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Research paper

Application of EEG/ERP and Eye Tracking in Underlying Mechanism of Visual Attention of Auto Dealer's Advertisement – A Neuromarketing Research

Norlyiana Samsuri[1]*, Faruque Reza[2], Tahamina Begum[3], Nasir Yusoff[4], Badrisyah Idris[5], Hazim Omar[6], Salmi Mohd Isa[7],

[1]*Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kelantan. E-mail:lyiana_av@yahoo.com*
[2]*Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kelantan*
[3]*Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kelantan*
[4]*Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kelantan*
[5]*Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kelantan*
[6]*Department of Neurosciences, School of Medical Sciences, Universiti Sains Malaysia, Kelantan*
[7]*Graduate School of Business, Universiti Sains Malaysia, Penang*

Abstract

This study aims to detect the level of attention and gaze behavior on diverse display design of advertisement through the applications of Event Related Potential (ERP) and Eye Tracking. Total of 15 subjects participated in ERP, while two subjects (out of 15) participated in Eye Tracking. The N200 ERP component was recorded using 128-sensor net. The result of the ERP and gaze behavior showed consistent results that subjects were more attentive to the Vertex Reared Grouped (VRG) view compared to Vertex Frontal Grouped (VFG) view, and more attentive to the Right Lateral Grouped (RLG) view compared to Left Lateral Grouped (LLG) view in Session 1 and Session 3 respectively. Visual interpretation of scan path together with fixation duration and saccade duration of gaze behavior data revealed that VRG view and RLG view attracted more attention than its counterpart. For Session 2, the results of the ERP and gaze behavior indicated that subjects were equally attentive to the Right Lateral Singular (RLS) view and Left Lateral Singular (LLS) view. Gaze behavior showed that scan path during RLS view and LLS view indicated similar amount of gaze in both display designs. For cost-effective and limited space advertising, it is advisable that marketers prioritize display design of VRG view than its counterpart and RLG view than its counterpart.

Keywords: *Display design; Event Related Potential (ERP); Eye tracking; Neuromarketing*

1. Introduction

Neuromarketing is the new hybrid that offers intuitive insight and methods from Neuroscience to enhance understanding in Consumer Behaviour. Neuromarketing is a division of the general field of Neuroeconomics, which is an interdisciplinary field that combines Economics, Neuroscience and Psychology, to study the function of the brain in decision-making situations [1]. Based on the resultant techniques derived from Neurosciences better identification and understanding of cerebral mechanisms fundamental to consumer's behavior is possible. Main shift from Conventional Marketing to Neuromarketing is where instead of measuring the outward expression to focus on the inward processes and real behavior. Conventional Marketing methods to predict the effectiveness of advertisement indicated flaws as it depends on willingness and capability of subject to describe their thoughts and emotions as they were exposed to advertising [2]. People presumed that they are capable to describe their own cognitive processes. While in reality, individuals are incapable to self-assess and self-report as cognitive processes have subconscious components. Moreover, as individual have no desire to participate, they have high inclination to transmit incorrect information especially when the topic is very sensitive or when they feel the need for social acceptance. Therefore, the responses obtained were not genuine as they were filtered by the individual's consciousness before it is reported [3]. Methods applied by Conventional Marketing harvest subjective data which do not carried the same level of accuracy as in Neuromarketing, where in Neuromarketing subjects do not have control over the information collected [3-6]. Emotional engagement, memory retention, purchase intention, novelty, awareness and attention were some of the effectiveness indicators that can be measured through Neuromarketing [7]. The significance of Neuromarketing lies in it access to richer and less biased marketing insights [3, 8-10].

Electroencephalography or more commonly known as EEG is a non-invasive tool which is capable of capturing and recording the electrical signals produced by brainwaves' activity through the use of electrode sensors on the scalp [7]. An event related potential is the measured brain response that is the direct result of a specific sensory, cognitive or motor event [11-12]. ERP are EEG changes that were time-locked to events such as sensory, motor and cognitive. N200 ERP component or also known as N2 is a negative deflection that peaks 200ms to 350ms post-stimulus and is found primarily over anterior scalp sites. N200

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negativity is caused by a deviation from preceding stimuli. The N200 typically is evoked before a motor response, suggesting its link to the cognitive processes of stimulus labeling and distinction. Past research focused on the N200 as a mismatch detector, but it has also been found to reflect executive cognitive control functions and has recently been used in the study of language [13].

