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Research paper

Emotional Arousal Substrate in Relation to Eysenck Theory of Extraversion

Nasir Yusoff[1]*, Nik NurAzhani Anuar[1], Wan Nor Arifin[2], Tahamina Begum[1], Faruque Reza[1]

1. Department of Neurosciences, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, MalaysiaUnit of Biostatistics and Research Methodology, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia

**Corresponding author E-mail: nasirff@usm.my*

Abstract

Background: Eysenck theory posits that extraverts possess a trait of personality that is associated with personal enjoyment. **Objectives:** This study aims to examine the combination effect of extraversion and arousal intensity on the neural process of emotional arousal. **Methods:** This study was implemented in two parts – (1) Validation of Extraversion-Five Factor Non Verbal Personality Questionnaire (E-FF-NPQ) for personality screening, and (2) Event Related Potential (ERP)/electroencephalograph (EEG) recording session. In part one, the E-FF-NPQ was validated by 153 respondents, recruited from Universiti Sains Malaysia. In part two, after having their personality trait screened, electroencephalogram was recorded in 90 participants (N=30 for each personality) during the Event Related Potential session. Emotional arousal pictures that were taken randomly from the International Affective Picture System (IAPS) were used as visual stimuli and divided into three categories (high, moderate, low) based on the normative mean values of IAPS. **Results:** Interaction effect of the extraversion trait and emotional arousal intensity was detected in the frontal region as indicated by the latency of N200. **Conclusion:** The Theory of Eysenck on the connection between extraversion and well-being is almost supported.

Keywords: *emotional arousal; event-related potentials; extraverts; P300 component; Eysenck Theory*

1. Introduction

According to Eysenck's Personality Theory,[1] extraversion is proposed as one of the three important dimensions in human personality – the other two being neuroticism and psychoticism. It was suggested that personality is derived from the functioning of the autonomic nervous system (ANS), which depends on the balance between the excitation and inhibition processes of the nervous system. It was also said that the level of activity in the ascending reticular activating system (ARAS) determines the degree of extraversion trait. Based on the extraversion-introversion continnum, clear definitions of these two charactristics of personality have been clarified. Extraversion is described as a trait of personality that is characterized by sociable, outgoing, talkative and easygoing attributes. On the other hand, people with introverted traits exhibit characteristics such as passive, careful, thoughtful, controlled and calm. Meanwhile, ambiversion – the personality trait that belongs to the middle of the continnum, is said to stand in between the characteristics of the extraverts and introverts. With regards to emotional arousal, Eysenck postulated that extraverted people have lower arousal; thus, they tend to seek out more intense stimuli. This is different than introverts who usually achieved optimal level of arousal at a much lower level of stimulation.

Extraversion is said to be a trait of personality that is related to one's subjective well-being and personal happiness.[2-6]. Subjective well-being that refers to the affective and cognitive ways in evaluating our own life, was reported as an important factor predicting one's psychological condition such as depression (e.g., [7]). The robust connection between subjective well-being and extraversion trait of personality has been demonstrated in previous longitudinal studies (over a period of 10 years follow-up).[8-9] It was found that extraversion influenced the brain reactivity to emotional stimuli (e.g., [10]) with results suggesting that its influence on the brain is distributed particularly in the prefrontal, cortical, and thalamus regions.[11] It was also shown that event-related brain potential (such as the late positive potential) was processed by extraverts when responding to stimuli with emotional content.[12] Therefore, earlier argument hypothesized that extraversion as an personality trait that was more sensitive to signals of reward compared to introverts, which is a personality trait that was postulated as more susceptible to punishment.[13] In addition, it was stated that extraversion evokes the function of corticolimbic–dopaminergic flow – a neurobiological system which is important for incentive and reward motivation.[14]

Arousal (beside valence) with its calm to excited continuum, is recognized as one of the main dimensions in emotion-related studies.[15] Arousing stimuli indicated high capacity to evoke the process of emotion [16,17,18] at widespread cortical networks [19] and were regarded as a significant affective factor in influencing the perception of time.[20,21] Even though there were some conflicting findings,[22] arousal generally occurs at longer latencies [23] and tends to indicate greater effect in affective oddball processing than valence as valence minimally influences EEG amplitude.[24] In addition, the intrinsic and evaluative contexts of the stimuli modulated the affective picture processing of arousal.[25] From the functional Magnetic Resonance Imaging (fMRI) finding, Anders et al. [26] claimed that peripheral physiologic responses along the calm-excited continuum of arousal varied with thalamic and frontomedial activity.

