EEG Based Study of Pictorial Advertisement Impact on Customers' Market Preferences

Anshika Kesari, Rajesh Singla, and Prerna Singh

Abstract Neuromarketing is a way to detect elicited brain activities while customer is engaged toward various products and brands. This paper presents a study regarding customers' engagement with various products and brands available in the market using electroencephalography (EEG). A total of 10 test subjects were presented with a collage of still pictures from the TV commercials, and their brain activity was recorded. Power spectral density (PSD) was obtained from the acquired signals using fast Fourier transform (FFT) technique, and absolute power was obtained. The results showed that test subjects felt change in elicitation in the theta wave and a pattern can be seen in theta band power. This study implies that the variation in theta band power when compared with the Delighted–Terrible (D-T) scale rating changes which signify the same outcome. Hence, the present work would help in effective evaluation of the change in market demands of various products and brands with the help of pictorial advertisement.

Keywords EEG · Neuromarketing · D-T scale · Theta band power

1 Introduction

Neuromarketing, an integration of neuroscience and marketing, signifies research work in the zone of marketing. It focuses on the study of the behavioral response of consumers to an external stimulus based on marketing. Neuromarketing can be exceptionally useful when it comes to marketing research. The ability to measure physiological consumer responses to everything from a product's packaging to the ad with which you are promoting it is valuable, especially when you follow up with an in-depth interview about why the consumer felt the way they did. This can give

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you incredible insight into how effective your current campaigns are and what you can do to improve them.

The first neuromarketing experiment was conducted at Baylor University of Medicine by Montague, Professor of Neuroscience. The experiment involved scanning brains of a group of individuals in a functional magnetic resonance imaging (fMRI) machine in which the individuals were asked to consume either Pepsi or Coca-Cola without revealing their brands [1, 2]. According to his study, with no knowledge of the brand of the product, the individuals preferred Pepsi over Coca-Cola in contrast to their choice of Coca-Cola over Pepsi with the brand name already revealed to them [3]. A major conclusion of this study was the revelation of activation of some parts of the brain depending on the awareness of the brand of the product that they are consuming. It was demonstrated that a well-known brand (Coca-Cola, in this case) has the potential of activating the frontal cortex. Usually, the frontal lobe corresponds to executive function (EF) of managing attention, controlling short-term memory, thinking, and planning. Several techniques have been presented in the literature for measuring some of the physiological responses to pictorial advertisements.

However, only three non-invasive methods have proven their worth in the measurement and mapping of brain activities including EEG, magneto-encephalography (MEG) and fMRI. The cost of maintenance, insurance, and portability issues restricted the use of an fMRI instrument in other experiments [4]. MEG instrument provides a map of neuron activity in spatiotemporal information. However, the technical complexities involved in device configuration along with higher cost limits its usage among researchers in the field of neuromarketing [5, 6]. To overcome the limitation of the above-mentioned issues, we considered EEG device due to its high-resolution data with lower maintenance and supports cost in comparison with fMRI and MEG instruments.

2 Literature Survey

2.1 Link Between EEG Recording, Analysis, and Choice

Advertisement design involving eye-catchy packing, taglines, colors displayed and luscious shape embrace customers' desire and thus, generate an impact on the customers' choice and shopping practices. One of the recent works in this field include the study conducted by Kumar et al. [7] which combines EEG signals and sentiment analysis of product reviews to achieve a multimodal rating prediction framework for consumer products. Sequentially, 14 categories of products having varieties of colors and textures were displayed and their EEG signals were recorded. Additionally, a framework for prediction of consumer's choice for a product was proposed by Yadava et al. [8] where different products were shown to the users to record their EEG signals. These signals were modeled using Hidden Markov Model (HMM) classifier

for user's choice prediction. Also, frequency content of brain waves was successfully utilized to investigate the "customers" preferences based on like/dislike [9]. A change in the spectral activity among various parts of the brain (frontal, parietal, and occipital) was demonstrated depending on the preference of the customers. Telpaz et al. [5] revealed that the future preferences of customers can be predicted by using the EEG signals due to the increase in the N200 component at the mid-frontal electrode site for preferred products. Moreover, the preferences for shoe products were successfully predicted by Baldo et al. [10] through EEG data. It was demonstrated that an increase in company profit can be achieved by using the brain scan-based prediction which is more reliable than the self-report-based prediction. In an experiment conducted by Yilmaz et al. on multichannel EEG recording [11], it was found that the most informative channels for discrimination between consumer preferences are revealed by the F7 and T6 channels in the low-frequency band.