Eye Tracking is a tool for visual attention analysis and it seeks to associate visual attention with cognitive and emotional responses of consumers [14]. Eye Tracking enables researcher to observe subjects' visual behavior as they perceived advertisement and observed the way the advertisement influence subjects' attention and cognitive processing. In Eye Tracking, high-speed camera is used to precisely record a subject's gaze to assess visual attention. These cameras are mounted on a flat surface or are worn by the subjects. Eye Tracking is equipped with capability in measuring focus of consumers' attention, the pattern of visual behavior of fixations of the gaze, dilation of the pupils and focus [14-16]. Eye movement measured the number of fixations or the dwell time of the eyes during introduction to stimuli. Eye movements are believed to be related to attention, memory and information processing. For example, the number of fixations per second was used in studies as an accurate indicator of attention to advertising, where higher number of fixations indicated higher attention [17]. Apart from that, Eye Tracking measures the size of the pupil or pupil dilation. Longer pupil dilation would correspond to the subject's better processing of the information [7]. The measurement of the pupils was concurred with the areas and the frequency of observation that the subject spent focusing on the presented stimuli.

2. Methodology

This study was approved by Human Ethical Committee of Universiti Sains Malaysia with the reference number (USMKK/PPP/JePeM267.2[7]). All the data were kept as private and confidential. Data were collected from 15 subjects (age: 22.73±1.71 years) (mean±SD). Sample size was calculated by one statistician using Power and Sample Size software. Two healthy subjects (out of 15 subjects in ERP) participated in Eye Tracking.

2.1. Experimental Design

This study was designed into three experimental sessions. In Session 1, display designs of interest were VFG (Vertex Frontal Grouped) view and VRG (Vertex Reared Grouped) view. In Session 2, display designs of interest were RLS (Right Lateral Singular) view and LLS (Left Lateral Singular) view. In Session 3, display designs of interest were RLG (Right Lateral Grouped) view and LLG (Left Lateral Grouped) view. Visual stimuli of ERP were presented through E-prime software using the three stimuli visual oddball ERP paradigm where car pictures was established as a target while building pictures was established as a neutral. Every session was designed with a fixation point (+) as initiates followed by target and standard neutral stimuli (randomly presented) for 1.5 seconds with interstimulus intervals (ISI) of 3 seconds. A total of 60 grouped pictures were implemented in the paradigm of Session 1 and Session 3, while in Session 2 total of 90 single image pictures were utilized. Fig. 1 demonstrated the experimental design in Session 1 (left), Session 2 (middle) and Session 3 (right). Stimulus of Eye Tracking was established through SMI Experiment Centre software, constructed in the video format (.avi). Stimulus incorporated a total of 16 pictures which was presented for 15 seconds for grouped pictures whereas 10 seconds for single image pictures. The stimulus was then synchronized with the iView System.

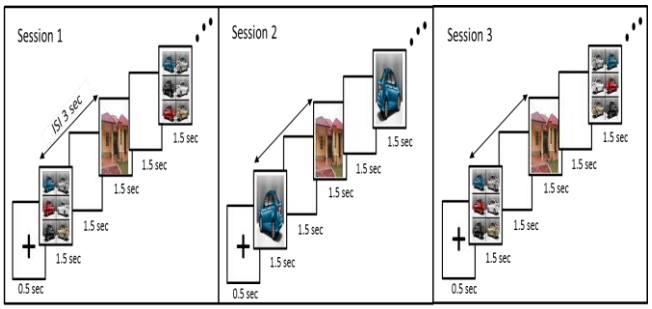

Fig. 1: Experimental paradigm of Session 1, Session 2 and Session 3

2.2. Procedure

Task procedure in Session 1 were to press button "1" as quickly as possible when subject perceive the VRG view of the car and to press button "2" as quickly as possible when subject perceive the VFG view of the car. Task procedure in Session 2 were to press button "1" as quickly as possible when subject perceive the RLS view of the car and to press button "2" as quickly as possible when subject perceive the LLS view of the car. Task procedure in Session 3 were to press button "1" as quickly as possible when subject perceive the RLG view of the car and to press button "2" as quickly as possible when subject perceive the LLG view of the car. In all the three sessions, subjects were instructed not to press any button when neutral stimulus was on display. The distance between presentation of stimuli and subject was approximately 80 cm. The ERP session was recorded through 128 channels HydroCell Geodesic Sensor Net (GSN).

Eye Tracking in this study used MEG 250 where video images were recorded and the image information was send through an optical fibre to iView System Version 2.7 to be processed. The iView System analyzed the eye images in real-time by detecting pupil, calculating the centre and eliminating artifacts. SMI experiment Center was used to create and run experiment paradigm which then synchronized with iView system for further processing of data. Camera was aligned centrally in front of the subject's eye and the distance between subject's eye and camera was between 100- 180 cm. Calibration was then set-up to 9 point with corner correction. Data was recorded when the stimulus was presented and the output from the system which was in binaryiView Data File (IDF) were then loaded to SMI Behavioural and Gaze Analysis Program (BeGaze) version 3.4.

