EVALUATING NEUROMARKETING TECHNIQUE ON CONSUMER SATISFACTION USING EEG IMAGING

N.A. Mahamad[1], M.K.M. Amin[1] and O. Mikami[2]

[1]Malaysia-Japan International Institute of Technology,
Universiti Teknologi Malaysia, 54100 Kuala Lumpur, Malaysia.

[2]Department of Optical and Imaging Science & Technology,
School of Engineering, Tokai University,
Hiratsuka, Kanagawa, 259-1292 Japan.

Corresponding Author's Email: [1]mkamalma@utm.my

Article History: Received 23 December 2018; Revised 23 April 2019;
Accepted 22 October 2019

ABSTRACT: This article presents an evaluation of consumer satisfaction using the EEG brain imaging technique. Involvement of brain science into marketing research has sparked great interest recently since traditional marketing solely dependent on questionnaires. Consumers are normally less cooperative with marketers when they made an unexplained decision by answering the questionnaires. In response to this problem, the EEG imaging technique could be used to identify the consumer response by analyzing their brain activities. A low-cost Emotiv EPOC EEG Neuroheadset was used in this experiment. Theta (ϑ) 4-8 Hz, Alpha (α) 8 to 12 Hz and Beta (β) 12-25 Hz waves are the basis for determining the brain activation. Popular shoes product advertisement on price reduction were displayed on the computer screen to observe the subject's responses. The topographic maps result of the brain showed that the frontal lobe and the right part of the brain activated the most which indicates the contentment or satisfaction behaviour. Further analysis on the power spectral density showed that higher synchronization of Theta (ϑ), Alpha (α) and Beta (β) bands were more apparent in the right frontal lobe which thus confirmed a significant correlation of marketing decisions with the brain activities.

KEYWORDS: *Consumer Satisfaction; EEG; Neuromarketing*

1.0 INTRODUCTION

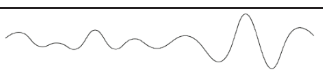
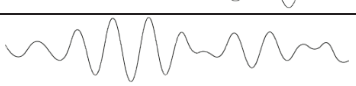
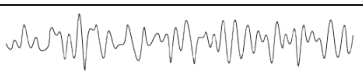
Evaluating consumer satisfaction has become the preference in marketing and neuroscience. Neuro-marketers should understand the consumer needs using the new approach in order to attract the satisfaction of the consumer with its products [1]. For instance, marketers should focus more on the design and the presentation of the products. The products should be highly compatible with consumer

personal preferences. In contrast, a neuroscientist should focus on the practical application of neurological findings to understand the consumer response. Neuromarketing is one of the fields of study on evaluating consumer satisfaction which provides an overview of consumer behavior that makes it capable to express the reasons of preferences in the structure of marketing [2]. The practical implementation which is brought by neuroscience help to strategize the market. This study emphasis on the condition and the processes of neural respond [3]. The neuroimaging device employed to search for information, understand consumers and serve its customers [4-5].

Previous research showed that the marketers used the traditional techniques, usually asked participants for feedback about the test material. However, they make an unexplained decision and less cooperates with the marketers [6]. In response to the new finding coined as neuromarketing, this study seeks to examine and evaluate the consumer behavior through the EEG recording of brain activities in relation to the marketing products designed while being exposed to the several advertisements, the attractiveness, brand, price and items. The underlying brain responses result whether the test material is satisfied the consumer or not and without asking for feedback. Therefore, Electroencephalography (EEG) is one of the most versatile techniques that can capture the data of electrical activity generated in the form of a brain signal where a neuron experiences the change in the action potential such as vibration that will sense by the electrode and generate an electrical signal [7].

EEG is generally described in terms of the frequency band, Hertz (Hz) [8]. Table 1 shows the external simulation of brain states related to emotion [9].

Table 1: Frequency bands [9]

Type of brainwaves	Waveforms	Frequency bands	Mental state and condition
Theta waves		4 - 8 Hz	Deep relaxation
Alpha waves		8 -12 Hz	Absorb information and highly desirable
Beta waves		12 -25 Hz	Full conscious awareness and attention

Emotions are a central component of consumer responses which creates an emotional attachment in consumers' mind whether to maintain or change the status of preferences [4, 10]. The engagement of consumer with the brand and choices has become a priority of neuro-marketers. Satisfied consumers have a strong emotional attachment to the product, interesting advertisement and more details were easily remembered, consumer tends to spend more money on the product and the recurring consumer of the same brand shows that they are extremely satisfied with the products [3]. The fear of monetary loss when a purchase is made triggers a rush of pain in the brain (pain sector). By adjusting the prices with the payment options such as, once notice an odd number 99, 1999 will help to determine consumer satisfaction and willingness to pay [5]. Too many choices of brands actually will hurt the ability of the consumer to be satisfied with the brands [3]. Consumer preference or choices process for evaluating the consumer satisfaction generally related to the consumer attention, interest, desire and action [11].

