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ASIAN JOURNAL OF
SCIENCE AND TECHNOLOGY

ISSN: 0976-3376

Asian Journal of Science and Technology
Vol. 07, Issue, 05, pp.3006-3014, May, 2016

RESEARCH ARTICLE

VISUALIZATION OF COGNITIVE RESPONSE AND GAZE BEHAVIOR TO THE DISPLAY DESIGN OF VERTEX REARED AND VERTEX FRONTAL VIEW FROM AUTO DEALER'S ADVERTISEMENT

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ARTICLE INFO

Article History:
Received 16th February, 2016
Received in revised form
24th March, 2016
Accepted 17th April, 2016
Published online 30th May, 2016

Key words:
Visualization,
Event Related Potential (ERP), Vertex Reared Grouped (VRG), Vertex Frontal Grouped (VFG), Eye Tracking,
Neuromarketing.

ABSTRACT

To determine the cognitive function of consumers during advertisement is important in respect to different display design to improve the selling of product. Our previous studies were focused on lateral views, this time we aimed to detect the level of attention and gaze behavior on diverse display settings of auto advertising using the event related potential (ERP) and the eye tracking techniques among 15 healthy volunteers. The ERPs were done using 128-sensor net. Subjects pushed button '1' and '2' when see the 'Vertex Frontal Group/VFG' (face to face) view and the 'Vertex Reared Grouped/ VRG' (back to back) view respectively as early as possible. Building pictures were the neutral stimuli. Two subjects (out of 15) were participated for the 'Eye Tracking' to measure the fixation duration, pupil size and attention map of eye movement as a gaze behavioral response. The N100 and the P300 ERP components were analyzed at 19 electrodes sites. The higher amplitudes and the shorter latencies of the N100 and the P300 ERP components were found at most electrode positions during the VRG view compared to the VFG view when the VRG view acquired shorter reaction time. Gaze behavior results revealed that subjects had longer fixation duration and larger pupil size during the VRG view compared to the VFG view and also were more interested in silver color during the VRG view. The results of the ERP and the 'Eye Tracking' were consistent. We concluded that subjects had more visual searching perception, selective attention, and visual identification during display setting of the VRG view with color preferences.

INTRODUCTION

In recent years, neuromarketing has extended a great role in marketing. Different fields such as Neuroscience, Psychology, Social science, Economics, Sociology, and Mathematics etc. are now involved with marketing in order to improve the marketing field in various ways. Advertisement is one way among of them. The techniques of products advertisement are an important way to draw attention from consumers which is the vital to increase the probability of sales. However marketing is facing a difficult situation due to lack of charming advertisement and moreover there are lots of competitions among products (Engel, Blackwell, and Miniard, 1995). Conventional Marketing invested over $40 billion only for advertising to see the effectiveness of their investment.

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But the main problem of conventional marketing is that this method totally depends on consumers' willingness and capability (Morin, 2000) that means customers 'self reports'.This 'self report' is not actually cognitive function. Consumers 'self report' is one type of conscious report where behind of this conscious report there are some subconscious components, which is important to know about the real intention and attention of consumers to a product. These subconscious components of cognitive function can be explained in various ways. We can study the brain function during decision making situation using the field of Neuroeconomics and simply Neuromarketing is a division of Neuroeconomics (Kenning and Plassmann, 2005). Besides this, Neuromarketing is using Neuroscience technology to find out consumers internal, subconscious reaction to one product and their plan of buying products. Using neuroscience techniques, we can identify and understand customers' behaviors more easily as these techniques are directly reflect to the brain neuronal mechanism. To prevent marketing failure, dealers can increase the effectiveness of the advertisement using these neuronal results without relying subjective reports (Renvoiséand Morin, 2005). There are various types of neuroscience techniques such as magnetoencephalography (MEG), event related potential (ERP), functional magnetic resonance imaging (fMRI), electroencephalography (EEG), magnetic resonance imaging (MRI), positron emission tomography (PET), Eye Tracking etc that were applied in Neuromarketing research. ERP is one non-invasive technique where huge electrical activities of millions neuronal signals can be detected over the scalp. ERP is a time locked voltage fluctuated recording derived from on-going EEG and evoked of sensory, motor or cognitive processes (Friedman and Johnson, 2000; Friedman, Cycowicz, and Gaeta, 2001; Kuperberg, 2008). Electrodes are generally attached with scalp by gel or conduction solution.

During ERP, electrodes can measures electrical signal as voltage fluctuations which are generated by the brain in evoked condition. ERP can confine very small voltages that are generated in the brain in response of specific event or stimuli conditions with excellent temporal resolution. This temporal resolution investigated temporally in detail about the processes of underlying cognitive functions with early and late component. Early components reflect sensory processing and late components reflect higher cognitive processing (Woodman and Luck, 2003). ERPs consist of positive and negative deflections that are usually called ERP components. The ERP components are two types; exogenous and endogenous. The early components are exogenous and they reflect of the physical parameters of the stimuli within first 100 milliseconds after stimuli. On the other hand, late component is the endogenous and they reflect information processing (Sur andSinha, 2009). Therefore to evaluate the exogenous and endogenous both information, we used ERP techniques with analyzing early component, the N100 and late component, the P300 ERP components.