2.3. Data Collection

This study was designed into three experimental sessions. Net-Station software was used to acquire amplitudes values of the N200 ERP component at 19 electrode sites during three display design in all the three sessions. The raw data was filtered with 0.03-30 Hz, segmented with a window of 100ms before and 800ms after stimulation. The baseline was corrected with 100 ms before stimulation. Eye movement, eye blink and movement artifact were removed with artifact detection tool in Net-Station software. Normality test, Kurtosis and skewness were done before testing significance value. One-way ANOVA analysis for amplitudes of N200 ERP component between display designs of interest for each session was done using Statistical Package for the Social Science version 22 (SPSS 22) software.

3. Results

3.1. ERP Components

Fig. 2 illustrated grand average waveforms of the N200 ERP component at 19 electrode sites (Fz, Cz, Pz, FP1, FP2, F3, F4, F7, F8, C3, C4, T3, T4, P3, P4, O1 and O2) during Session 1 (left), Session 2 (middle) and Session 3 (right).

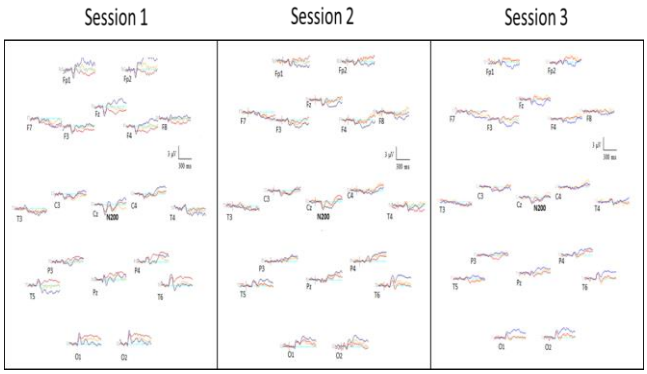

Fig. 2: Grand average waveform of the N200 ERP component during Session 1, Session 2 and Session 3

3.1.1. Amplitudes of N200 Component during Session1

One-way ANOVA analysis revealed that there was significant difference in mean N200 amplitude for the three display designs (VRG, VFG and Neutral). Post-hoc multiple comparisons using Bonferroni test indicated that the mean N200 amplitude for VRG view was significantly higher at six scalp sites, Fz [F (2, 42) = 7.14, P=0.002], Fp1 [F (2, 42) = 7.92, P=0.001], Fp2 [F (2, 42) = 8.23, P=0.001], F4 [F (2, 42) = 10.70, P=0.001], F8 [F (2, 42) = 4.26, P=0.02] and C4 [F (2, 42) = 3.86, P=0.03], while Neutral was significantly higher compare to VRG view and VFG view at one scalp site T5 [F (2, 42) = 4.13, P=0.02].Overall significant (Fz, Fp1, Fp2, F4, F8, C4) and non-significant (Cz, F3, F7, C3, T3, T4) higher amplitudes of N200 ERP component were observed during VRG view compared to VFG view and Neutral pictures. The trend of higher amplitude of N200 ERP component at maximum sites intensely support that the visual identification task of VRG view was stronger compared to VFG view.

Table 1: Amplitudes of the N200 ERP component during Session 1

Site	VRG view (mean ± SD)	VFG view (mean ± SD)	Neutral picture (mean ± SD)	F (df)	P	*Sig.*
N200 ERP Component Amplitudes (in µV) mean±SD)						
Fz	**4.21±3.28**	**1.77±1.92**	**1.21±1.23**	**7.14(2,4)**	***0.002***	**S**
Cz	2.99±1.9	1.57±1.69	2.1±1.99	2.19(2,42)	0.12	NS
Pz	3.38±2.36	2.6±2.12	3.43±2.15	0.67(2,42)	0.52	NS
Fp1	**6.36±5.14**	**3.19±1.92**	**1.71±1.35**	**7.92(2,42)**	***0.001***	**S**
Fp2	**7.05±4.51**	**4.08±3.08**	**2.09±2.04**	**8.23(2,42)**	***0.001***	**S**
F3	2.27±1.23	1.47±1.15	1.46±1.48	1.92(2,42)	0.16	NS
F4	**3.57±1.68**	**2.12±1.93**	**0.95±0.82**	**10.70(2,42)**	***0.001***	**S**
F7	1.96±1.19	1.03±0.92	1.15±1.25	3.12(2,42)	0.06	NS
F8	**2.46±1.15**	**2.05±1.93**	**1.04±0.72**	**4.26(2,42)**	***0.02***	**S**
C3	2±1.32	1.05±1.05	1.39±1.17	2.47(2,42)	0.1	NS
C4	**3.1±1.62**	**2.06±1.93**	**1.42±1.41**	**3.86(2,42)**	***0.03***	**S**
T3	1.53±1.87	1.19±1.04	1.06±0.95	0.48(2,42)	0.62	NS
T4	1.86±2.1	1.67±1.69	1.78±1.48	0.04(2,42)	0.96	NS
T5	**1.57±1.37**	**1.62±1**	**2.92±1.87**	**4.13(2,42)**	***0.02***	**S**
T6	2.53±2.43	2.61±2.46	3.96±2.7	1.51(2,42)	0.23	NS
P3	2.22±1.96	1.43±1.41	2.44±1.8	1.38(2,42)	0.26	NS
P4	3.32±1.75	2.58±1.86	3.86±2.13	1.68(2,42)	0.2	NS
O1	3.05±3.03	3.71±3.01	4.09±2.49	0.51(2,42)	0.6	NS
O2	3.74±4.57	3.98±3.52	4.59±3.59	0.19(2,42)	0.83	NS