In psychological studies using Event Related Potential (ERP) technique to investigate the underlying mechanisms of emotional process, components such as N200 [27-28] and P300 [24,29-31] had been found. The component of parietal P300 was recognized to index controlled evaluative process [32] and as a late marker to determine the impact of extraversion on emotion.[33-34] Meanwhile, a component of N200 was revealed to reflect the attention orienting response in an oddball task.[35] Carretie et al. [16] found that negative and positive arousing stimuli induced highest amplitude at several ERP components such as at the P200post and P340post located at the visual association cortex. In addition, the greater effect was seen from the high level of arousal stimuli, indicated by the larger late positive components.[36] In another study, high intensity of arousal induced larger amplitudes for the N200, P300, early slow wave, and late slow wave components.[24] Moreover, late positive potential was found to be induced by high arousal stimuli.[25] As replicated by other studies, emotional stimuli were observed to produce greater amplitude of late positive-polarity potentials (compared with neutral stimuli) [37] that were modulated at the parietal sites [19] and indicated some differences of the pattern of late positive potentials in the affective/non-affective judgement. [38] It was reported that, higher amplitudes of emotional substrate such as the P3b was seen at several posterior sites as a response to emotional pictures.[39] In another study, the P300 amplitude indicated responsivity to perceptual capacity, however not to the motor capacity.[40] It was also observed that P300 pointed to the selective visual attention to different natures of emotion (such as erotica and mutilation) whereby such effect was seen in the range of 400–600 milisecond after stimulus onset.

In this study, we were interested to examine the combination effect of three personalities (extravert, ambivert and introvert) and the intensity of emotional arousal (low, moderate and high) on the neural substrate underlying the process of emotional arousal. We included two personalities in the non-extravert group (ambivert and introvert) as a control for extravert (Between-subjects effect: extravert, ambivert and introvert) in order to particularise the influence of those personalities over the intensity of emotional arousal (Within-subject effect: low, moderate, high) in the analysis of a two-way mixed design; and such analysis had not been paid attention to in previous studies. In previous bi-comparison studies (extravert versus ambivert), the domination of extraverts in reaction to emotional stimuli for P300 component had been reported.[33-34,41] Meanwhile, slight difference was reported for N200 component, whereby the pronounced effect was observed from both personalities (extravert versus ambivert) in response to high negative emotional stimuli. [41] In the meantime, other previous bi-comparison studies (extravert versus introvert), also indicated the dominance of extraversion on introversion, as revealed by the higher amplitude of P300 component in extraverts, relative to introverts.[42] Even though the scenario was sometimes inconsistent,[43] it was believed that the amplitude of P300 component reflected in extraverts was more rapidly habituated than introverts.[44] Since extraverts are suggested to have a personality trait with lower arousal and thus, tend to seek out more intense stimuli,[1] we hypothesized that extraverts would be more susceptible to the intensity of emotional arousal, than non-extraverts (ambiverts and introverts). Our hypothesis is linking up to the fact that higher level of subjective well-being in extraverts may infer that extraverts are better at regulating emotions which is critical for mood balancing and therefore improving well-being.[45-47] In addition, extraversion is considered a personality trait that is more sensitive to signals of reward,[13] as well as more superior in attention-related motor process, as indexed by the psychophysiological substrate,[48] than non-extraversion. The Event Related Potential (ERP) technique was employed as it is advantageous in exploring the spatiotemporal features of the emotional effect. Accordingly, ERP is a valuable technique for observing different electrophysiological components that represent the various cognitive stages in relation to emotion, perception and attention as well as detecting abnormalities in the process of cognition.[49-50] Since biological and physiological of human body greatly connected with our patterns of thoughts, feelings and behaviours (personality), it is timely to assess this factor and its influence on people's well-being and therefore, revising and establishing the theory of Eysenck (on the connection between extraversion and well-being) that was proposed many decades ago.