Eye Tracking is the Neuroscience method that was also used in previous research to determine the outcome of marketing stimuli. In this method, visual attention and visual behaviors can be measured through the gaze point and pupil dilation (Zurawicki, 2010). Eye fixation time is longer and at the same time pupil dilation is also larger during giving more attention and emotion to an object (Nielsen andPermice, 2009; Wang, 2011). Besides this, visual behaviors can be analyzed in real-time by monitoring the fixation points in images (Hansen andJi, 2010). Moreover, Eye Tracking and cognitive processes are closely related (Jacob andKarn, 2003). Person can be cognitively processed when long time observation to the words or images. This is called fixation duration, and gaze direction indicated focus of attention (Petersen and Posner, 2012). Even certain point of interest also can be detected in the images by Eye Tracking technique (Zhao and Koch, 2013). Therefore, Eye Tracking method gives us more relevant information about pattern of visual fixation which is related with attention even from different marketing issues (Piqueras-Fiszman, Velasco, Salgado-Montejo, and Spence, 2013). Our prior studies were focused on lateral views (Samsuri, 2016a and 2016b), in this study, we aimed to determine the level of attention among consumers during ‘face to face’ and ‘back to back’ car display design by using both the ERP and the Eye Tracking study which information would be more effective during advertisement.

MATERILS AND METHODS

Ethical approval was obtained from the local Ethical Committee of Universiti Sains Malaysia. Participants signed in the written inform consent form before starting experiment. All data were kept as private and confidential. In total, 15 healthy subjects with age of 22.73±1.71 (mean±SD) (years) were recruited. Nine (9) of them were female and six (6) were male. Subjects with right-handed were 11 and left-handed were four (4). Without these, nine (9) of the subjects were Chinese, four (4) were Malay and two (2) were Indian.

ERP study

Stimuli

Visual oddball paradigm was used for the ERP study where the car pictures and traditional building images (neutral stimuli) were used as target and standard stimuli, respectively. Car pictures were collected from internet which was open source and there was no mark of copyright restriction. This study composed of 60 grouped pictures of Vertex Reared Grouped view (VRG, back to back display) and Vertex Frontal Grouped View (VFG, face to face display) and considered pseudo randomly in three categories according to transposition of cars respective to its color (e.g in one picture if red colored car is on the top, in other picture it would be in the middle and so on). Each grouped picture contained six cars in different six colors (Blue Lagoon, Genetic Silver, Solid White, Tranquility Black, Elegant Brown and Fire Red). All the pictures were bitmap image with the size of 2.91MB and with the dimension (1150 width × 885 heights) of pixels. The stimuli were presented on a 22” LCD computer which was approximately 80 cm away from the subject. The stimuli were presented by E-prime software version 2.8(Psychology Software Tools, Inc., Sharpsburg, Pennsylvania, USA), 128 channels HydroCell Geodesic Sensor Net (GSN) was used for EEG/ERP recording.

ERP Study

Subjects were instructed to press button ‘1’ when see the Vertex Frontal Grouped (VFG) (face to face) view of the car and press button ‘2’ when see the Vertex Reared Grouped (VRG) (back to back) view of the car as quickly and as correctly as possible. Subjects were instructed not to press any button when see pictures of building (neutral stimulus). The session began with fixation (+) point and followed by the stimulus for 1.5 sec. Stimuli were presented in random order at interstimulus intervals (ISI) 3 sec. Figure 1 illustrated the experimental paradigm of stimulus and task procedure of this study.

Eye Tracking

SensoMotoric Instruments (SMI) experiment Center software was used for stimulation of video as (.avi) format which was 60 sec duration. The stimulus was then synchronized with the iView System.The camera and illumination unit was mounted on the mounting rack. Camera was placed centrally aligned in front of the subject’s eye. The distance between subject’s eye and camera was between 100- 180 cm.

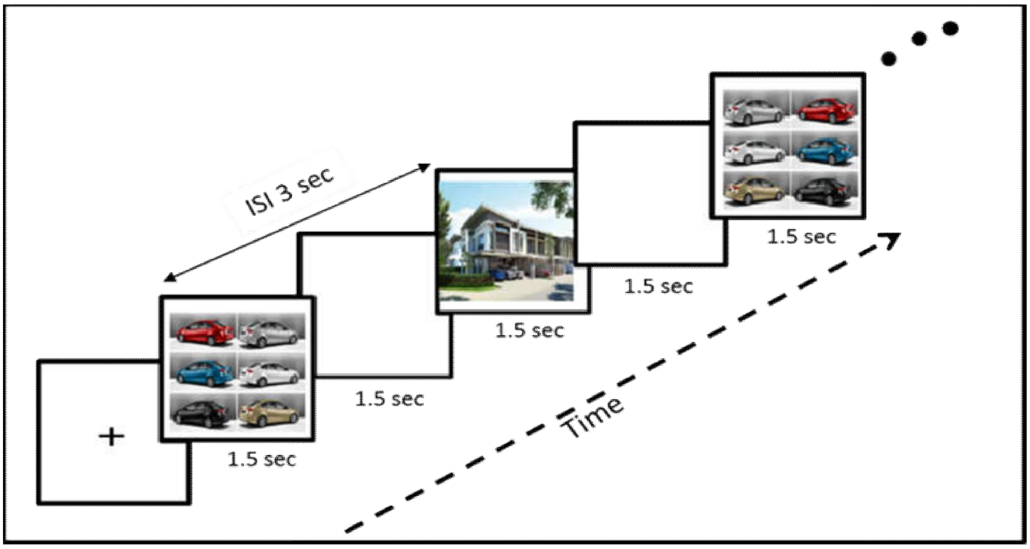

Fig. 1. Experimental paradigm showed visual stimuli represented as 'Vertex Reared Grouped View: VRG' (back to back) and 'Vertex Frontal Grouped View: VFG' (face to face) auto views with neutral pictures (pictures of building)