The frontal lobes are the major parts of the brain which can support consciousness of human thinking, problem-solving, emotional, behavioral control, judgment, attention and social skills as shown in Figure 1 [12, 14]. The frontal asymmetry measure as a diagnostic tool in order to examine the potential of stimuli [14]. Consumer preference or choices process for evaluating the consumer satisfaction generally related to the consumer attention, interest, desire and action. Figure 1 shows the main brain areas of interest used in this study.

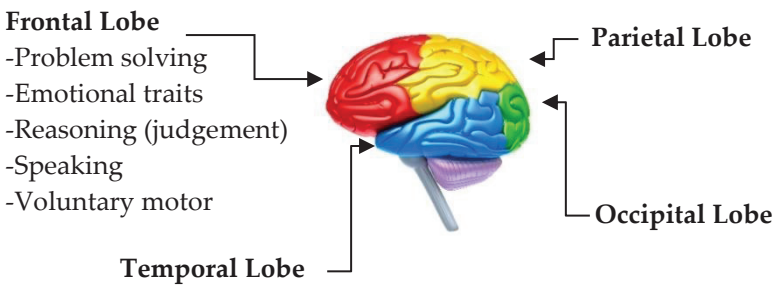


Figure 1: Section of brain lobes [12]

Table 2 represents the channels of the frontal lobe [15] and Figure 2 represents eight frontal channels location based on the International 10-20 system to sample surface electrical activity across all brain regions [16].

Table 2: Channel of frontal lobes [15]

Channel	1	2	3	4	11	12	13	14
Channel Number	AF3	F7	F3	FC5	FC6	F4	F8	AF4

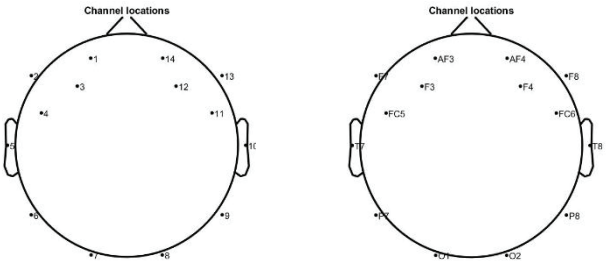


Figure 2: Eight frontal channels location [16]

Moreover, the right part of the brain indicates the contentment; satisfaction area and the excitement; attention [17]. Figure 3 shows the metric model of interpretation of emotions.

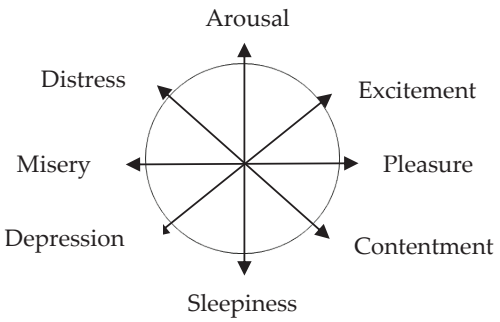


Figure 3: Two-dimensional model of emotion [17]

2.0 METHODOLOGY

2.1 Ethics Statement and Subjects

Five healthy subjects, both male and female from 20-25 years old and subjects must free from disease and medication were selected. The subjects were briefed on the experiment's protocol and signed the informed consent before the experiments. The experiment will be conducted in a room with an air-conditioner (24 °C).

2.2 Project Flow

Figure 4 shows the flowchart of the experiment.