2. Methodology

2.1. Subjects

Since this study was conducted in two parts (Part one – validation of Extraversion-Five Factor-Nonverbal Personality Questionnaire (E-FF-NPQ) for personality screening; Part two – Event Related Potential (ERP)/electroencephalograph (EEG) recording session), we have two different groups of sample. In part one of the study, a total of 153 postgraduate and undergraduate students from Universiti Sains Malaysia (USM), selected via stratified random sampling, agreed to self-rate the E-FF-NPQ. Majority of the respondents were female (85%), of Malay ethnicity (78%) and undertaking bachelor's degree (82%). Mean age of all respondents was 22 (±2.13) years old.

Meanwhile in part two of the study, a total of 90 volunteers (60% were female and 56% were of Chinese ethnicity) from Kota Bharu area, located in Kelantan, Malaysia were recruited. Their mean age was 22.51 (±1.96) years old, with 88% of them completing bachelor's degree at Universiti Sains Malaysia, Health Campus. All participants were right handed with 40% reported to be left eye dominant. More than half (73%) had vision problem, however, corrected by glasses and contact lenses. Participants (30 for each group) were grouped into three groups – Extraversion (Mean=22.27±4.24), Ambiversion (Mean=12.07±1.84) and Introversion (Mean=7.67 ± 5.25). Personality scores of the Extraversion-Five Factor-Personality Questionnaire (E-FF-NPQ) between these three groups were significant [$F(2, 87) = 103.22$, $p<.05$]. Since extraversion was reported to have negative correlation with social anxiety/social phobia (e.g. [51]), we make sure that our participants were emotionally stable, indexed by the neuroticism trait [mean=17.67±6.56, which was below the high neurotic cut off value of ≥22 scores (Raykov's rho of 0.68 and Intraclass Correlation Coefficient of 0.75), measured by the validated version of the Neuroticism-FF-NPQ scale. Similar procedure (to Extraversion-FF-NPQ) was undertaken in validation of the Neuroticism-FF-NPQ]. In addition, it was said that neuroticism moderated the effect of extraversion on life satisfaction.[52]

2.2. Procedure

Study protocol was approved by the Human Ethical Committee of Universiti Sains Malaysia (reference number: USM/JEPeM/15040127). All participants were allowed to withdraw from the study as participation was on a voluntary basis. Prior to any assessment, the study objectives were fully explained to the participants and written informed consent was provided upon agreement to participate in the study. This study was implemented in two parts – (a) Validation of Extraversion-Five Factor-Nonverbal Personality Questionnaire (E-FF-NPQ) for personality screening and (b) Event Related Potential (ERP)/ electroencephalograph (EEG) recording session.

2.2.1. Validation of the Extraversion-Five Factor-Nonverbal Personality Questionnaire (E-FF-NPQ) for personality screening

In the first part of the study, validation of the E-FF-NPQ [53] was undertaken among 153 respondents (selected via stratified random sampling from Universiti Sains Malaysia, Health Campus), in order to have a validated personality tool for screening of personality (extravert, ambivert or introvert). Respondents with a lifetime history of a major medical disorder, uncorrected visual acuity, a history of affective disorder, and who were using psychiatric medication were excluded from the study.

Since English is not the main language in Malaysia, we chose this non-verbal questionnaire as it has the advantage in measuring personality in a cross-cultural context especially for those encountering language barriers. In addition, in order to cater to the group of respondents that was not able to understand the instruction of the scale, the original instruction was translated into Malay language by applying the forward and backward translation methods.[54]

The original Extraversion scale consists of 12 items extracted from the 60-item full version of FF-NPQ that measures five main areas of personality – Extraversion, Agreeableness, Conscientiousness, Neuroticism and Openness to Experience.[53] A series of figures delineating behaviors related to extraversion and non-extraversion constructs were presented to the respondents. Respondents estimated the likelihood to engage in the types of behavior as shown in the booklet on a seven-point Likert scales, ranging from 1 (being "extremely unlikely") to 7 (being "extremely likely").

