

Original Research Article

Title:

Enhanced Cognitive Function in Higher Education: A colour stimuli ERP Study

Running title: Educational influence on colour.

ABSTRACT

Background: Higher education directly related to the higher cognitive function. There is lack of information about educational influence on different colours. We investigated educational influences on different colours using event related potential (ERP) study.

Method: 128-sensor net was used for ERP study on low (G1), medium (G2) and high (G3) educational groups. N= 17 in each group. Participants were asked to press button '1' when like and press '2' when dislike the colours. Reaction times (RTs), the amplitudes and latencies of the N200 and the P300 ERP components were analysed in these three groups.

Results: The values of the mean differences of the like and the dislike choice were calculated in case of the amplitudes and the latencies for both components. Seven electrode locations showed clear of expression of the N200 and the P300 components. The G3 evoked significantly higher (at T6) amplitudes of the N200 and the P300 components and also non significantly at other most of the channel where the G1 evoked non-significantly shorter amplitudes at most of the locations. The G3 showed non significantly smaller and the G1 showed longer latencies for both of the components. RTs were significantly shorter in the G3, then the G2 and the G1 reflected significantly longer RTs.

Conclusion: We concluded that low education group has lack of attention, cognitive function, and longer processing time due to lack of higher brain level connection in case of different

colour perception. Eventually, Higher education improves attention and cognitive function by improving higher level of connection which is important for the quality of life.

Keywords: Colours, stimuli, N200, P300, education, cognitive function.

1. INTRODUCTION

Education developed our skills, knowledge in any aspects, mainly problem solving skills and other cognitive functions [1, 2] by improving brain's ability [3, 4]. Higher education reflects on the higher cognitive functions [5] but it can be declined in elderly [6]. Influence of the various educational levels on theta [7], delta [8], and on the different shapes and their arrangements [5, 9] were investigated previously. Still there is no study to investigate the influence of the various educational levels on different colours.

In medical fields, different types of colours were used to assess the cognitive function for the diagnostic purposes [10, 11] which are important for the therapeutic plans for the patients. There are different types of neuropsychology tests related colours. The Weigl Colour-Form Sorting Test, Wisconsin Card Sorting Test, Stroop Test etc are frequently used for the neuropsychology assessment among psychiatric patients, memory disorder patients, Parkinson disease etc [12, 13, 14]. Using different colours, Ishihara chart can detect the impairment of colour perception of the patients [15, 16]. Colour can be used as a therapy among cancer patients also [17, 18]. Patients come from different educational backgrounds. On that basis, the results of neuropsychology tests might be variable depending on the educational levels which carried to the different management strategy. Therefore it is important to investigate the educational influence on the different colours.

We used event related potential (ERP) study to explore the educational influence on the colours in the human brain. ERP signal can measure directly the neural activity in a specific event [19, 20]. The recorded signal is mainly influenced electrical field of the head scalp which comes from the current of the extracellular regions [21, 22], and they are reflected as the ERP components. The N200 ERP component is a negative going waveform that evoked 200-350 ms of post-stimulus and reflects executive cognitive function [23]. The N200 has subcomponents of *N2a*, *N2b*, *N2pc* which reflects mainly occipital-temporal regions. The P300 ERP component is the positive deflection and usually range from 250 ms to 900 ms where typically evoked during 300-400 ms²⁴ and reflects at Cz and Pz areas [25]. The N200 and the P300 ERP components are related with cognitive function [23]. Therefore we analyzed these two components to assess visual cognitive function; and there is a lack of the information of educational influence on different colour stimuli in human brain on electrophysiology level. The aim of this study is to investigate the influence of education on different colours in low, medium and high educational groups with using ERP study.

2. METHODS

2.1 Ethical Permission

We achieved ethical permission from ethical committee of Universiti Sains Malaysia (USM) (USMKK/PPP/JEPeM (232.3(8))).

2.2 Study population

Sample size was calculated by one statistician using Power and Sample size (PS) software. Participants were recruited with e-mail advertisement, personal communication and/or internet. Subjects were grouped as low (G1), medium (G2) and high (G3) educational groups based on their highest educational level (n= 17 in each group). Educational groups were according to Malaysian educational system. Low educational group was completed SPM

(Sijil Pelajaran Malaysia), medium educational group completed STP (Sijil Tinggi Pelajaran Malaysia) and high educational group completed Diploma, Degree, Masters, PhD etc.