Significant if p≤.050

3.1.2. Amplitudes of N200 Component during Session 2

The results revealed that although maximum areas evoked higher amplitude in Neutral, the target display were LLS view and RLS view. One-way ANOVA analysis revealed that there was significant difference in mean N200 amplitude for the three display designs (RLS, LLS and Neutral). Post-hoc multiple comparisons using Bonferroni test indicated that the mean N200 amplitude for RLS was significantly higher at three scalp sites, F4 [F (2, 42) =3.72, P=0.03], F8 [F (2, 42) =3.57, P=0.04] and C4 [F (2, 42) =3.52, P=0.04], while Neutral was significantly higher at T6 [F (2, 42) = 5.50, P=0.008]. However, overall non-significant (Cz, Fp1, F3, C3) areas higher amplitudes of N200 ERP component during LLS view compared to RLS view were observed. Four locations (F4, F8 C4) showed significant and (T6) showed non-significant higher amplitudes of N200 ERP component during RLS view. The affinity of higher amplitude of N200 ERP component at maximum sites for display design of LLS view indicated that subjects had more visual perception in fast identification during visual presentation of LLS view as compared to RLS view.

Table 2: Amplitudes of the N200 ERP component during Session 2

Site	VRG view (mean ± SD)	VFG view (mean ± SD)	Neutral picture (mean ± SD)	F (df)	P	*Sig.*
N200 ERP Component Amplitudes (in µV) mean±SD)						
Fz	1.58±1.18	1.8±1.73	1.3±0.91	0.53(2,42)	0.59	NS
Cz	2.45±1.57	2.59±2.88	1.89±1.36	0.49(2,42)	0.62	NS
Pz	3.11±1.58	2.85±2.12	3.42±1.84	0.35(2,42)	0.71	NS
Fp1	1.88±1.23	2.93±2.08	1.6±1.09	3.13(2,42)	0.05	NS
Fp2	3.16±2.35	2.87±2.61	1.89±1.45	1.37(2,42)	0.27	NS
F3	0.84±0.66	1.9±1.56	1.38±1.37	2.65(2,42)	0.08	NS
F4	**2.56±1.81**	**1.8±2.01**	**0.96±0.68**	**3.72(2,42)**	***0.03***	**S**
F7	0.85±0.54	1.13±0.75	1.18±0.7	1.02(2,42)	0.37	NS
F8	**2.36±2.46**	**1.22±1.27**	**0.85±0.42**	**3.57(2,42)**	***0.04***	**S**
C3	1.02±0.6	1.79±1.93	1.32±1.06	1.27(2,42)	0.29	NS
C4	**3.05±1.53**	**2.07±1.79**	**1.72±0.99**	**3.25(2,42)**	***0.05***	**S**
T3	1.08±1.02	1.44±2.41	1.8±1.89	0.56(2,42)	0.57	NS
T4	1.86±1.23	1.38±1.42	2.58±1.54	2.73(2,42)	0.08	NS
T5	2.2±1.8	1.78±1.36	3.26±1.76	3.16(2,42)	0.05	NS
T6	**2.46±1.67**	**2.02±1.55**	**4.69±3.4**	**5.50(2,42)**	***0.008***	**S**
P3	1.87±1.37	2.33±2.3	2.75±1.8	0.83(2,42)	0.44	NS
P4	3.3±1.92	2.34±1.78	3.83±1.86	2.47(2,42)	0.1	NS
O1	3.03±2.11	3.04±2.64	4.322.19±	1.52(2,42)	0.23	NS
O2	3.6±2.46	3.07±2.51	4.82±3.41	1.50(2,42)	0.23	NS