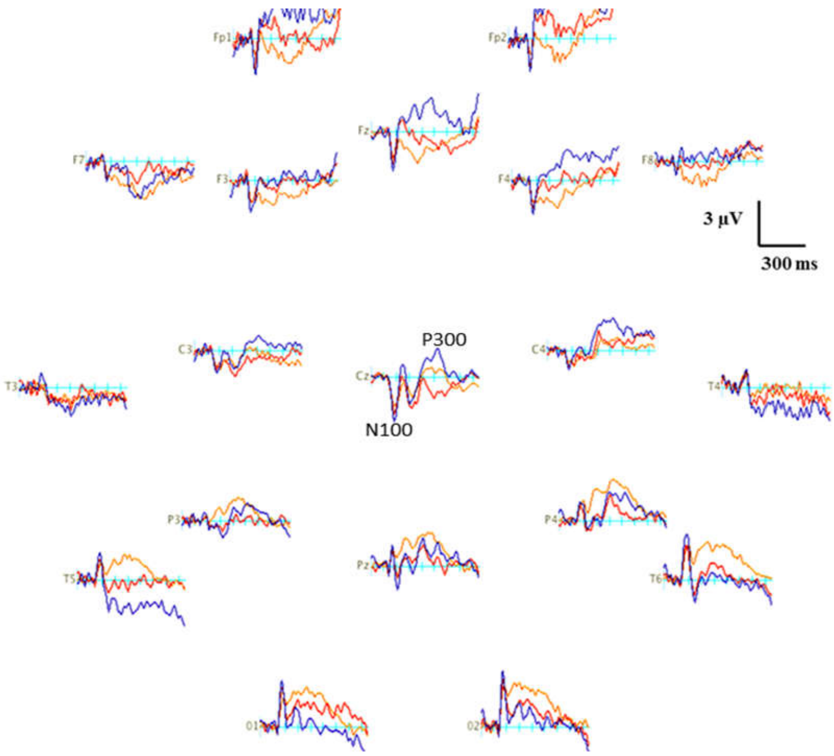

Fig. 2. Grand average waveform of the N100 and the P300 ERP components (representative at middle) at 19 scalp sites during the display design of the Vertex Reared Grouped View (VRG) (blue line), the Vertex Frontal Grouped (VFG) View (red line) and the Neutral (orange line) picture presentation in this study

The eye and illumination camera was correctly adjusted till the eye is focused and both cross hairs of pupil and cornea reflex were visible. Calibration was then set-up to 9 point with corner correction. The stimulus was presented to the subject on computer monitor. Subject was told to look at the pictures in the video presented. Data was recorded when the stimulus was presented. The output from the system was then loaded to SMI Behavioral and Gaze Analysis Program (BeGaze). BeGaze provided various data views to analyze gaze data included Custom Trial Selector, AOI Editor, Semantic Gaze Mapping, Gaze Replay, Bee Swarm, Scan Path, Focus Map, Heat Map, Key Performance Indicators, Gridded AOIs, AOI Sequence Chart, Binning Chart, Event Statistics Line Graph.

Data analysis

Net Station software 5.2 (Electrical Geodesics, Inc., Eugene, OR, USA) was used to obtain the value of the amplitudes and latencies of the N100 and the P300 ERP components. Data was filtered with 0.03-30 Hz with sampling rate of 250 Hz. Eye movement (>40 µV), eye blink (>70 µV) and movement artifact (>70 µV) were detected and removed by artifact detection method using Net Station software. Data was segmented from (-100) ms to 800 ms. Baseline was corrected at 100 ms before stimulation. Normality test was done by 'Kurtosis and skewness' before testing significance level. To see significance level, we used one way-ANOVA test for the amplitudes and latencies of the N100 and the P300 components and independent t-test was used in case of reaction time using Statistical Package for Social Sciences (SPSS) version 22.0 software.

RESULTS

Grand average waveforms of the N100 and the P300 ERP components were shown in Figure 2 at 19 electrode channels (Fz, Cz, Pz, Fp1, Fp2, F3, F4, F7, F8, C3, C4, T3, T4, T5, T6, P3, P4, O1 and O2) in 15 subjects during this neuro marketing study.

Amplitudes and Latencies of the N100 ERP Component

The N100 ERP component were evoked and identified during this study. One way ANOVA analysis discovered that the mean N100 amplitude for the three display settings (VRG, VFG and Neutral) have significant difference. Post-hoc multiple comparisons indicated that the mean N100 amplitude for the VRG view was significantly increased compared to the other two stimuli at four scalp sites, Fp2 [F (2, 42) =3.451, P=0.041], F4 [F (2, 42) = 4.17, P=0.02], C4 [F (2, 42) = 3.22, P= 0.05] and T3 [F (2, 42) = 3.22, P= 0.05]. Moreover, the mean N100 amplitude for the VFG group was not significantly different from either the VRG or the Neutral group.