2.3 ERP stimuli and recording

ERP was done in MEG/ERP laboratory at Hospital Universiti Sains Malaysia (HUSM). ERP was recorded in a dimly lit, electrically shielded and sound treated room. Subjects were comfortably seated in ERP room with a 22" LCD computer placed at a 1 m away of distance. Different colour stimuli were presented using E-prime software (v 2.0 software (Psychology Software Tools, Inc., Sharpsburg, Pennsylvania, USA). ERP recording was done with 128-channel sensor net. 20 different colours were used as stimuli (13×17 cm) which were presented randomly on a white background for 1.4 s with 1.0 s inter-stimulus interval (ISI). Experimental paradigm was shown in Figure 1. Subjects were instructed to push 'button 1' if like and push 'button 2' if dislike. All data was recorded in Net-Station software 5.2 (Electrical Geodesics, Inc., Eugene, OR, USA).

2.4 Data analysis

Band pass filter was 0.3-30 Hz with stimulus rate of 0.5 Hz. Electrode impedance was within 0-50 K Ω . Using Net-Station software we collected the mean differences between like and dislike stimuli for the amplitudes and the latencies of the N200 and the P300 ERP components. Values were analysed for total 19 channels (FP1, FP2, F3, F4, F7, F8, Fz, C3, C4, Cz, P3, P4, Pz, T3, T4, T5, T6, O1, and O2 electrodes). Data was segmented as (-100—800) ms, baseline was corrected from 100 ms before stimulation. Eye blink, eye movement and movement artefact were removed using artefact detection tool in Net-Station software. Significance level was detected by

using Statistical Package for the Social Sciences 22 (SPSS22) software with one way analysis of variance (ANOVA) analysis. The significance level was set as $p < 0.05$.

3. RESULTS

Grand average waveform of the amplitudes and the latencies of the N200 and the P300 ERP components were shown in Figure 2a (G1), Figure 2b (G2) and Figure 2c (G3). Values of mean differences of like and dislike colour stimuli were collected for the amplitudes and the latencies of the N200 and the P300 ERP components (Table 1 and 2).

3.1 Reaction times (RTs) analysis

We don't have any analysis on correct response as our experimental paradigm was like and dislike choice on different colours. Therefore we analysed only reaction times (RTs) which were compared among three groups. One way ANOVA analysis revealed that the RTs of the higher education (G3) (mean $\pm$ SD, 763.8 $\pm$ 239.53) group were significantly reduced compared to the medium (G2) ($P = 0.03$, 907 $\pm$ 242.50) and the low (G1) ($P = 0.0002$, 1145.52 $\pm$ 416.59) education groups (Figure 3). G2 showed significantly next shorter RTs comparing with the G1 ($P = 0.03$). Eventually the low education group (G1) showed significantly longer RTs compared to the high (G3) and the medium (G2) education groups (Figure 3).

3.2 The N200 Component

The amplitudes of the N200 were clearly distributed at seven electrode sites of T4, T5, T6, P3, P4, O1 and O2. Highest amplitudes were evoked at all of these channels in G3 comparing with the G2 and the G1 which were significant at T6 and non-significant at other sites. Group effect was significant at T6, $F(df) = 4.57 (2,57)$, $P = 0.01$. On the other side, G2 evoked higher amplitudes of the N200 ERP component at most of the sites (6 out of 7 sites) (T4, T6, P3, P4, O1 and O2) comparing with the G1. However G1 evoked lowest amplitudes among

three groups (Table 1). In case of latencies of the N200 component, G3 possessed shortest latencies at most of the locations (5 out of 7 locations) (T4, T6, P4, O1 and O2) among three groups and next shorter latencies were in G2 (5 out of 7 locations) (T4, T5, T6, P4 and O2) (Table 1).

However in both amplitudes and latencies of the N200 component, G1 (low education group) always evoked the smallest amplitudes and the longest latencies at most of the sites compared to the G2 and the G3 (Table 1).

3.3 The P300 Component

The results of the P300 component were consistent of the results of the N200 component. The G3 evoked highest amplitudes of the P300 at most of the sites (6 out of 7 locations) (T4, T5, T6, P4, O1 and O2) comparing with the G2 and the G1 (Table 2). The G2 gained the next higher amplitudes at most of the location (5 out of 7 locations) (T4, T6, P4 and O2) comparing with the G1. Significant group effect was observed at T6, $F(df)=3.19 (2,57)$, $P=0.05$ (Table 2). Shortest latencies of the P300 component were evoked in the all groups, the G3 (T3, T6), the G2 (T5, P3, P4, O1, O2) and the G1 (T4). Next shorter latencies were in different location in the G3 (P3, P4, O1), the G2 (T5) and in the G1 (T3, T5, O2) (Table 2). After all, the G1 evoked the smallest amplitudes and the shortest latencies comparing the G2 and the G3 in case of the P300 component at most of the sites.

