

TANOVA was applied on power spectral density and ANOVA was applied on global field power. Both the found to be significant for selective subjects and the analysis was done by calculating mean values of global field power for those selective subjects.

RESULTS

Emotion Recognition Results

After calculating the fractal dimension values, a table was made containing all the dimension values for electrodes AF3 and AF4 (valence), and FC6 (arousal) for all the 18 subjects during each segment of the video clip. Frontal Asymmetry (AF3-AF4) was also calculated. Mean for valence and arousal was found to be 0.041 and 5.651. If the dimension value of FC6 (arousal)

was found to be greater than the mean, then arousal is considered high. Similarly based on the value of asymmetry, AF3-F4, and comparing it with the mean of valence, it was classified as either positive or negative. The emotion is thus classified as the following: positive high (happy), positive low (sad), negative high (fear/disgust), negative low (sad).

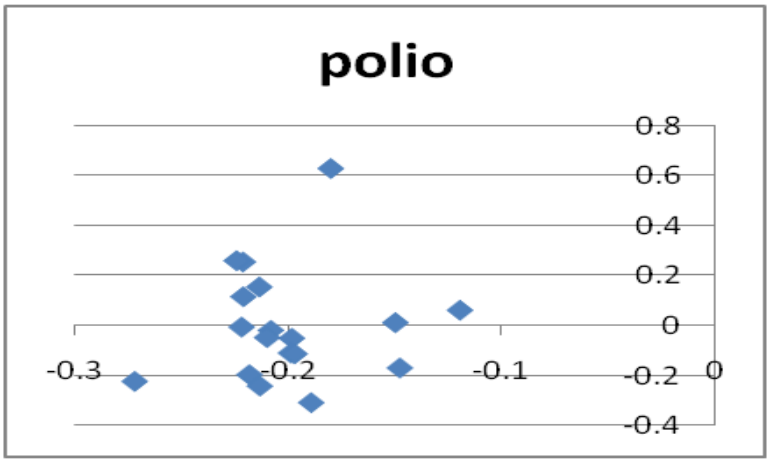

Fig 2: Emotion for Polio ad on the Arousal Valance plot.

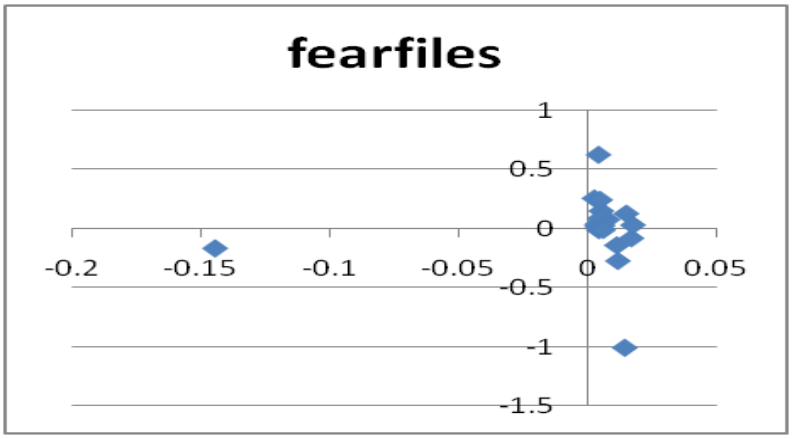

Fig 3: Emotion for Fear flies ad on the Arousal Valance plot.

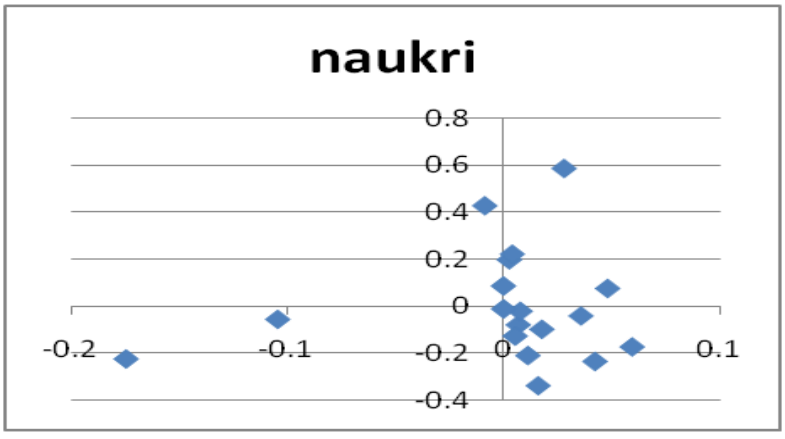

Fig 4: Emotion for Naukri ad on the Arousal Valance plot.

The Figures 2 through 4 indicates that the participants responded with similar emotions for the commercials.

Spectral Attention Results

After calculating the maximum power for all the subjects during the advertisements in the channels AF3 and AF4, Higher the maximum power, higher is the spectral attention towards the audio visual stimulus.

Specific Activation Results

Global field power values and their mean is calculated and tabulated (Table 2) for the activation of specific Broadman areas.

Table 2: Mean Values of Global field power for 18 subjects.