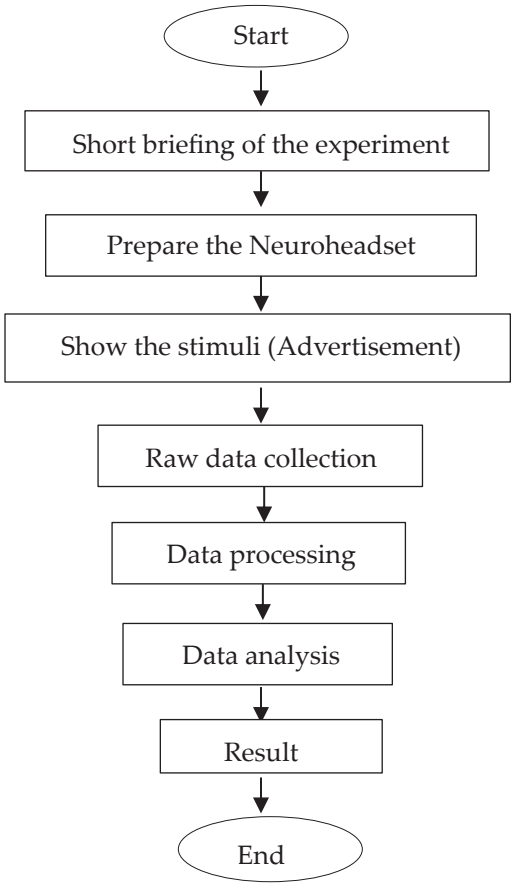


Figure 4: Flowchart of the experiment

Subjects will be instructed to sit, the Neuroheadset will be mounted at subject's head and were required to minimize their movement during observing the stimuli to ensure as little noise recorded as possible so that, it did not affect the process of collecting the data. The data was collected by using TestBench software when the electrodes picking up the signal during the presentation of stimuli. The extraction of data is by using EEGLAB, MATLAB where the signals were processed to obtain the channel spectra and the brain maps. For the analysis, the electrical brain wave signals were saved as raw data in .edf format and were filtered and transform into Fast Fourier Transform FFT. Then, the results will be plotted in the form of channel spectra and maps.

2.3 Stimuli

The experiment was repeated three times in order to get the effectiveness of the system. The sequence in one experiment was illustrated as shown in Figure 5. Two different stimuli are used based on the attractiveness, brand, price and items designed. Figure 6 was presented with a full of information, highest price reduction and attractive of product design whereas, Figure 7 was presented with less of information details, lower price reduction and simple of product design. Both are the same brand and amount of price paid.

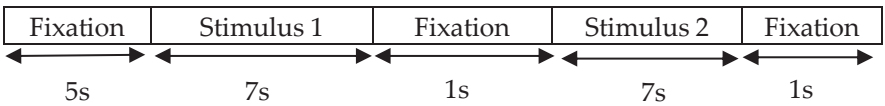


Figure 5: Sequence in one experimental session

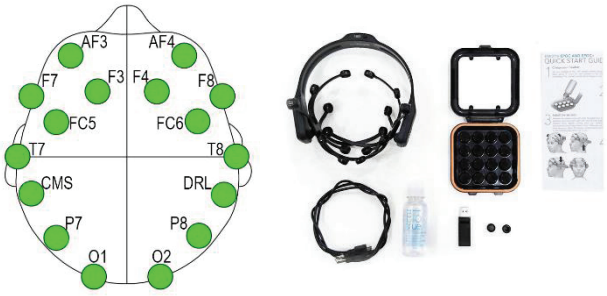
During the experiment, subjects observed two different of stimuli, advertisement 1 and advertisement 2. Each of the stimuli has their own details. The experiment started with 5 seconds fixation, followed by 7 seconds of the first stimulus, 1 second of fixation, followed by 7 seconds of the second stimulus, 1 second of fixation and end of the one experiment. Figures 6 and 7 show the first and second advertisements.

Figure 6: First advertisement [20]

Figure 7: Second advertisement [20]

2.4 Hardware and Software

Sixteenth electrodes channels of Emotiv Epoc was used. The sensors were moistened with the saline solution produced a good signal between electrodes and scalp. The USB dongle is required to communicate between the headset and the computer.



(a) (b)

Figure 8: (a) 16 electrodes and (b) Emotiv Epoc sensor with accessories

The software used in this study is TechSmith Camtasia used as a tool to set up the stimuli and built-in one clip of the project and as a recorder during stimuli presentation and record the brain signal simultaneously [18]. Emotiv Testbench Panel software is used to collect the raw data and 128Hz sampling rate was chosen [19]. Next, the interactive EEGLAB of Matlab toolbox was used to process, filter and transform the raw data into Fast Fourier Transform based on specified brainwaves of Theta (ϑ), Alpha (α) and Beta (β) ranging from 4 to 25 Hz [8]. Using the EEGLAB, the results will be illustrated in the form of channel spectra and topology of the brain maps. Microsoft Excel was used to illustrate the statistical data of power spectral density. In order to validate their responses and choices regarding the stimuli, a questionnaire was prepared to be answered by subjects after the experimental session.