4. DISCUSSION

In this study, we investigated educational influence on different colour choice among the low (G1), the medium (G2) and the high educational levels (G3) with event related potential (ERP) study. Reaction times (RTs) were significantly higher in the G1 compared to the G2 and the G3. The higher amplitudes and the longer latencies of the N200 and the P300 ERP

components were evoked at most of the locations in the G3 and then G2. T6 area showed significant group effect for the amplitudes of both the N200 and the P300 component (Table 1 and 2). G1 (low education level) evoked the shortest amplitudes and the longest latencies for both the components at most of the sites.

Being an early ERP component, the N200 reveals the basic information about sensory processing of the stimuli at the lower level and on the other hand, later ERP component, the P300 reflects the perceptual and cognitive processing of the stimuli at the higher level [26]. Higher amplitudes of the N200 component proved higher attention [27] and the P300 amplitudes are directly proportional with the perceptual and cognitive processing [28]. Kok et al (2004) investigated that higher amplitude of the P300 component reflects the higher level of the cognitive function like orientation of attention, response modulation, and response resolution etc [29]. Taking these interpretations about amplitudes of the N200 and the P300 ERP components we assume that there might be a possibility that high education improved attention, cognitive processing and as a whole higher level of cognitive function as higher amplitudes of these two components were evoked in the high education group. As this reflection was not at all channels but most of the channels and not all channels are significant therefore we mentioned only about a possibility. On the other hand the low education group took the opposite interpretation of the high education group.

The N200 latency has an expression on the basis of the discrimination and classification of the visual stimuli that means on the basis of the rapid registration of the visual input which has positive correlation with the latencies of the N200 [30]. Then this evidence suggest us that, low education took longer registration for color input in the G1 as the G1 evoked longer latencies at most of the electrode positions compared to the G2 and the G3. There was rapid registration of

color input for the G3 which was reflected by higher education (Table 1). The P300 latency conveys the message of timing to interpret the stimulus [31] about attention, learning process, decision making etc of cognitive processes. Therefore, there might be a longer processing time for attention, learning, decision making etc in the lower education group (G1) as there was non-significant longer latencies of the P300 ERP component at most of the electrode positions in this group. The higher education might made the G3 and then G2 groups in more quicker timing process of cognitive functions with the evidence of the significant and non-significant smaller latencies of the P300 component (Table 2). As we interpreted like a ‘possibility’ about the amplitudes of the N200 and the P300 components, this interpretation also acceptable for the latencies of these two components as there were only trends of longer latencies in the low education group but no clear significance at most of the sites.

Slow information processing depends on the connection between cortico-subcortical and cortico-cortical structure [32, 33]. Higher education might have influence to improve this connection which was proved in the behavioral study (reaction time). Higher education gave us significantly shorter RTs compared to the other two groups, and it means higher education gave more connection in the G3 and then in the G2 which was lack in the G1 due to deficiency of education (significantly longer RTs in G1, Figure 3).

5. CONCLUSION

We studied educational influences on different colors with ERP study in low, medium and high education groups. On the basis of the results, we concluded that there might be a possibility that the low education group has low attention, low higher level of cognitive function with reduced learning process, decision making etc. during different color perception. Besides these, the low education group might have longer processing time due to lack of the connection

in higher brain level during color processing. Therefore, we finally concluded that higher education is important to improve higher level of connection which leads to the higher cognitive function on the purpose of improving quality of life.

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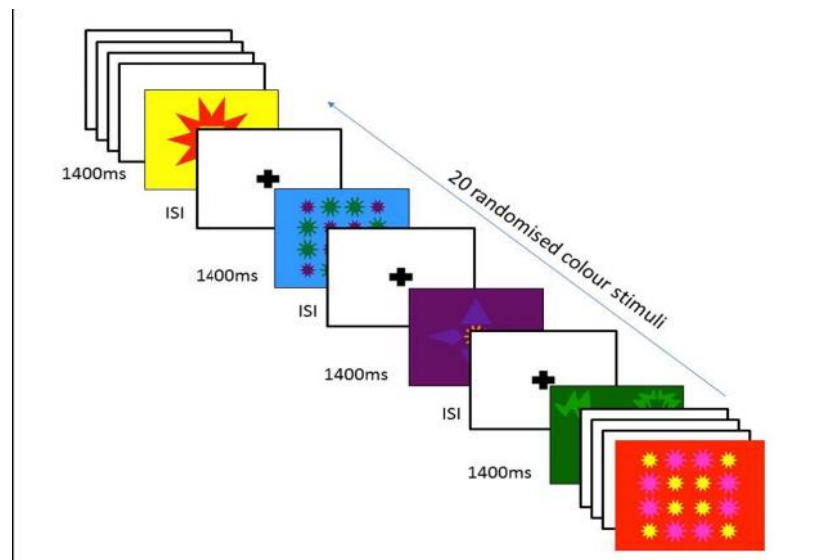
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278 Figure 1