2.2 Technical Aspects of Rating

For rating purpose in neuromarketing, various Likert scales are present. Andrews and Withey [12] in 1976 proposed the 7-point D-T Scale which takes information from the participants regarding their views and perceptions of life by asking them to provide a response from seven mood adjectives as shown in Fig. 1. Moreover, the suitability of rating scale depending on the customer satisfaction level for marketing studies has been explored [13]. Christina calculated convergent and divergent validity coefficients for the AM Happy Scale [14]. The results were in confirmation with those of multimethod-multitrait analysis of different measures of happiness. These include the D-T Scale and Cantril's life satisfaction self-anchoring ladder rating. Also, an investigation was performed on the positive and negative effects of happiness [15] along with using the Global Happiness Scale, Affect Balance Scale, and D-T Scale.

The theta band activities were related to the subsequent pleasantness ratings of various products. Hence, for observing the theta band power (TBP) variation in the brain, a setup was made to measure the various changes and elicitations irrespective of others. The subjects were presented collage pictures of 15 items (3 brands, 5 products in each brand). Also, a 7-point Likert scale, where 1 represents "terrible" and 7 represents "delighted" was used regarding participants response to these items in the beginning as well as at the end of the experiment.
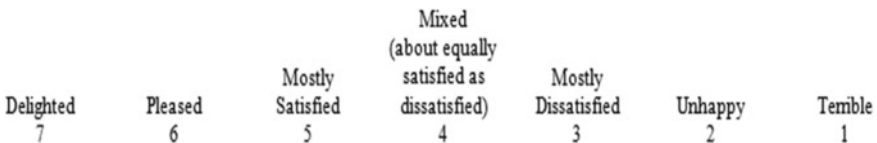
Delighted	Pleased	Mostly Satisfied	Mixed (about equally satisfied as dissatisfied)	Mostly Dissatisfied	Unhappy	Terrible
7	6	5	4	3	2	1

Fig. 1 7-point Delighted–Terrible (D-T) scale

3 Methodology

3.1 Experimental Design

In this experiment, 6 male and 4 female students aged between 23 and 26 years from the university actively participated with their due consent. A waveguard EEG cap of 32 channels was used, and EEG recording was performed on 18 channels (Fp1, F3, F7, FC5, T7, P3, P7, O1, Fz, Pz, O2, P8, P4, T8, FC6, F8, F4, Fp2) and Cpz as reference electrode using International 10–20 system standardized by the American Encephalographic Society (see Fig. 2). A sampling frequency of 512 Hz was used during the EEG recording.

At the starting, D-T scale rating sheet was provided to each participant for marking their emotional responses in order to observe their preferences. Secondly, a consent form was signed by the participant, and after that, the instructions regarding the whole experiment were provided to acquire the better results. Thirdly, EEG recording was started and a list of products was displayed which the whole stimulus was going to have and after that the randomized sequence of collaged photographs appeared. As gender, age, and opinions may vary for different subjects, hence various options were provided to reduce biasing. During the presentation of the photograph collage series of 5 products having 3 brands each, none of the frames were lost. The order of appearance of each picture was randomized so that overlapping of elicitations can be prevented. The whole experimental design is shown in Fig. 3.

The experimental paradigm involves 5 blocks, each block having 3 different brands. The participants are allowed to switch to the next photograph according to their choice. Each block has three varieties of single product; hence, in total there are 15 photographs sequencing. A sample of the stimulus is shown in Fig. 4. After completion of the recording task, second D-T scale rating sheet was given for marking the new felt emotions.

Fig. 2 Experimental setup for data acquisition

Fig. 3 Protocol of the proposed approach used during the entire experimental procedure

Fig. 4 Photo collages of chocolate category with its brands which was shown to the participants during EEG recording in randomized manner

3.2 Preprocessing and Feature Extraction

The preprocessing of the raw signals acquired during EEG was done using software, a band-pass filter filtered the frequencies below 0.3 Hz and over 30 Hz. After that artifact correction was applied artifacts like blinks, movements, etc., produced during the experiment with principal component analysis (PCA). Finally, baseline correction was applied which uses the inter-stimulus points and subtracted on the segments.