However, overall significant and non-significant higher amplitudes of the N100 component were observed at all sites except F3 and T4 during the VRG view compared with the VFG view. F3 and T4 evoked non-significant higher amplitudes of the N100 component during the VFG view compared with the VRG view (Table 1). Besides this, the VRG view evoked significant (F7, F8) and non-significant (Cz, T4) shorter latencies of N100 component compared to the neutral stimuli where mostfronto-central (Fz, Pz, Fp1, Fp2, F3, F4, C3, C4, T3, T5) sites showed non-significant shorter latencies of the VFG view compared with the neutral stimuli. Significant group effects were observed at Pz [F (2, 42) = 3.933, P =0.03], F7 [F (2, 42) = 3.98, P =0.03] and F8 [F (2, 42) = 3.77, P =0.03] areas. Temporo-parieto-occipital (T6, P3, P4, O1, O2) areas evoked shortest latencies of the N100 component during the neutral picture compared with the other two views. However, the VRG view evoked shorter latency of N100 component at Cz, F7, F8, T4 and T6 areas compared with the VFG view (Table 1).

Amplitudes and Latencies of the P300 ERP Component

With the N100 component, the P300 ERP component also evoked and identified during this study. One way ANOVA study revealed that considerable differences among the mean P300 amplitude for the three display design (VRG, VFG and Neutral).

Table 1. Amplitudes and latencies of the N100 ERP component (mean±SD)

Sites	VRG view (mean ± SD)	VFG view (mean ± SD)	Neutral (mean ± SD)	F (df)	P	*Significance*
N100 ERP Component Amplitudes (in µV) (mean±SD)						
Fz	1.37±1.18	1.35±1.52	.523±.384	2.17(2,42)	.127	NS
Cz	0.66±0.49	0.62±0.61	0.43±0.29	0.91(2,42)	0.41	NS
Pz	2.25±1.98	1.67±1.37	1.82±1.28	0.54(2,42)	0.59	NS
Fp1	2.64±2.36	2.09±2.03	1.20±1.07	2.171(2,42)	.127	NS
Fp2	3.09±2.17	2.59±2.49	1.22±1.12	3.451(2,42)	*0.041*	S
F3	0.99±0.88	1.18±1.36	0.5±0.53	1.88(2,42)	0.17	NS
F4	1.18±0.98	0.72±0.79	0.37±0.43	4.17(2,42)	*0.02*	S
F7	1.36±1.16	0.88±0.87	0.6±0.77	2.42(2,42)	0.1	NS
F8	1.87±1.54	1.4±1.61	0.78±1.75	1.65(2,42)	0.2	NS
C3	0.61±0.57	0.51±0.69	0.29±0.32	1.35(2,42)	0.27	NS
C4	0.99±1	0.61±0.83	0.28±0.22	3.22(2,42)	*0.05*	S
T3	2.58±2.42	1.39±1.35	1.1±0.94	3.22(2,42)	*0.05*	S
T4	2.19±1.32	2.31±2.06	1.76±1.87	0.40(2,42)	0.68	NS
T5	2.95±2.01	2.44±2.1	2.03±1.57	0.86(2,42)	0.43	NS
T6	3.96±2.23	3.13±1.85	3.08±1.7	0.97(2,42)	0.39	NS
P3	1.4±1.18	1.11±0.89	0.98±0.84	0.72(2,42)	0.49	NS
P4	2.33±1.48	1.76±1.21	1.93±1.28	0.74(2,42)	0.49	NS
O1	4.15±3.65	3.73±2.61	2.7±1.84	1.05(2,42)	0.36	NS
O2	5.03±3.32	3.96±2.64	3.73±2.53	0.89(2,42)	0.42	NS
N100 ERP Component Latencies (in ms) (mean±SD)						
Fz	120.2±10.63	115.7±20.86	122.1±15.91	0.61(2,42)	0.55	NS
Cz	129.3±17.47	129.8±23.85	135.7±18.54	0.47(2,42)	0.63	NS
Pz	137.3±26.34	114.6±34.92	107.7±28.78	3.93(2,42)	*0.03*	S
Fp1	122.6±12.79	114.6±17.86	120±19.65	0.86(2,42)	0.43	NS
Fp2	121.8±9.425	116.2±17.72	122.1±15.18	0.78(2,42)	0.47	NS
F3	125.3±16.4	114.1±19.87	124±19.53	1.61(2,42)	0.21	NS
F4	121.6±12.17	117.6±20.55	132.8±20.96	2.77(2,42)	0.07	NS
F7	117.3±18.24	119.4±22.51	136.5±20.33	3.98(2,42)	*0.03*	S
F8	111.4±13.34	114.9±20.47	129.3±21.78	3.77(2,42)	*0.03*	S
C3	124.5±18	121.6±24.97	133±22.19	1.11(2,42)	0.34	NS
C4	123.7±20.47	122.4±26.56	134.4±21.79	1.22(2,42)	0.31	NS
T3	119.2±27.84	113.8±29.03	121.8±22.92	0.35(2,42)	0.71	NS
T4	100.8±23.81	104.2±26.81	114.4±28.15	1.08(2,42)	0.35	NS
T5	120.8±35.39	106.9±32.82	114.6±30.97	0.66(2,42)	0.52	NS
T6	93.6±25.55	103.4±31.95	90.4±17.61	1.05(2,42)	0.36	NS
P3	133±31.54	113±28.94	109.8±29.81	2.61(2,42)	0.09	NS
P4	113.6±32.27	111.7±31.18	95.4±20.5	1.84(2,42)	0.17	NS
O1	121.3±34.76	102.13±31.49	99.4±26.57	2.20(2,42)	0.12	NS
O2	111.7±33.13	103.4±31.88	93.6±21.74	1.43(2,42)	0.25	NS