Ads/Clips	AF3	F7	F3	FC5	T7	P7	O1
Baseline	247.68	256.42	256.94	234.77	238.92	240.89	233.19
Popeye Clip	125.21	130.35	128.42	119.92	119.77	126.23	136.51
Polio	126.49	131.90	129.68	120.56	119.35	125.04	134.36
Naukri	130.11	134.36	133.88	124.01	119.86	121.37	136.36
Oreo	126.28	132.39	129.81	122.55	120.53	124.68	135.48
Fear flies	127.10	131.82	130.47	121.04	120.93	124.79	134.36
Tom and Jerry Clip	122.59	127.68	125.71	116.10	117.36	120.81	137.66
National Anthem	124.58	128.52	127.58	118.39	118.87	123.01	131.55
Coke	132.77	133.52	136.87	124.39	116.50	122.01	131.09
Camlin Markers	126.14	130.54	128.99	120.12	112.91	123.25	131.87
1920 movie	134.93	137.86	139.42	128.07	117.40	118.89	133.42
Baseline	128.33	131.09	134.10	122.16	120.44	124.13	142.35

DISCUSSION

Neuromarketing is a novel trend that is fast replacing the generic term of marketing. The multinational companies are establishing neuromarketing laboratories for commercial design of their marketable products. It enables the advertisements to tap into the subconscious and unconscious mind of the to-be consumer of their product and thus leading to the modification of marketing strategy which benefits both the consumer and the producer (Agarwal and Xavier 2015). EEG was chosen due to its high temporal resolution and flexibility of the portable signal acquisition system. A cartoon documentary was selected to keep the participant interested throughout the video and commercials to evoke strong emotions for the specific age group selected for the study.

Higuchi fractal dimension was chosen as it is one of the best and most unique tool for emotion recognition (Liu and Sourina 2014). Global field power and maximum power was chosen since it was found to be significant feature and also for the fact that these features can aid in the computation of spectral activation and attention respectively.

From the results of global field power and maximum power, out of the 18 participants, 11 of them followed the same trend. Higher global field power correlates to higher activation in that specific Broadman Area. Electrode position of P8 showed higher activation throughout the video, FC5 and FC6 showed activation in polio and National Anthem ads i.e. ads with a social message. O1 and O2 showed activation in Fearflies ad and the 1920 movie clip. It indicates that these ads need more visuo-spatial processing. F4 position showed activation in the ads featuring celebrities as Broadman Area 8, corresponding to F4, activates during memory retrieval. F3 was activated during the Tom and Jerry clip i.e. when a clip is shown repeatedly. AF3 showed a greater activation during Naukri ad, i.e. when a video evokes criticism. AF4 was stimulated during National Anthem ad i.e. when feelings of patriotism are evoked.

After processing the signal and calculating the values for maximum power for the data during each commercial segment. It was found that higher the value maximum power higher was the attention towards the video. Maximum power was found to be higher for serious commercials and the commercials that were lesser known to Indian costumers as compared to those that are frequently aired in the Indian programs. Spectral activity from the frontal and parietal areas were found to be higher for of the commercials that were liked compared to the activity triggered by those that were not liked. Known brands were processed in the areas of brain responsible for positive emotions, while the unknown ones in the negative emotion areas.

The results obtained from Higuchi's algorithm were the dimension values for the electrode positions AF3 and AF4 for emotions, where in AF3 corresponds to positive emotions and AF4 to negative ones and FC6 for arousal. The values were tabulated and mean was calculated for arousal and valance, from which a threshold is determined based on which emotions were classified. It was found that the emotions based on the social ads did not depend on fact that it was endorsed by a celebrity or not. But for non-social relevant ads, it did matter to some extend but still a major contribution for emotion generation is dependent on the storyline of the advertisement.

CONCLUSION

The field of 'Neuromarketing' or 'Consumer Neuroscience' research has started gaining momentum for the scientific enquiry to understand the consumer behavior. It has been described as 'Applying the methods of neurology lab to the question of the advertising world', taking cue from neuro economics. Neuro economics, which describes itself as the

application of neuro scientific methods to analyze and understand economically relevant behavior. It, therefore, defines Neuromarketing as the application of neuroscientific methods to analyze and understand human behavior in relation with the markets and marketing exchanges (Wilson, Gaines et al. 2008). Advancement and innovation in neuro-imaging and EEG recording over the past three decades has transformed human neuroscience. The need to observe localized brain activity in living human beings has opened a path to tremendous scientific progress. Their recent advance to understand human behavioral aspects and decision making process has provided unprecedented opportunities for marketers to provide better products to the consumers. This will in turn allow producing products largely aligned with the needs of the consumers, saving the product failure and rejection costs by the consumer base and will help to serve the requirements of the community in a better way.

To trace the subconscious and unconscious mind with greater accuracy, EEG systems with more electrodes and other neuroimaging techniques with portability can be used. A more effective video, the type which is usually seen on television sets can be used with the commercials to check the effectiveness of advertisements on the consumer base. An ERP study can be performed with different brands and concepts as presentations in an oddball paradigm, which can be processed for P300 component can be implemented in the future. The P300 component provides immense information about neural activity of the fundamental cognitive operations, especially the activity of updating the working memory and orienting response. The traditional tools and techniques used in consumer research for understanding and explaining the consumer behavior are developed to study the conscious component responsible for the decision making process. While a greater part of this process is governed by the subconscious mind which needs to be studied and explained for better understanding of the human decision making process. However a predisposition to a particular brand elicited through neuro-research has a high degree of correlation with the purchase behavior of the consumers.

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