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283 Figure 2a
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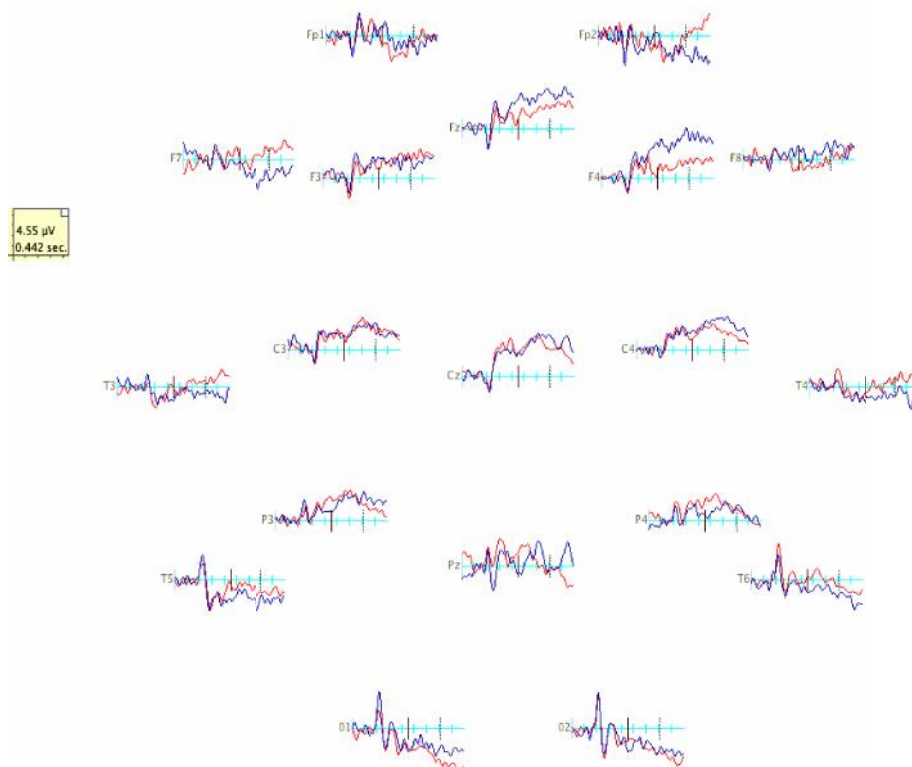