Note: ns: non-significant, n: significant, p<=.05

Table 2. Amplitudes and latencies of P300 ERP component (mean± SD)

Sites	VRG view (mean ± SD)	VFG view (mean ± SD)	Neutral pic (mean ± SD)	F (df)	P	*Significance*
		P300 ERP Component Amplitudes (in µV) (mean±SD)				
Fz	5.22±3.82	2.62±2.16	1.61±1.29	7.44(2,42)	*0.002*	S
Cz	3.73±2.24	1.98±1.67	2.23±2.09	3.29(2,42)	*0.05*	S
Pz	4.12±2.44	2.88±2.35	3.17±1.91	1.24(2,42)	0.3	NS
Fp1	7.69±6.63	4.55±3.14	3.11±2.43	4.13(2,42)	0.02	S
Fp2	8.97±6.01	5.93±4.39	4.13±3.63	3.92(2,42)	0.03	S
F3	3.05±1.69	2.86±2.38	1.73±1.5	2.14(2,42)	0.13	NS
F4	4.61±2.73	3.21±2.23	1.81±1.27	6.25(2,42)	*0.004*	S
F7	2.49±1.4	2.05±1.8	1.85±1.38	0.67(2,42)	0.52	NS
F8	3.77±3.3	3.37±3.15	1.56±1.52	2.69(2,42)	0.08	NS
C3	2.86±1.91	1.69±1.51	1.5±1.21	3.29(2,42)	*0.05*	S
C4	3.87±1.86	2.83±2.52	2.06±1.36	3.18(2,42)	0.05	NS
T3	2.65±2.32	2.16±1.45	1.45±1.24	1.82(2,42)	0.18	NS
T4	2.88±2.06	2.33±2.31	2.01±1.65	0.70(2,42)	0.5	NS
T5	2.1±1.62	2.08±1.14	2.75±1.82	0.91(2,42)	0.41	NS
T6	2.451.89±	2.55±2.02	3.43±2.02	1.12(2,42)	0.34	NS
P3	2.93±1.96	2.1±1.52	2.39±1.7	088(2,42)	0.42	NS
P4	3.85±1.84	2.81±1.95	3.65±2	1.21(2,42)	0.31	NS
O1	3.44±2.45	3.67±2.29	3.73±2.09	0.07(2,42)	0.94	NS
O2	3.48±3.09	3.74±2.5	3.96±2.71	0.11(2,42)	0.9	NS
		P300 ERP Component Latencies (in ms) (mean±SD)				
Fz	448.5±116.7	503.2±157.3	591.2±133	4.16(2,42)	*0.02*	S
Cz	478.6±117	532.2±145.9	480.2±113.7	0.87(2,42)	0.43	NS
Pz	450.6±116.5	438.4±115	413±86.6	0.48(2,42)	0.62	NS
Fp1	492.8±141.7	470.4±150.8	586.1±148.1	2.62(2,42)	0.09	NS
Fp2	461±138	523.7±169.8	555.7±139.7	1.55(2,42)	0.23	NS
F3	542.4±113	468±138.8	563.2±152.4	2.04(2,42)	0.14	NS
F4	475.7±130.5	478.4±163.4	555.7±133.9	1.51(2,42)	0.23	NS
F7	530.6±153.9	479.4±120.7	542.1±140.2	0.87(2,42)	0.43	NS
F8	508±142.7	560±143.1	568.5±131.4	0.83(2,42)	0.44	NS
C3	482.1±116.2	486.4±134.4	458.9±92.58	0.25(2,42)	0.78	NS
C4	483.7±111.1	466.1±144.1	530.4±124.3	1.02(2,42)	0.37	NS
T3	520.2±109.1	483.2±142.8	509.3±135.2	0.32(2,42)	0.73	NS
T4	479.4±124.2	462.1±141.2	494.4±118.7	0.24(2,42)	0.79	NS
T5	513.8±118.6	446.9±118	408±97.68	3.43(2,42)	*0.04*	S
T6	417.8±134.5	413.8±111.1	382.6±77.15	0.46(2,42)	0.64	NS
P3	463.2±113.4	461±127.3	414.4±70.97	1.00(2,42)	0.38	NS
P4	422.4±85.96	430.9±125.2	389.3±62.47	0.81(2,42)	0.45	NS
O1	477.6±137.6	484.2±138.5	361.3±58.91	5.17(2,42)	*0.01*	S
O2	426.9±137	450.4±118.9	392.5±99.32	0.89(2,42)	0.42	NS

Note: ns: non-significant, n: significant, p<=.05

Post-hoc multiple comparisons using Bonferronitest indicated that the mean P300 amplitude for the VRG view was remarkably increased compared with the neutral display at six scalp sites, Fz [F (2, 42) = 744, P= 0.00], Cz [F (2, 42) = 3.293, P=0.05], Fp1 [F (2, 42) = 4.13, P= 0.02], Fp2 [F (2, 42) = 3.92, P=0.03], F4 [F (2, 42) = 6.25, P=0.004] and C3 [F (2, 42) = 3.29, P= 0.05]. But the mean P300 amplitude for the VFG view was not significantly different from either the VRG or the Neutral.