3.0 RESULT AND DISCUSSION

The result from the activity of the brain signal correlates with the response in choices regarding the stimuli for eliciting their satisfactory.

3.1 Channel Spectra and Maps

Channel spectra and topology of the brain maps from these experiments are depicted in Figure 9 and 10. It reflected the results of consumer satisfaction by referring to the two-dimensional model of emotion in Figure 2. Both figures are based on the frequency bands.

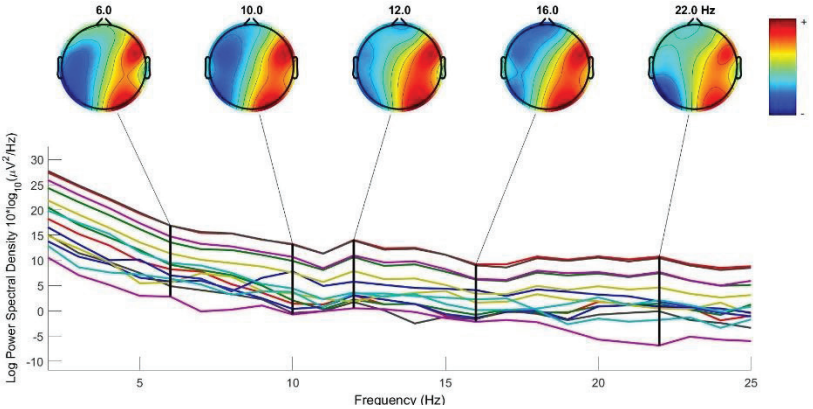


Figure 9: Channel spectra and map of stimulus 1 in the range of 4 to 25 Hz

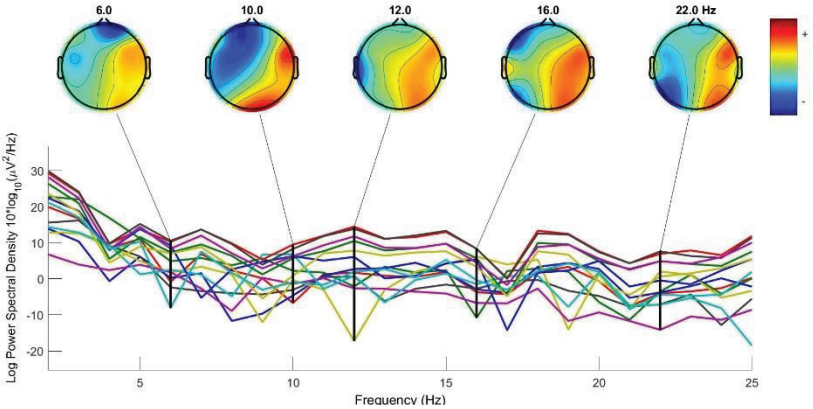


Figure 10: Channel spectra and map of stimulus 2 in the range of 4 to 25 Hz

Each colour configuration has its character which represents the spectrum of the channel activity. Blue represents a negative potential, while red represents a positive potential. In addition, green represents the average activity, and yellow is a moderate increase in activity [12]. The activation of the electrical signal in the brain represented as red colour. Figure 9 and 10 showed the brain was activated where the data of red colour concentrated at the right frontal lobe of the contentment or satisfaction area [17].

3.2 Statistical Analysis of Power Spectral Density

For the brevity, Table 3 shows the statistical average of power spectral density based on eight channels location for the first subject. The table is shown as an example to show how the data is tabulated. Note that, Theta 1, Alpha 1 and Beta 1 represent the stimulus 1. Whereas, Theta 2, Alpha 2, Beta 2 represent for stimulus 2. Next, the statistical average of

power spectral density was analyzed and discussed further for the other four subjects.