Figure 2b

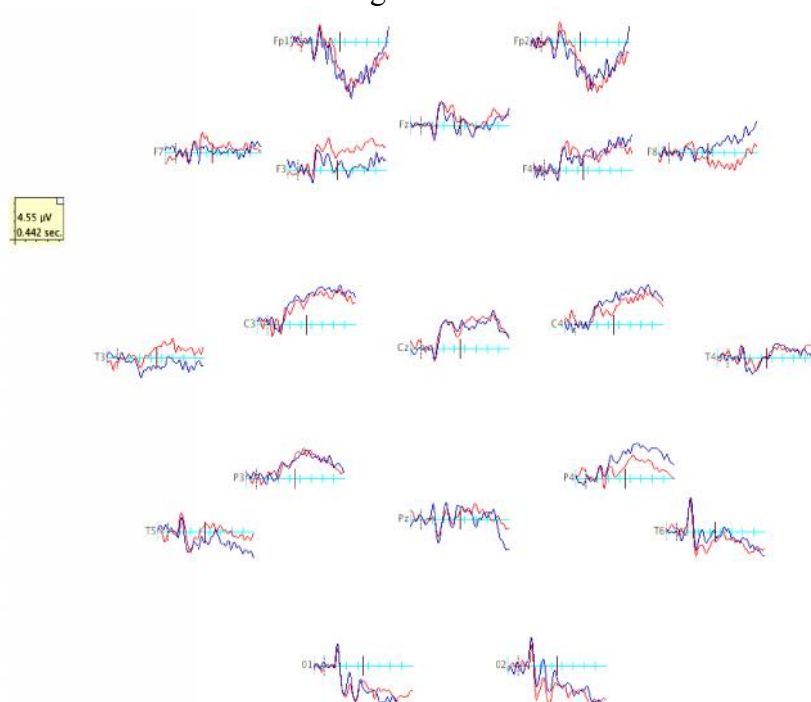
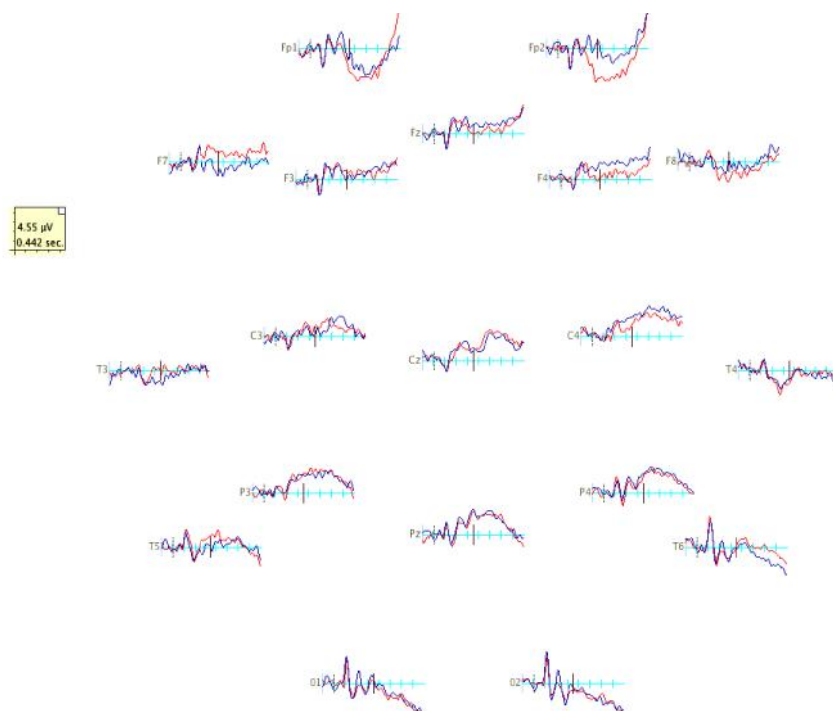


Figure 2c

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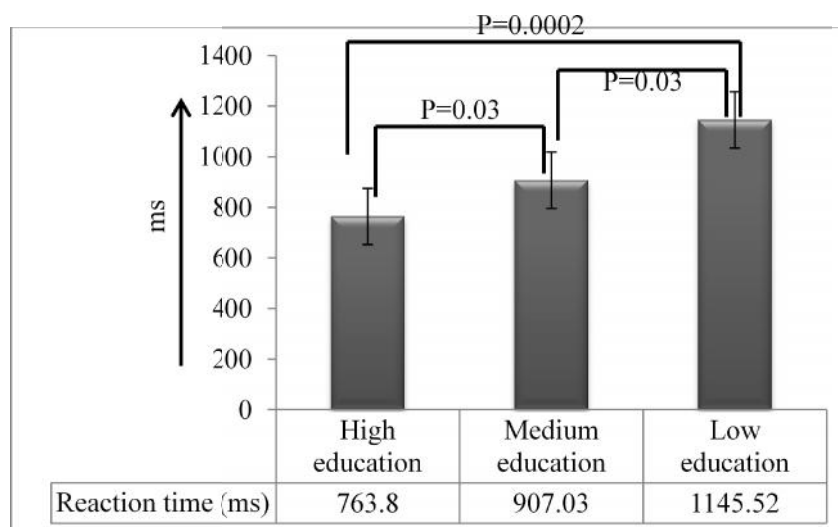
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Figure 3