However, overall significant and non-significant higher amplitudes of the P300 component were found at all sites except at T5, T6, O1 and O2 during the VRG view compared with the VFG view. T5, T6, O1 and O2 evoked non-significant higher amplitudes of the P300 during Neutral. But in case of the P300 component latency, few areas evoked significant (Fz) and non-significant (Cz, Fp2, F4, F8) shorter latencies during the VRG view compared with other two views. Significant group effects were observed at Fz [F (2, 42) = 4.16, P=0.02] during the VRG view, whereas at T5 [F (2, 42) = 3.43, P=0.04] and O1 [F (2, 42) = 5.17, P=0.01] during the Neutral. Eight electrode positions (Fz, Cz, F4, F8, C3, P4, O1 and O2) evoked shorter latencies of the P300 component during the VRG view compared to the VFG view (Table 2).

Reaction Time

The mean reaction time (mean±SD) (in ms) for the VFG view (598.4±207.9) was longer than the VRG view (592.4±207.6). The results of Independent t-test showed that the differences of reaction time between the VFG and the VRG views was not statistically significant (P=0.757, 95%, CI: -32.43, 44.57) (Figure 3, Table 3).

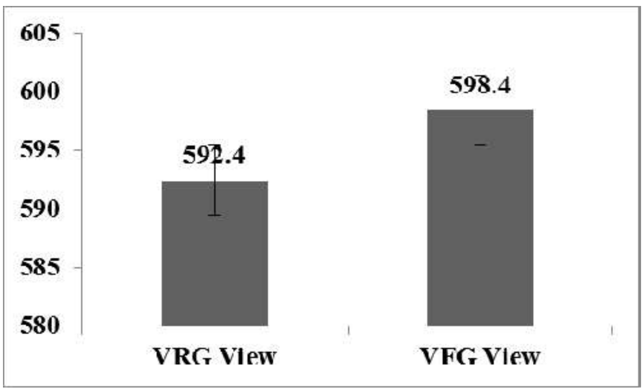

Fig. 3. Reaction time during the VRG view and the VFG view

Table 3. Feedback status of the the VRG view and the VFG view

Variables	Feedback			Total
	Correct	Incorrect	No Response	
VFG view	209	10	6	225
	E = 213	E = 6.5	E = 5.5	
VRG view	217	3	5	225
	E = 213	E = 6.5	E = 5.5	
Total	426	13	11	450

There was no significant association between view and feedback status using Pearson Chi-square test (P=0.135). However, the bar chart indicated higher corrects, lower incorrect and lower no response feedback during the VRG view compared with the VFG view (Figure 4, Table 3).

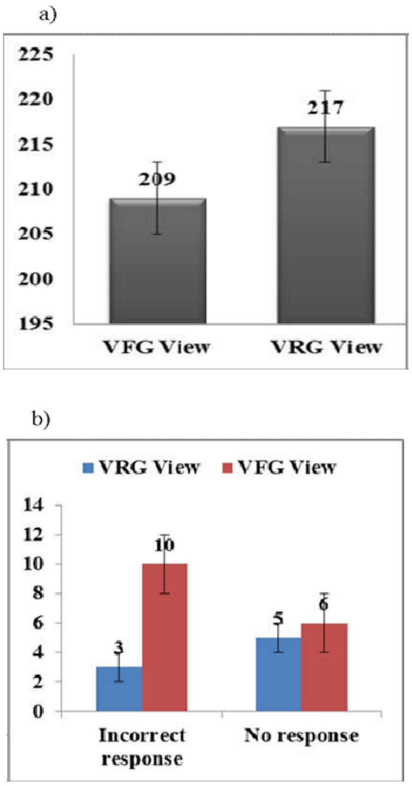

Fig. 4. Correct (a), incorrect and no response (b) feedback status of the VRG and the VFG view. I- sign indicates error bars with of standard error

Eye tracking – case studies

Fixation Duration and pupil size

The Area of Interest (AOI) was observed by measuring fixation duration time and size of the pupil. Both subject 1 and 2 showed longer fixation time (mean±SD) (714.2±501.7 and199.0±0.0, respectively) and larger pupil size(50.72±1.468 and 34.70±0.00, respectively)for silver AOI compared to the other AOI during the VRG view(Figure 5).Both subjects revealed longer fixation time (mean±SD) (582.2±762.2 and 140.4±62.78, respectively) and larger pupil size (49.40±0.959 and 33.70 ± 2.688, respectively) for elegant brown AOI compared to the other AOI during the VFG view (Figure 5)

Attention Maps (Heat map and Focus map)

The Focus Map showed gaze patterns over the stimuli images which were visualized as a transparent map. With the Focus Map data view, gaze patterns were visualized by altering the transparency of the stimulus display based on the amount of attention received. The Gaze patterns reflected as a color map in Heat map analysis. Colors can be changed according to the amount of attention to the design. The mapping of heat map focused on the hot spot which means more fixated points. Higher fixated areas were shown with red, less with yellow and the least with green. Figure 6 showed attention maps during display design of the VRG view and the VFG view. The analysis of focus map and heat map revealed that subject 1 received more amount of gaze during display design of the VRG view while subject 2received unpredictable amount of gaze.