Table 3: Average of power spectral density based on channel locations for the first subject

Channels	Theta 1	Theta 2	Alpha 1	Alpha 2	Beta 1	Beta 2
1	12.78055	12.97811	8.968315	9.174481	6.085681	6.0557
2	19.65763	17.41162	12.74366	12.15919	8.424133	7.98651
3	12.17684	11.94539	8.614918	9.062827	5.689444	5.562137
4	10.24538	9.64111	7.198883	6.11184	5.310295	4.014974
11	17.42489	16.00156	13.65012	13.33908	11.05996	10.62729
12	12.24901	10.53515	8.351452	7.93638	6.144616	5.398014
13	13.90029	12.94613	10.12019	9.637593	8.096417	7.774642
14	13.0387	11.92503	9.096089	8.98686	6.497922	6.61586
Average	13.934161	12.923013	9.842953	9.551031	7.163558	6.754391

Based on the average of power spectral density for eight-channel locations of the frontal lobe in Table 3, the average was compared for all subjects as shown in Table 4.

Table 4: Average of power spectral density for all subjects

Subjects	Theta 1	Alpha 1	Beta 1	Theta 2	Alpha 2	Beta 2
1	13.93416	9.842953	7.163558	12.92301	9.551031	6.754391
2	21.05793	15.70559	12.62444	17.7609	13.26495	10.78724
3	15.27966	12.78922	8.77164	14.72964	11.16397	8.252467
4	12.1169	8.95633	4.921853	12.20073	9.211115	5.075739
5	15.71091	14.11586	7.231097	17.38101	15.82289	9.305953

From Table 4, the power spectral density was generated in graphical form to show their satisfaction as shown in Figure 11. Based on the graphical of power spectral density in Figure 11, three subjects showed their preferences for the first advertisement. The high amount of theta wave is dominant to represent the deep relaxation state. Followed by alpha waves that showing the subjects were in the state of calm and considered to be highly desirable and beta waves showing the state of an attention. The attractive product and interesting advertisement with the better information was increasingly remembered by consumers that satisfied their needs. The price is one of the indicators which helps to determine the willingness to purchase.

For instance, the high amount of price reduction in stimulus 1 reduces the fear of monetary loss when a purchase is made which also triggers less pain sector in the brain. There are slightly different in brain activity for subject 4 and 5, showed that the subject's preferences for the second advertisement. Even though the price reduction is low which can

trigger the pain sector in the brain, these might because the participants tend to decide to read fewer details of information and tend to choose the simple design of the products. The same brand was used because too many choices of brands will hurt the ability of consumer preferences. In order to establish the cutting-edge technology, neuroscientific techniques could identify consumer thought by analysing human brain signal on the preference based on the psychological processes, as the results showed the synchronization by using EEG and questionnaire validation. Therefore, the engagement of consumer with marketing presentation affected the brain behaviour.

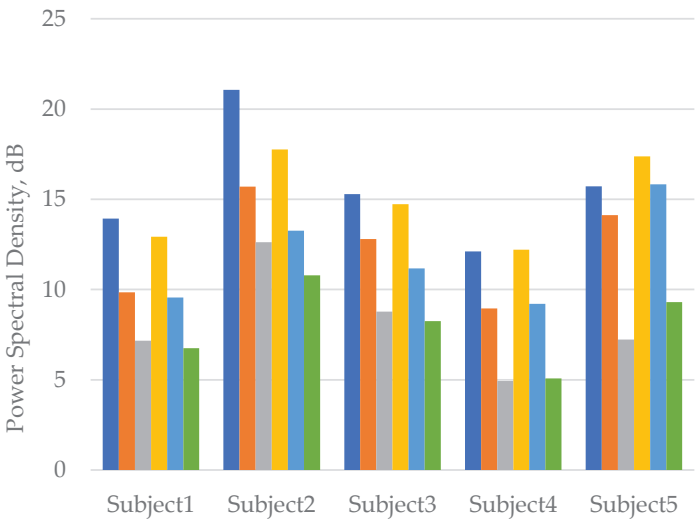


Figure 11: Graph of power spectral density, dB in all subjects

4.0 CONCLUSION

The study concluded that evaluation of marketing stimuli on consumer brain activities did give insight on their behavior towards advertisement which could help marketers to go beyond the traditional way and to strategize marketing based on advertising, pricing, branding, and product design where the choice preference of consumer can be predicted. Therefore, neuromarketing approach would be significantly useful when consumer brain signal can be quantified. The spectral analysis showed a higher synchronization of Theta (ϑ), Alpha (α) and Beta (β) bands more apparent in the right frontal regions and contentment or satisfaction area of the brain. For future research, further investigation should be performed on the extraction and analysis of the consumer satisfaction based on the average difference of age and gender.