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Table 1

Sites	Low education/G1 (mean $\pm$ SD)	Medium education/G2 (mean $\pm$ SD)	High education/ G3 (mean $\pm$ SD)	F (df)	P	Significance
N200 ERP Component Amplitudes (in μV) (mean$\pm$SD)						
Fz	4.74 $\pm$ 3.39	2.83 $\pm$ 3.66	3.91 $\pm$ 3.99	1.37(2,57)	0.26	NS
Cz	2.76 $\pm$ 2.25	3.38 $\pm$ 3.53	3.13 $\pm$ 2.31	0.30(2,57)	0.75	NS
Pz	4.40 $\pm$ 3.98	3.50 $\pm$ 3.49	2.38 $\pm$ 6.54	1.02(2,57)	0.37	NS
Fp1	6.20 $\pm$ 5.74	4.67 $\pm$ 4.77	5.67 $\pm$ 6.18	0.39(2,57)	0.68	NS
Fp2	4.80 $\pm$ 5.16	4.13 $\pm$ 4.68	6.22 $\pm$ 6.27	0.97(2,57)	0.38	NS
F3	4.41 $\pm$ 3.56	2.00 $\pm$ 3.88	2.98 $\pm$ 4.24	1.99(2,57)	0.14	NS
F4	5.74 $\pm$ 3.35	3.65 $\pm$ 3.80	4.14 $\pm$ 3.45	2.12(2,57)	0.13	NS
F7	5.11 $\pm$ 4.10	2.77 $\pm$ 3.97	1.95 $\pm$ 3.50	4.57(2,57)	0.01	S
F8	4.65 $\pm$ 3.64	4.87 $\pm$ 4.55	4.31 $\pm$ 5.06	0.10(2,57)	0.91	NS
C3	3.17 $\pm$ 2.61	4.21 $\pm$ 4.02	2.62 $\pm$ 4.18	1.12(2,57)	0.33	NS
C4	3.58 $\pm$ 3.09	4.15 $\pm$ 3.41	3.60 $\pm$ 2.75	0.24(2,57)	0.79	NS
T3	4.12 $\pm$ 2.73	2.21 $\pm$ 3.73	2.86 $\pm$ 3.94	1.59(2,57)	0.21	NS
T4	2.66 $\pm$ 2.27	3.10 $\pm$ 3.36	3.64 $\pm$ 3.79	0.58(2,57)	0.56	NS
T5	2.45 $\pm$ 2.47	2.12 $\pm$ 2.70	3.08 $\pm$ 4.13	0.55(2,57)	0.58	NS
T6	1.16 $\pm$ 2.75	3.74 $\pm$ 2.71	4.90 $\pm$ 7.12	3.50(2,57)	0.04	S
P3	2.85 $\pm$ 3.27	3.07 $\pm$ 2.97	2.95 $\pm$ 3.56	0.02(2,57)	0.98	NS
P4	2.43 $\pm$ 2.96	3.86 $\pm$ 3.41	3.86 $\pm$ 4.07	1.22(2,57)	0.30	NS
O1	3.74 $\pm$ 2.42	3.24 $\pm$ 3.72	4.52 $\pm$ 3.56	0.98(2,57)	0.38	NS
O2	2.50 $\pm$ 3.27	4.00 $\pm$ 3.13	4.54 $\pm$ 3.45	2.53(2,57)	0.09	NS
N200 ERP Component Latencies (in ms) (mean$\pm$SD)						
Fz	285.64 $\pm$ 63.28	275.40 $\pm$ 60.00	291.38 $\pm$ 76.69	0.33(2,57)	0.72	NS
Cz	288.00 $\pm$ 70.80	285.80 $\pm$ 66.95	304.38 $\pm$ 76.07	0.53(2,57)	0.59	NS
Pz	320.00 $\pm$ 66.77	305.40 $\pm$ 74.44	293.50 $\pm$ 72.66	0.90(2,57)	0.41	NS
Fp1	268.91 $\pm$ 46.81	272.40 $\pm$ 55.21	278.63 $\pm$ 68.67	0.19(2,57)	0.83	NS
Fp2	296.55 $\pm$ 63.21	267.00 $\pm$ 54.32	284.75 $\pm$ 79.31	0.98(2,57)	0.38	NS
F3	288.73 $\pm$ 67.18	307.40 $\pm$ 58.07	306.25 $\pm$ 67.49	0.59(2,57)	0.57	NS
F4	279.45 $\pm$ 58.35	269.40 $\pm$ 70.06	274.50 $\pm$ 69.12	0.12(2,57)	0.89	NS
F7	290.91 $\pm$ 65.46	309.40 $\pm$ 65.25	312.50 $\pm$ 65.15	0.77(2,57)	0.47	NS
F8	316.36 $\pm$ 70.52	262.60 $\pm$ 73.44	279.88 $\pm$ 74.84	3.03(2,57)	0.06	NS
C3	301.45 $\pm$ 68.55	301.20 $\pm$ 67.46	311.50 $\pm$ 64.03	0.21(2,57)	0.81	NS
C4	288.55 $\pm$ 55.88	275.40 $\pm$ 61.15	287.50 $\pm$ 66.77	0.30(2,57)	0.74	NS
T3	294.18 $\pm$ 52.31	328.00 $\pm$ 62.24	326.50 $\pm$ 52.83	2.73(2,57)	0.07	NS
T4	308.36 $\pm$ 74.43	273.60 $\pm$ 70.00	296.50 $\pm$ 72.60	1.24(2,57)	0.30	NS
T5	303.45 $\pm$ 58.88	297.00 $\pm$ 73.51	311.38 $\pm$ 60.65	0.32(2,57)	0.73	NS
T6	317.45 $\pm$ 65.02	315.80 $\pm$ 74.19	293.50 $\pm$ 60.64	1.13(2,57)	0.33	NS
P3	289.64 $\pm$ 59.03	312.80 $\pm$ 72.39	304.38 $\pm$ 66.70	0.67(2,57)	0.51	NS
P4	299.64 $\pm$ 60.54	287.20 $\pm$ 73.69	293.38 $\pm$ 62.62	0.19(2,57)	0.83	NS
O1	310.73 $\pm$ 54.82	316.60 $\pm$ 64.45	291.50 $\pm$ 63.10	1.23(2,57)	0.30	NS
O2	327.45 $\pm$ 66.32	319.80 $\pm$ 68.54	309.75 $\pm$ 68.46	0.46(2,57)	0.64	NS