Significant if p≤.050

3.1.3. Amplitudes of N200 Component during Session 3

One-way ANOVA analysis revealed that there was significant difference in mean N200 amplitude for the three display designs (RLG, LLG and Neutral). Post-hoc multiple comparisons using Bonferroni test indicated that the mean N200 amplitude for RLG view was significantly higher at five scalp sites, Fz [F (2, 42) =5.12, P=0.01], Fp1 [F (2, 42) =3.53, P=0.04], Fp2 [F (2, 42) =3.50, P=0.04], F4 [F (2, 42) =4.06, P=0.03], F8 [F (2, 42) =4.79, P=0.01], while Neutral was significantly higher at T6 [F (2, 44) = 3.64, P=0.04]. Overall significant (Fz, Fp1, Fp2, F4, F8) and non-significant (Cz, F3, F7, C3, C4, T4, P3) areas higher amplitudes of N200 ERP component during RLG view compared to LLGS view were observed. The trend of higher amplitude of N200 ERP component at maximum sites intensely support that the visual identification task of RLG view was stronger compared to LLG view.

Table 3: Amplitudes of the N200 ERP component during Session 3

Site	VRG view (mean ± SD)	VFG view (mean ± SD)	Neutral picture (mean ± SD)	F (df)	P	*Sig.*
N200 ERP Component Amplitudes (in µV) mean±SD)						
Fz	**3.17±2.55**	**1.72±1.54**	**1.15±0.85**	**5.12(2,42)**	***0.01***	**S**
Cz	2.78±2.76	1.51±1.84	1.65±1.57	1.60(2,42)	0.21	NS
Pz	2.61±2.13	1.49±1.35	2.78±2.13	2.0(2,42)	0.15	NS
Fp1	**3.99±3.54**	**2.83±2.64**	**1.44±1.13**	**3.53(2,42)**	***0.04***	**S**
Fp2	**4.42±3.52**	**2.85±2.75**	**1.73±1.83**	**3.50(2,42)**	***0.04***	**S**
F3	2.36±2.08	2.01±2.3	1.04±0.90	2.02(2,42)	0.15	NS
F4	**3.02±2.62**	**1.57±1.44**	**1.24±0.98**	**4.06(2,42)**	***0.03***	**S**
F7	1.97±2.41	1.73±1.91	0.55±0.64	2.64(2,42)	0.08	NS
F8	**2.73±2.45**	**1.25±1.45**	**0.91±0.8**	**4.79(2,42)**	***0.01***	**S**
C3	1.51±1.63	1.22±1.56	1.12±1.07	0.29(2,42)	0.75	NS
C4	2.86±2.66	1.45±1.86	1.54±1.65	2.09(2,42)	0.14	NS
T3	1.27±1.3	1.32±1.46	0.59±0.96	1.54(2,42)	0.23	NS

T4	1.7±1.63	1.39±1.88	1.63±1.15	0.15(2,42)	0.86	NS
T5	1.69±1.64	1.21±1.17	1.7±1.63	0.53(2,42)	0.6	NS
T6	**2.03±1.46**	**1.6±1.45**	**3.32±2.38**	**3.64(2,42)**	***0.04***	**S**
P3	2.4±2.3	1.02±1.4	1.84±2.3	1.75(2,42)	0.19	NS
P4	2.75±2.21	2.08±1.98	2.88±2.14	0.62(2,42)	0.54	NS
O1	2.39±1.83	1.53±1.81	3.43±2.96	2.64(2,42)	0.08	NS
O2	2.8±2.12	2.31±2.41	4.17±3.13	2.07(2,42)	0.14	NS