ACKNOWLEDGMENTS

The authors would like to thank members of Bio-cognition Laboratory of Bio-inspired System Technology research group, Malaysian-Japan International Institute of Technology (MJIIT). This work was supported by UTM research grant under PY/2017/01721 and the cost center Q.K130000.2643.15J37.

REFERENCES

[1] R.N. Khushaba, C. Wise, S. Kodagoda, J. Louviere, B.E. Kahn and C. Townsend "Consumer neuroscience: assessing the brain response to marketing stimuli using electroencephalogram (EEG) and eye tracking", *Expert Systems with Applications*, vol. 40, no. 9, pp. 3803-3812, 2013.

[2] V.A. Roth, "The potential of neuromarketing as a marketing tool", Bachelor thesis, Faculty of Management and Governance, University of Twente, Netherlands, 2014.

[3] R. Dooley, *Brainfluence: 100 ways to persuade and convince consumers with neuromarketing.* New Jersey: John Wiley & Sons, 2012.

[4] V. Sebastian, "Neuromarketing and evaluation of cognitive and emotional responses of consumers to marketing stimuli", *Procedia-Social and Behavioral Sciences,* vol. 127, pp. 753-757, 2014.

[5] J.G. Vargas-Hernandez and A.A. Burgos-Campero, "Analytical approach to neuromarketing as a business strategy, *Journal of Euromarketing*, vol. 22, pp. 64-73, 2013.

[6] F. Babiloni, "Consumer neuroscience: A new area of study for biomedical engineers", *IEEE Pulse,* vol. 3, no. 3, pp. 21-23, 2012.

[7] S. Darafsheh. (2017). *How does brain sensing technology work?* [Online]. Available: https://www.iotforall.com/brain-sensing-technology-muse-headband/

[8] iMOTIONS. (2019). *Electroencephalography (EEG)* [Online]. Available: https://imotions.com/guides/electroencephalography-eeg/

[9] Y.Y. Lee and S. Hsieh, "Classifying different emotional states by means of EEG based functional connectivity patterns," *PLoS ONE*, vol. 9, no. 4, pp. 1-13, 2014.

[10] W.Y. Hsu, "An integrated-mental brainwave system for analyses and judgments of consumer preference", *Telematics and Informatics*, vol. 34, no. 5, pp. 518-526, 2017.

[11] Y. Liu, O. Sourina and M.R. Hafiyyandi, "EEG-based emotion-adaptive advertising," in Humaine Association Conference on Affective Computing and Intelligent Interaction, Geneva, Switzerland, 2013, pp. 843-848.

[12] N. Jalaudin and M.K.M. Amin, "EEG analysis on human reflection towards relaxation of mind," *Malaysian Journal of Fundamental and Applied Sciences*, vol. 15, no. 2, pp. 185-189, 2019.

[13] M. Yadava, P. Kumar, R. Saini, P.P. Roy and D.P. Dogra, "Analysis of EEG signals and its application to neuromarketing", *Multimedia Tools and Applications*, vol. 76, no. 18, pp. 19087-19111, 2017.

[14] R. Ohme, D. Reykowska, D. Wiener and A. Choromanska, "Application of frontal EEG asymmetry to advertising research", *Journal of Economic Psychology*, vol. 31, no. 5, pp. 785-793, 2010.

[15] N. Behboodin, M. Kamal, K. Natsume and T. Kitajima, "Frequency analysis of brain signals for biometric application," *International Journal of Pure and Applied Mathematics*, vol. 118, no. 24, pp. 1-14, 2018.

[16] Trans Cranial Technologies Ltd. (2012). *10/20 System Positioning Manual* [Online]. Available: http://chgd.umich.edu/wp-content/uploads/2014/06/10-20_system_positioning.pdf

[17] S.P. Kvaale, "Emotion recognition in EEG: A neuroevolutionary approach," M.S. thesis, Department of Computer and Information Science, Norwegian University of Science and Technology, Trondheim, Norway, 2012.

[18] TechSmith Corporation. (2019). Camtasia: *Screen Recorder and Video Editor* [Online]. Available: https://www.techsmith.com/video-editor.html

[19] A.N. Alshbatat, P.J. Vial, P. Premaratne and L.C. Tran., "EEG-based brain-computer interface for automating home appliances", *Journal of Computers*, vol. 9, no. 9, pp. 2159-2166, 2014.

[20] Nike, Inc. (2019). *Nike Joyride Dual Run* [Online]. Available: https://www.nike.com/my/