Prior to feature extraction firstly, the data was normalized followed by windowing of one second of the dataset. Emotions have an impact on different bands of spectral power of EEG signal; thus, PSD was computed on each segment using FFT and for smooth power spectrum periodograms averaging was performed. Each electrode PSD was estimated using 1 s windows with 50% overlapping. The PSD from theta (4 Hz $< f <$ 8 Hz), alpha (8 Hz $< f <$ 12 Hz), and beta (12 Hz $< f <$ 30 Hz) bands were extracted and then converted into absolute power as features.
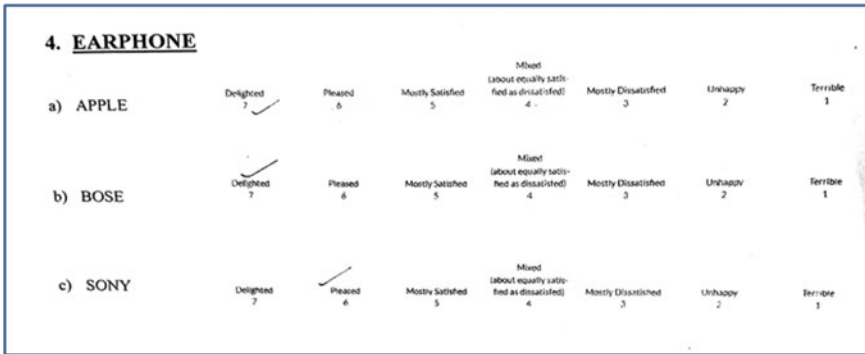
Fig. 5 Subject-assessed D-T scale rating sheet 1

4 Results and Discussions

Several studies have shown that EEG activity is linked with some aspect of consumer preferences, and neuromarketing is the one which tries to explore the neuronal basis of preferences of various products among the participants. In this paper, the whole analysis has been done on theta band wave. As the subjects were allowed to switch to the next slide whenever they were done with the previous one; thus, the least time interval taken by all the subjects was of 3 s. Hence, from each product a set of three features, i.e., TBP1, TBP2, TBP3, which represents theta band power obtained by calculating three respective means from the all whole data set of every item. The variation of each has been observed and plotted in bar graphs for all the items. Each participant's emotional responses were rated by using delighted/terrible rating.

When both EEG analysis and rating sheet were compared the variations came out to be approximately the same, i.e., when the preference of the subject was decreasing disappointment is shown, when it was increasing impressed emotion is appearing and when there is no change felt by the subject then neutral condition was seen. One of the best results of the recorded EEG and peripheral physiological signals of the participants in response to the collaged photograph is shown in Fig. 7, and their respective before and after feedback assessments are shown in Figs. 5 and 6.

5 Conclusion

The essence of this paper was to analyze the behavioral changes of consumers when they see the pictorial representation of various products and examining consistency in preferences and liking ratings. This research paper has achieved the proposed objective of finding the change in preference of an item from the whole list and then comparing it with the manual rating done by each participant at each phase of the experiment. The results successfully showed the relation between the EEG analysis
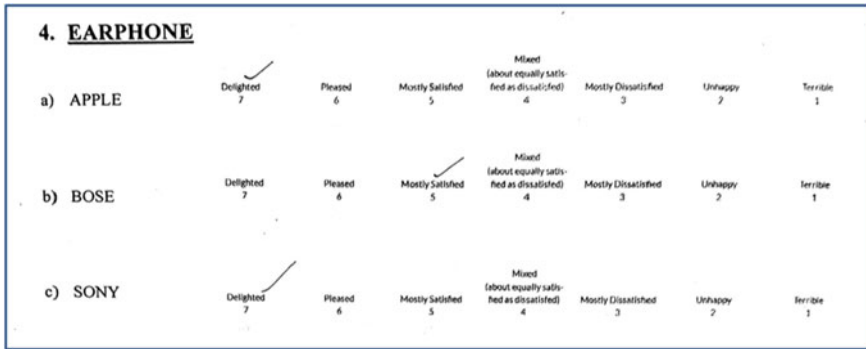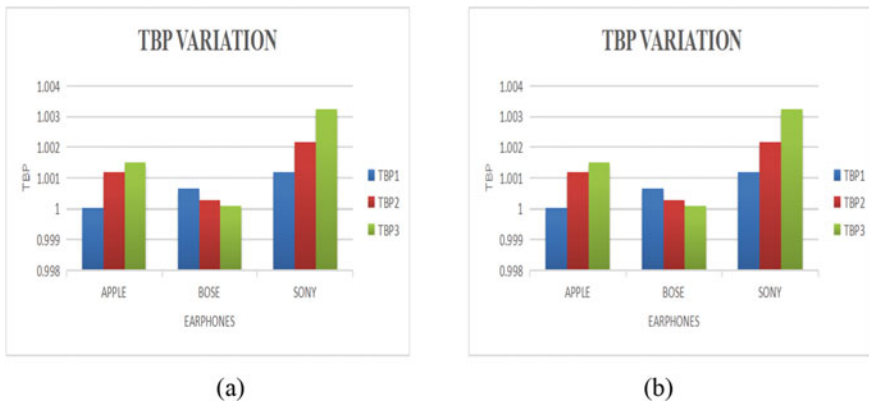
Fig. 6 Subject-assessed D-T scale rating sheet 2