Significant if p≤.050

3.2. Eye Tracking

3.2.1. Scan Path

Scan path recorded the information about paths of the eyes as it scan, view and analyze the visual field. The Scan path displayed the visualization of 2D plot over the stimulus video where usually, the plot is made up of fixations and saccades. Fixation point is displayed at the centre of a circle and the saccades are plotted as connecting lines in-between. Circle radius relates to the fixation duration while lines in-between relates to the saccade duration. In Session 1, Subject 1 (coral path) scan path presented greater path during VRG view with higher fixation duration (210.4 ± 112.4) and higher saccade duration (287.3 ± 492.6) compared to VFG view with fixation duration (143.1 ± 60.4) and saccade duration (157.3 ± 219.4). Subject 2 (blue path) scan path presented greater path during VRG view with higher fixation duration (714.3 ± 501.7) but smaller saccade duration (32.4 ± 40.0) compared to VFG view with fixation duration (522.3 ± 678.8) and saccade duration (72..5 ± 85.5). In Session 2 (black color car), Subject 1 (coral path) scan path presented greater path during LLS view with higher fixation duration (344.5 ± 427.1) and higher saccade duration (201.6 ± 231.2) compared to RLS view with fixation duration (333.3 ± 252.8) and saccade duration (136.6 ± 157.5). Subject 2 (blue path) scan path presented greater path during LLS view with higher fixation duration (957.3 ± 672.6) but smaller saccade duration (53.2 ± 79.9) compared to RLS view with fixation duration (630.2 ± 478.9) and saccade duration (65.1 ± 77.0). In Session 2 (blue car), Subject 1 (coral path) scan path presented greater path during LLS view with higher fixation duration (131.1 ± 27.6) but smaller saccade duration (318.3 ± 333.9) compared to RLS view with fixation duration (115.6 ± 32.3) and saccade duration (395.2 ± 352.0). Subject 2 (blue path) scan path presented greater path during RLS view with higher fixation duration (1350.6 ± 1457.4) but smaller saccade duration (34.4 ± 34.9) compared to LLS view with fixation duration (658.1 ± 677.7) and saccade duration (43.0 ± 50.1).). In Session 2 (gold car), Subject 1 (coral path) scan path presented greater path during RLS view with higher fixation duration (301.2 ± 201.5) and higher saccade duration (154.0 ± 366.4) compared to LLS view with fixation duration (219.3 ± 178.5) and saccade duration (139.5 ± 143.1). Subject 2 (blue path) scan path presented greater path during RLS view with higher fixation duration (1553.4 ± 915.1) but smaller saccade duration (19.6 ± 0.5) compared to LLS view with fixation duration (81.0 ± 957.6) and saccade duration (34.6 ± 34.3). In Session 2 (red car), Subject 1 (coral path) scan path presented greater path during LLS view with higher fixation duration (134.9 ± 43.6) and higher saccade duration (210.9 ± 212.8) compared to RLS view with fixation duration (121.7 ± 40.5) and saccade duration (121.7 ± 167.2). Subject 2 (blue path) scan path presented greater path during RLS view with higher fixation duration (750.2 ± 485.9) but smaller saccade duration (24.1 ± 16.8) compared to LLS view with fixation duration (592.5 ± 536.0) and saccade duration (63.1 ± 73.8). In Session 2 (silver car), Subject 1 (coral path) scan path presented greater path during LLS view with higher fixation duration (160.7 ± 61.5) but smaller saccade duration (141.4 ± 236.5) compared to RLS view with fixation duration (150.7 ± 65.5) and saccade duration (175.2 ± 424.1). Subject 2 (blue path) scan path presented greater path during RLS view with higher fixation duration (846.0 ± 505.7) but smaller saccade duration (31.1 ± 34.8) compared to LLS view with fixation duration (833.2 ± 632.7) and saccade duration (36.6 ± 35.0). In Session 2 (white car), Subject 1 (coral path) scan path presented greater path during LLS view with higher fixation duration (151.5 ± 65.2) but smaller saccade duration (134.2 ± 170.2) compared to RLS view with fixation duration (141.9 ± 52.1) and saccade duration (170.8 ± 196.2). Subject 2 (blue path) scan path presented greater path during LLS view with higher fixation duration (1396.6 ± 908.1) but smaller saccade duration (19.1 ± 0.4) compared to RLS view with fixation duration (549.8 ± 411.6) and saccade duration (26.9 ± 19.1). In Session 3, Subject 1 (coral path) scan path presented greater path during RLG view with higher fixation duration (203.6 ± 121.0) but smaller saccade duration (243.1 ± 413.2) compared to LLG view with fixation duration (115.1 ± 19.2) and saccade duration (1019.2 ± 1099.0). Subject 2 (blue path) scan path presented greater path during RLG view with higher fixation duration (888.7 ± 660.2) and higher saccade duration (44.3 ± 69.5) compared to LLG view with fixation duration (552.0 ± 421.5) and saccade duration (26.0 ± 23.6). Fig.3 showed the screenshot of scan path of subject 1 and subject 2 in Session 1 and Session 3 (above) and Session 2 (below).