Note: ns: nonsignificant, n: significant, $p \leq .05$

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Table 2

Sites	Low education/G1 (mean $\pm$ SD)	Medium education/G2 (mean $\pm$ SD)	High education/G3 (mean $\pm$ SD)	F (df)	P	Significance
P300 ERP Component Amplitudes (in μV) (mean$\pm$SD)						
Fz	6.37 $\pm$ 4.29	4.99 $\pm$ 4.77	5.16 $\pm$ 3.73	0.72(2,57)	0.49	NS
Cz	5.36 $\pm$ 4.20	4.20 $\pm$ 4.06	4.22 $\pm$ 2.76	0.78(2,57)	0.46	NS
Pz	6.95 $\pm$ 5.78	5.43 $\pm$ 5.86	4.67 $\pm$ 4.96	1.14(2,57)	0.33	NS
Fp1	7.84 $\pm$ 8.35	7.84 $\pm$ 7.37	7.04 $\pm$ 4.99	0.13(2,57)	0.88	NS
Fp2	6.36 $\pm$ 7.72	8.85 $\pm$ 7.82	8.15 $\pm$ 7.13	0.64(2,57)	0.53	NS
F3	5.52 $\pm$ 3.94	3.00 $\pm$ 4.77	4.80 $\pm$ 5.10	1.60(2,57)	0.21	NS
F4	6.92 $\pm$ 4.68	5.39 $\pm$ 5.20	5.43 $\pm$ 4.27	0.81(2,57)	0.45	NS
F7	6.97 $\pm$ 8.17	4.74 $\pm$ 5.27	4.00 $\pm$ 5.37	1.49(2,57)	0.23	NS
F8	6.34 $\pm$ 4.87	7.20 $\pm$ 5.90	5.74 $\pm$ 6.27	0.39(2,57)	0.68	NS
C3	4.44 $\pm$ 3.05	5.55 $\pm$ 4.28	4.15 $\pm$ 5.57	0.59(2,57)	0.56	NS
C4	5.28 $\pm$ 4.60	4.45 $\pm$ 3.41	4.49 $\pm$ 3.32	0.35(2,57)	0.70	NS
T3	4.67 $\pm$ 3.96	3.31 $\pm$ 5.55	4.62 $\pm$ 4.78	0.60(2,57)	0.60	NS
T4	2.82 $\pm$ 2.78	4.14 $\pm$ 4.29	4.90 $\pm$ 4.82	2.04(2,57)	0.14	NS
T5	3.13 $\pm$ 3.94	2.91 $\pm$ 3.31	4.98 $\pm$ 5.11	1.84(2,57)	0.17	NS
T6	2.26 $\pm$ 3.46	4.17 $\pm$ 2.04	6.42 $\pm$ 8.48	3.19(2,57)	0.05	S
P3	4.85 $\pm$ 3.66	3.74 $\pm$ 3.44	4.29 $\pm$ 3.66	0.50(2,57)	0.61	NS
P4	4.43 $\pm$ 4.18	5.17 $\pm$ 3.61	4.69 $\pm$ 4.53	0.17(2,57)	0.84	NS
O1	5.72 $\pm$ 4.31	4.13 $\pm$ 3.77	6.08 $\pm$ 3.73	1.61(2,57)	0.21	NS
O2	4.05 $\pm$ 3.70	4.86 $\pm$ 4.12	5.84 $\pm$ 4.00	1.38(2,57)	0.26	NS
P300 ERP Component Latencies (in ms) (mean$\pm$SD)						
Fz	534.18 $\pm$ 165.73	608.40 $\pm$ 178.06	515.13 $\pm$ 154.24	2.06(2,57)	0.13	NS
Cz	633.82 $\pm$ 137.05	532.20 $\pm$ 179.17	555.00 $\pm$ 166.58	2.38(2,57)	0.10	NS
Pz	602.00 $\pm$ 153.78	518.60 $\pm$ 161.03	596.00 $\pm$ 159.94	1.86(2,57)	0.16	NS
Fp1	461.64 $\pm$ 132.74	591.80 $\pm$ 158.99	490.88 $\pm$ 154.71	4.39(2,57)	0.02	S
Fp2	491.45 $\pm$ 155.67	578.60 $\pm$ 159.43	487.13 $\pm$ 154.47	2.41(2,57)	0.10	NS
F3	517.27 $\pm$ 165.20	547.40 $\pm$ 160.20	577.75 $\pm$ 150.91	0.97(2,57)	0.39	NS
F4	512.73 $\pm$ 173.99	529.00 $\pm$ 162.02	563.63 $\pm$ 146.77	0.72(2,57)	0.49	NS
F7	565.27 $\pm$ 185.38	611.60 $\pm$ 168.55	568.75 $\pm$ 148.88	0.52(2,57)	0.59	NS