DISCUSSION

In this study, we aimed to detect attention level of the cognitive function during different display design of the car in the face to face (VFG) and the back to back (VRG) car views by using the ERP and the eye tracking (gaze behavior) study. Here display designs of interest were the VRG view and the VFG view. Higher amplitude of the N100 and the P300 ERP component at most sites and shorter latencies at few sites were found during display design of the VRG view compared to the VFG view. Subjects took shorter (reaction) time during VRG view for the selection of this display. The Eye tracking results revealed that both subjects indicated common interest in silver color during the display design of the VRG view and elegant brown color during the display setting of the VFG view. More visual attention were detected in both subjects during display design of the VRG view compared with the VFG view as the VRG view indicated longer fixation duration and larger pupil size which was revealed by gaze behavior data analysis. Both the ERP and the gaze behavior data showed consistent results that subjects were more attentive to the display design of the VRG view compared with the VFG view. The N100 ERP component usually reflected of selective attention, early selection for later pattern recognition and intended bias processing (Vogel and Luck, 2000; Key, Dove, and Maguire, 2005).

The visual N100 ERP component is observed over the occipital area (Hopf, Vogel, Woodman, Heinze, and Luck, 2002), which is consistent with our results as the amplitudes of the N100 at O1 and O2 were the highest compared to the other electrode sites (Table 1). The amplitude and latency of the N100 component rely on the stimulus modality (Key, Dove, and Maguire, 2005). The amplitudes of the N100 component is larger during more attention compared to the least attention or neutral stimuli (Luck *et al*., 1994; Luck and Yard, 1995; Vogel and Luck, 2000). The facilitated amplitude is explained as the enhanced processing of the attended area (Luck, 1995; Coull, 1998) which is the unique properties of the stimuli (Mangun, Hillyard, and Luck, 1993). Moreover, stimulus angularity and luminance can directly influence on the amplitude of the N100 ERP (Johannes, Münte, Heinze, and Mangun, 1995; Ito *et al*., 1999). We found more visual selective attention during the visual presentation of the VRG view as they attended more to the VRG view stimulus and hence produced higher N100 amplitude during the visual presentation of the VRG view compared with the VFG view at most scalp sites. The longer latency of the N100 was due to the complexity to process the stimulus. One of the reasons which manipulate the latency of the N100 is the processing effort (Callaway and Halliday, 1982).

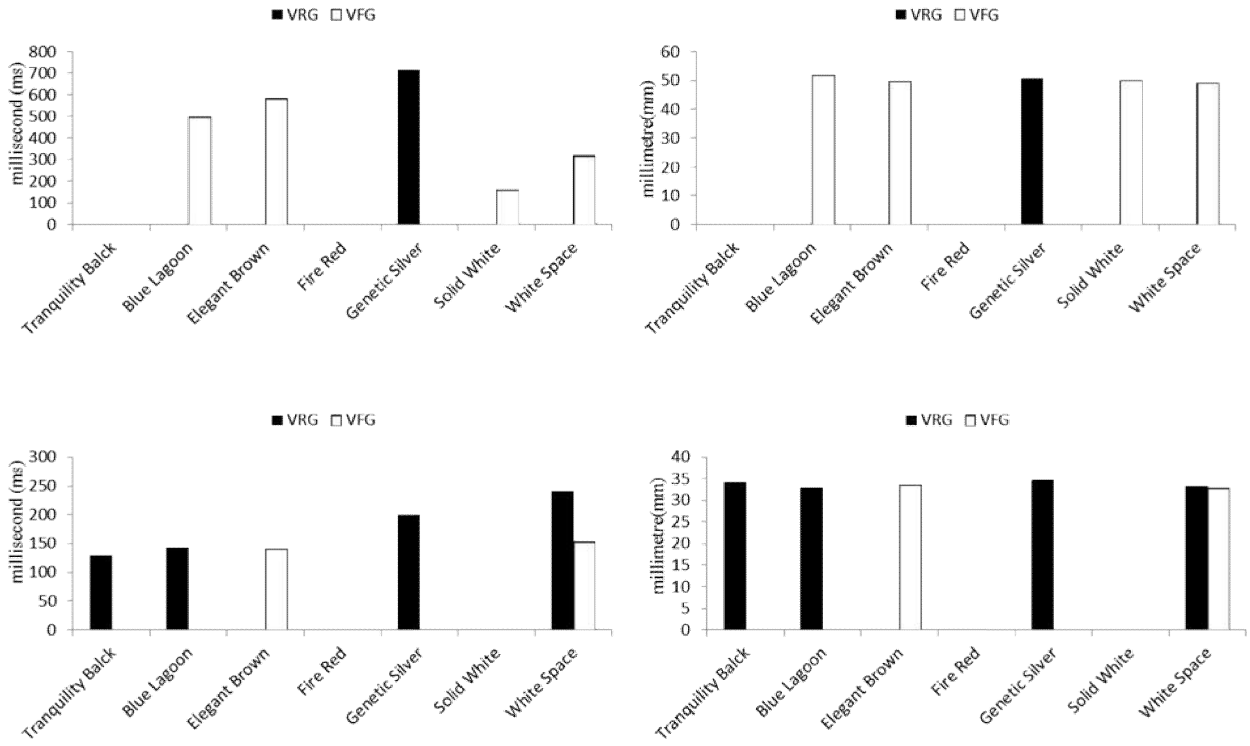

Fig. 5. Eye tracking data of Area of Interest (AOI) fixation time in millisecond (left panel) and Pupil size in millimetre (right panel) during the Vertex Reared Grouped (VRG, black bar) and the Vertex Frontal Grouped (VFG, white bar) viewing from Subject 1 (upper panel) and Subject 2 (lower panel)