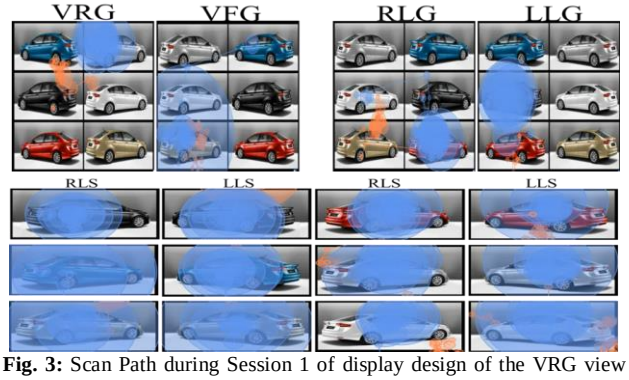

Fig. 3: Scan Path during Session 1 of display design of the VRG view and the VFG view (above left), Session 2 of display design RLS view and LLS view (below) and Session 3 of display design RLG view and the LLG view (above right)

3.2.2. Key Performance Indicators (Kpi)

The Key Performance Indicators (KPI) main view displayed quantitative and visible gaze responses from overlay on Areas of Interest (AOI). There are few available indicators as part of the KPIs. One of the indicators is average fixation which is the sum of average fixation time per subject in an AOI divided by number of selected subjects. In Session 1, during VRG view, Subject 1 highest average fixation was 200ms at silver car AOI whereas Subject 2 highest average fixation was 715ms also at silver car AOI. During VFG view, Subject 1 highest average fixation was 141ms at gold car AOI whereas Subject 2 highest average fixation was at 583ms also at the gold car AOI. In Session 2 (black car), Subject 1 highest average fixation was 100ms during LLS view whereas Subject 2 highest average fixation was 958ms also during LLS view. In Session 2 (blue car), Subject 2 highest average fixation was 790ms during RLS view whereas Subject 1 has no highest average fixation on any display design. In Session 2 (gold car), Subject 1 highest average fixation was 140ms during RLS view whereas Subject 2 highest average fixation was 1554ms also during RLS view. In Session 2 (red car), Subject 1 highest average fixation was 122ms during LLS view whereas Subject 2 highest average fixation was 751ms also during RLS view. In Session 2 (silver car), Subject 1 highest average fixation was 140ms during both LLS and RLS view whereas Subject 2 highest average fixation was 807ms also during RLS view. In Session 2 (white car), Subject 1 highest average fixation was 220ms during LLS view whereas Subject 2 highest average fixation was 1580ms also during LLS view. In Session 3, during RLG view, Subject 1 highest average fixation was 240ms at white car AOI whereas Subject 2 highest average fixation was 709ms at red car AOI. During LLG view, Subject 1 highest average fixation was 107ms at red car AOI whereas

Subject 2 highest average fixation was at 960ms at the black car AOI.

4. Discussion and Conclusion

The central findings of this study were about cognitive response and gaze behavior to the display design of auto dealer's advertisement. In Session 1, the trend of higher amplitude of N200 ERP component support that the visual identification task of VRG view was stronger compared to VFG view. In Session 2, the affinity of higher amplitude of N200 ERP component at LLS view indicated that subjects had more visual perception in fast identification during visual presentation of LLS view as compared to RLS view. In Session 3, the trend of higher amplitude of N200 ERP component support that the visual identification task of RLG view was stronger compared to LLG view. N200 is typically evoked before the motor response, suggesting its link to the cognitive processes of stimulus identification and distinction [18]. According to Balconi [19], N200 is distributed more on the frontal sites for both conscious and unconscious stimulus attention. This was consistent with the result in this study where N200 was spread slightly more towards the frontal site. N200 shown greater amplitude in subliminal condition compared to the supraliminal one that is attention is greater when the subjects only perceived the stimulus and elaborated it automatically, without awareness than when they consciously do it. Subjects had stronger visual identification task during visual presentation of VRG view, LLS view and RLG view as they had to unconsciously elaborate and comprehend stimulus before deciding. Hence, higher amplitude of N200 ERP component at maximum sites of those three display designs was produced. One of the research found that attention index is higher in subliminal condition because the subjects have to unconsciously elaborate and comprehend the stimuli before taking decision to purchase [20]. Gaze behavior data of subject 1 and subject 2 indicated more visual attention during display design of VRG view compared to VFG view as VRG view indicated longer fixation duration and saccade duration. Gaze behaviors showed equal attentiveness to the display design of LLS view and RLS view. Gaze behavior data of both subjects indicated that there was more visual attention during display design of RLG view compared to LLG view as RLG view indicated longer fixation duration. The application of Eye Tracking allowed measurement in fixation (looking at the same place for a while) and saccade (movement of eyes between fixations) which were related to the information on the screen and behavioral choices during an experiment. Fixation is the moment when eyes are fixed on an object and it is possible to enjoy it in detail and time lengths of fixations indicate attention, while pupil size is the pupil dilation responses and serve as identification for attention and emotion [21]. Gaze behaviors of both subjects showed common interest in silver color during display design of VRG view, while gaze behaviors during display design of VFG view showed common interest in gold color. Subject 1 indicated interest in white color whereas Subject 2 indicated interest in red color during display design of RLS view. Subject 1 indicated interest in red color whereas Subject 2 indicated interest in black color during display design of LLG view. Eye Tracking data were able to provided additional informational such as the color of interest. Our results showed that using Neuroscience methods such as ERP and Eye Tracking, automotive companies can better understand the conscious and unconscious consumers' thinking and tailor specific marketing strategy.