Fig. 7 Statistical representation of theta band power (TBP) variation of single product with 3 brands of a subject across **a** P7 and **b** P8 electrodes

and D-T scale. For higher accuracy of the correlation the number of participants should be increased which will lead to better results. In conclusion, neuromarketing is the biggest tool which can be really helpful for the company in improving the creation of the product as well as the style, colors, textures, and techniques they use. In other words, the whole promotional representation of a product should be more interesting, more valuable, and more attractive that mainly affects the costumers' brain, hence resulting in rapid escalation in market demand of respective product.

References

1. Morin C (2011) Neuromarketing: the new science of consumer behavior. Society 48(2):131–135. https://doi.org/10.1007/s12115-010-9408-1

2. Vecchiato G et al (2011) On the use of EEG or MEG brain imaging tools in neuromarketing research. Comput Intell Neurosci May 2014. https://doi.org/10.1155/2011/643489
3. Madan CR (2010) Neuromarketing: the next step in market research? Eureka 1(1):34–42. https://doi.org/10.29173/eureka7786
4. Berns GS, Moore SE (2012) A neural predictor of cultural popularity. J Consum Psychol 22(1):154–160. https://doi.org/10.1016/j.jcps.2011.05.001
5. Telpaz A, Webb R, Levy DJ (2015) Using EEG to predict consumers' future choices. J Mark Res 52(4):511–529. https://doi.org/10.1509/jmr.13.0564
6. Murugappan M, Murugappan S, Balaganapathy B, Gerard C (2014) Wireless EEG signals based Neuromarketing system using Fast Fourier Transform (FFT). In: Proceedings 2014 IEEE 10th international colloquium on signal processing and its applications CSPA, pp 25–30. https://doi.org/10.1109/CSPA.2014.6805714
7. Kumar S, Yadava M, Roy PP (2019) Fusion of EEG response and sentiment analysis of products review to predict customer satisfaction. Inf Fusion 52(Nov 2018):41–52. https://doi.org/10.1016/j.inffus.2018.11.001
8. Yadava M, Kumar P, Saini R, Roy PP, Dogr DP (2017) Analysis of EEG signals and its application to neuromarketing. Multimed Tools Appl 76(18):19087–19111
9. Khushaba RN, Greenacre L, Kodagoda S, Louviere J, Burke S, Dissanayake G (2012) Choice modeling and the brain: a study on the electroencephalogram (EEG) of preferences. Expert Syst Appl 39(16):12378–12388. https://doi.org/10.1016/j.eswa.2012.04.084
10. Baldo D, Parikh H, Piu Y, Müller K-M (2015) Brain waves predict success of new fashion products: a practical application for the footwear retailing industry. J Creat Value 1(1):61–71. https://doi.org/10.1177/2394964315569625
11. Yilmaz B, Korkmaz S, Arslan DB, Güngör E, Asyali MH (2014) Like/dislike analysis using EEG: determination of most discriminative channels and frequencies. Comput Methods Programs Biomed 113(2):705–713. https://doi.org/10.1016/j.cmpb.2013.11.010
12. Andrews FM, Withey SB (2012) Social indicators of well-being: Americans' perceptions of life quality. Springer Science & Business Media
13. Westbrook RA (1980) A rating scale for measuring product/service satisfaction. J Mark 44(4):68. https://doi.org/10.2307/1251232
14. Moldovan CP (2018) Am happy scale: reliability and validity of a single-item measure of happiness. Diss Abstr Int Sect B Sci Eng 79(1-B(E))
15. Kaur H Gross national happiness index: a nation's pursuit of happiness