F8	508.36 $\pm$ 177.70	555.20 $\pm$ 153.47	560.13 $\pm$ 166.66	0.70(2,57)	0.50	NS
C3	574.91 $\pm$ 131.56	594.00 $\pm$ 170.72	564.25 $\pm$ 150.07	0.24(2,57)	0.79	NS
C4	564.55 $\pm$ 167.09	576.20 $\pm$ 158.52	539.88 $\pm$ 160.43	0.34(2,57)	0.71	NS
T3	592.36 $\pm$ 168.56	595.40 $\pm$ 159.18	570.63 $\pm$ 150.15	0.20(2,57)	0.82	NS
T4	483.27 $\pm$ 155.48	494.00 $\pm$ 144.24	577.13 $\pm$ 168.78	2.87(2,57)	0.06	NS
T5	555.45 $\pm$ 172.02	528.60 $\pm$ 158.66	588.38 $\pm$ 156.42	0.87(2,57)	0.42	NS
T6	603.45 $\pm$ 165.39	565.60 $\pm$ 152.44	547.13 $\pm$ 167.79	0.78(2,57)	0.46	NS
P3	649.27 $\pm$ 120.21	564.60 $\pm$ 155.40	641.38 $\pm$ 137.17	2.49(2,57)	0.09	NS
P4	601.45 $\pm$ 136.04	554.80 $\pm$ 162.85	581.63 $\pm$ 182.35	0.42(2,57)	0.66	NS
O1	600.91 $\pm$ 157.85	505.80 $\pm$ 146.17	588.50 $\pm$ 161.95	2.33(2,57)	0.11	NS
O2	565.82 $\pm$ 163.33	564.40 $\pm$ 137.02	579.50 $\pm$ 157.86	0.08(2,57)	0.92	NS

Note: ns: nonsignificant, n: significant, $p < .05$

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FIGURE LEGENDS

Figure 1: Stimulation paradigm using 20 randomised different colour stimuli for 1400 ms with 1000 ms ISI.

Figure 2a: Grand average waveforms of the N200 and the P300 ERP components at 19 electrode positions in low education group (G1). Blue and red colours represented like and dislike choice of colours, respectively.

Figure 2b: Grand average waveforms of the N200 and the P300 ERP components at 19 electrode positions in medium education group (G2). Blue and red colors represented like and dislike choice of colors, respectively.

Figure 2c: Grand average waveforms of the N200 and the P300 ERP components at 19 electrode positions in high education group (G3). Blue and red colors represented like and dislike choice of colors, respectively.

Figure 3: Reaction times (ms) were shown among high, medium and low educational groups.

Table 1: The amplitudes and the latencies of the N200 ERP component were shown among low (G1), medium (G2) and high (G3) education groups. The values were the mean differences of the like and dislike choice of colors.

Table 2: The amplitudes and the latencies of the P300 ERP component were shown among low (G1), medium (G2) and high (G3) education groups. The values were the mean differences of the like and dislike choice of colors.