The latency required longer time when giving more attention or effort to the complex or difficult task. In our case we assume that subjects did not give more effort to the VRG view as we found significant shorter latency during this view compared to the VFG view (Table 1). Subjects could pay attention easily as they liked to choose the VRG view of the car. The tendency of higher amplitude of the P300 ERP component at most sites and significant shorter latencies at few sites for the display design of the VRG view indicated that subjects had additional visual cognitive processing in decision making during the visual arrangement of the VRG view as compared to the VFG view. In general the P300 revealed cognitive processing and particularly reflected working memory processes (Polich, 2003). However, higher amplitudes of the P300 component reflected greater attention which means the stimulus information and shorter latency specified higher mental performance (Sur and Sinha, 2009). The amplitude of P300 is affected by attention (Strandburg *et al*., 1996; Overtoom *et al*., 1998), stimulus probability, stimulus relevance, the amount of processing resources available, the quality of selection (Johnstone, Barry, Anderson, and Coyle, 1996) and attention allocation (Jonkman *et al*., 2000). Subjects had extra visual cognitive processing during decision making to the visual presentation of the VRG view as compared to the VFG view as the VRG view stimuli were selected by the brain for continuous attentive processing. Hence, higher amplitude of the P300 ERP component at most sites was produced. By supporting the previous researches (Sur and Sinha, 2009; Strandburg *et al*., 1996; Overtoom *et al*., 1998) we also can say that subjects had greater attention with higher mental performance during choosing of the VRG view of the car which indicated subjects' higher cognitive and working memory function (Polich, 2003).

Latency of the P300 component was reported which was variable due to complexity of stimuli (McCarthy and Donchin, 1981), effectiveness of selection (Taylor, Sunohara, Khan, and Malone, 1997) and continuous attention (Strandburg *et al*., 1996). The longer latencies of the P300 at most sites for display design of the VRG view reflected stimulus complexity, effectiveness of selection or sustained attention. Significant shorter latency of the P300 on that case proved that subjects had less effort during selection of the VRG view. Although not statistically significant, the mean reaction time during the VRG view was shorter compared to the VFG view (Figure 3, Table 3). The reaction time is the interval time between presentation of stimuli and the voluntary response of the subjects (Jain, 2012; Ghuntla, Mehta, Gokhale, and Shah, 2014). Usually reaction time was expressed as milliseconds which are counted as the speed of flow of neurophysiological, cognitive and information processes (Baayen, and Milin, 2015). By this physiological parameter we can study about people's central information processing speed and the coordinated peripheral movement response (Batra *et al*., 2014; Balakrishnan *et al*., 2014). Taking all these points from the previous researches we can explain our result that, subject responded more quickly during stimulus presentation of VRG view compared to VFG view, this reflected fast processing information during the VRG view compared to the VFG view. Gaze behavior results indicated that visual attention was more during display design of the VRG view compared to the VFG view as the VRG view indicated longer fixation duration and larger pupil size. The application of the Eye Tracking method allowed us to measure fixation place (looking at the same place for a while) and pupil size (pupil dilation responses) which were related to the information on the screen and behavioral choices during an experiment.

Fig. 6. Eye tracking data of Attention maps (left and right panels are heat and focus map respectively) during display design of the VRG (upper four panels) and the VFG (lower four panels) view from subject 1 and subject 2

As the longer fixation duration and larger pupil size indicated more attention and emotion to the object (Nielsen andPermice, 2009; Wang, 2011), our data from Eye Tracking technique explained about human behavior such as subjects highlighting the focal points of attention and gaze behavioral patterns of navigations more towards display design of the VRG view compared to the VFG view. Gaze behaviors of both subjects showed common interest in silver color during display design of the VRG view, while gaze behaviors during display design of the VFG view showed common interest in gold color during display design of the VFG view (Figure 5).

Eye Tracking data were able to provided additional informational such as the color of interest. The focus map and heat map during display design of the VRG view and the VFG view for subject 1 indicated amount of gaze received was more to the vertex rear view of the car. While the focus map and heat map during display design of the VRG view and the VFG view for subject 2 indicated unpredictable amount of gaze (Figure 6). The ERP and gaze behaviors data showed consistent results that subjects were more attentive to the display setting of the VRG view compared to the VFG view.

Conclusion

This study focused to detect the level of attention among buyers on the different display design of the car using the ERP and the eye tracking procedure to explore effective automotive advertisements. Advertising is the most crucial part for automotive industries which would be more effective to get customer's attention to their product. The price for advertisement depends on the space or dimension or placement of the advertisement. Hence, marketers need to wisely use this space or placement for cost-effective. Angularity, geometric and color were factors that affect attention towards display design. For cost-effective and limited space advertising, marketers could design their advertisement based from the findings from this study. Between the VRG view and the VFG view, it is advisable that marketers prioritize display design of the VRG view as subjects were more attentive to angularity, volume and geometric features of the VRG view.

Acknowledgment

This work was supported by Short term grant (ref.304/PPSP/61311092) and RUI grant (ref. 1001/PPSP/812188) of Universiti Sains Malaysia (USM) for the authors T.B and N.Y respectively.

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