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References

[1] Kenning P & Plassmann H, "NeuroEconomics: An overview from an economic perspective", Brain Research Bulletin, Vol.67, No.5,(2005), pp. 343-354.
[2] Lee N, Broderick AJ & Chamberlain L, "What is 'neuromarketing'? A discussion and agenda for future research", International Journal of Psychophysiology, Vol.63, No.2,(2007), pp. 199-204.
[3] Hubert M & Kenning P, "A current overview of consumer neuroscience", Journal of Consumer Behaviour, Vol.7, No.4-5,(2008), pp. 272-292.
[4] Fugate DL, "Neuromarketing: a layman's look at neuroscience and its potential application to marketing practice", Journal of Consumer Marketing, Vol.24, No.7,(2007), pp. 385-394.
[5] Butler MJ, "Neuromarketing and the perception of knowledge", Journal of Consumer Behaviour, Vol.7, No.4-5,(2008), pp. 415-419.
[6] Ariely D & Berns GS, "Neuromarketing: the hope and hype of neuroimaging in business", Nature reviews neuroscience, Vol.11, No.4,(2010), pp. 284-292.
[7] [7] Sebastian V, "Neuromarketing and Evaluation of Cognitive and Emotional Responses of Consumers to Marketing Stimuli", Procedia-Social and Behavioral Sciences, Vol.127, (2014), pp. 753-757.
[8] Murphy ER, Illes J & Reiner PB, "Neuroethics of neuromarketing", Journal of Consumer Behaviour, Vol.7, No.4-5,(2008), pp. 293-302.
[9] Eser Z, Isin FB & Tolon M, "Perceptions of marketing academics, neurologists, and marketing professionals about neuromarketing", Journal of Marketing Management, Vol.27, No.7-8,(2011), pp. 854-868.
[10] Page G, "Scientific realism: What'neuromarketing'can and can't tell us about consumers", International Journal of Market Research, Vol.54, No.2,(2012), pp. 287-290.
[11] Otten LJ & Rugg MD, Interpreting event-related brain potentials, Event-related potentials: A methods handbook, MIT Press, Cambridge, (2005), pp. 3-16.
[12] Luck SJ, Ten simple rules for designing ERP experiments, Event-related potentials: A methods handbook, The MIT Press, London, England, (2005).
[13] Folstein JR & Van Petten C,"Influence of cognitive control and mismatch on the N2 component of the ERP: A review", Psychophysiology, Vol.45, No.1,(2008), pp. 152-170.
[14] dos Santos ROJ, de Oliveira JHC, Rocha JB & Giraldi JME, "Eye Tracking in Neuromarketing: A Research Agenda for Marketing Studies", International Journal of Psychological Studies, Vol.7, No.1,(2015), pp. 32.
[15] Vida, M, Turner J, Bulling A & Gellersen H, "Wearable Eye Tracking for mental health monitoring", Computer Communications, Vol.35, No.11,(2012), pp. 1306-1311.
[16] Fortunato VCR, Giraldi JME & de Oliveira JHC, "A review of studies on neuromarketing: Practical results, techniques, contributions and limitations", Journal of Management Research, Vol.6, No.2,(2014), pp. 201.
[17] Wang YJ & Minor MS, "Validity, reliability, and applicability of psychophysiological techniques in marketing research", Psychology & Marketing, Vol.25, No.2,(2008), pp. 197-232.
[18] Hoffman J, Event-related potentials and automatic and controlled processes, In Rohrbaugh JW & Parasuraman R, (Eds.), Event-related brain potentials: Basic issues and applications, Oxford University Press, New York, (1990), pp. 145-157.
[19]Balconi M & Mazza G, "Consciousness and emotion: ERP modulation and attentive vs. pre-attentive elaboration of emotional facial expressions by backward masking", Motivation and Emotion, Vol.33, No.2,(2009), pp. 113-124.
[20] Trezzi V & Balconi M, "Choice and preference. Neuropsychological, autonomic and cognitive measures in response to supraliminal/subliminal stimulation and emotional masking effect", PSYCHOFENIA, Vol.13, No.22,(2012), pp. 106-144.
[21] Wang JTY, Pupil dilation and Eye Tracking. A handbook of process tracing methods for decision research: A critical review and user's guide, Psychology Press, London, New York, (2011), pp. 185-204.