Internal structure of the revised Extraversion Scale (five items) was established by examining the composite reliability, which was determined by evaluating Raykov's rho [55] with acceptable values of reliability range from 0.70 to 0.95.[56] In addition, test-retest reliability analysis was also performed to determine the consistency of reliability of the Extraversion-FF-NPQ after one month by using the Intraclass Correlation Coefficient (ICC).[57] The ICC value <0.40 is considered poor, that between 0.40 and 0.75 is considered fair to good and ICC >0.75 is considered excellent.[58]. In this study, acceptable factor loadings (Raykov's rho=0.72) with good test-retest reliability (Intraclass Correlation Coefficient=0.67) was obtained. The total score of revised extraversion items was ranked in descending order – 76th–100th percentile represented high score, 25th–75th percentile represented moderate score and 0th–24th percentile represented low score to get the cut-off values as follows: extravert (scores of 17-35), ambivert (scores of 10-16) and introvert (scores of 1-9).

2.2.2. ERP Session/EEG Recording

Prior to ERP Session/EEG recording, upon agreeing to participate in the study and providing written informed consent, as well as obtaining demographic data, personality screening was done to determine the trait of personality by using the validated version of E-FF-NPQ. Participants responded to the E-FF-NPQ by estimating the likelihood to engage in the delineating behaviors as shown in the booklet. Personality trait of the participants was then determined, based on the cut-off scores. The internal consistency of E-FF-NPQ from 90 participants was excellent with Cronbach's alpha of 0.89. Participants were then directed to the electroencephalograph (EEG) recording room for net outfitting that was held at the same place – Neuroscience Laboratory, Hospital of Universiti Sains Malaysia.

In the second part of study, EEG recording/ERP session was implemented. Recruitment of the participants was done through advertisement (N=90 particpants; 30 participants for each personality trait). Young adults with abnormal or uncorrected to normal vision and who had a history of affective disorder were not selected as participants. The electroencephalograph (EEG) net outfitting was held at Neuroscience Laboratory, Hospital of Universiti Sains Malaysia. Participants'personality trait was withheld until the ERP session ended and was only given (for those interested) after the session. The study procedures and its accompanying risk (i.e., minimal fatigue only) were explained to the participants. Pre-training with 10 practice trials was used before either session in order to familiarize the subjects with the procedure.

Before the ERP/EEG recording session, electrolyte solution was prepared based on the standard protocol provided by Electrical Geodesics, Inc. (EGI). Electrolyte solution was changed every day while disinfecting solution was changed every 14 days. The participants' head circumference was measured along the brow ridge or glabella to determine the appropriate EEG net size – 56 cm and 58 cm.

During the ERP/EEG recording session that was held in the quiet and dark room with controlled room temperature, participants were seated about 100cm away from the monitor screen. Participants were reminded to limit their movements when the EEG recording was in session in order to reduce noise that might affect the quality of the data. Continuous EEG recordings was recorded with a 128 HydroCel GSN connected to a high-input impedance NetAmps 300 amplifier. Participants were asked to passively viewed the pictures presented during the ERP/EEG recording session. Participants were not aware of the categories of the pictures – high,moderate or low arousal. Electrodes impedances were kept below 50kΩ and the data was digitised at 250 Hz. High impedence (as indicated by unresponsive electrode) was improved by droplets of electrolyte solution that were added to the affected electrode.

2.2.3. Stimuli

A total of 30 universal emotional pictures was chosen randomly from the International Affective Picture System (IAPS).[15] These selected pictures were then grouped into three categories in which ten pictures were allocated for each category according to the intensities of arousal (high=scores of 7-9, moderate= score of 4-6, low=scores of 1-3).[15] The reference numbers of IAPS is presented at the end of this text. In order to obtain an equal distribution of various natures of the pictures (classified as nature, people activity, tragedy and object), we tried as much as we can to have an equal proportion from each type to represent each level of arousal intensity (high, moderate, low). All pictures were considered universal.

The passive viewing technique was designed using the E-Prime® 2.0 software with 30 trials being allocated in each experimental block that presented three different arousal levels – low, moderate, high. This paradigm was used in order to capture the emotion flow of the different personality traits towards the emotional arousal of three different intensities. Thus, for this reason, we created a 'moderate' category (IAPS with the mean strength of 4-6), as set up in the E-Prime software, instead of a single score of 'natural' category (IAPS with the mean strength of 5), in order to have an equal range between scores in the middle continuum, with low and high means. This equal range of rating was applied in a previous cross-cultural validation of IAPS as well.[59]

Stimulus presentation was controlled by the E-Prime software running on computer screen and viewed from a distance of 100 cm. During the session, participants passively viewed 30 images with various levels of arousal that were randomly presented from the computer screen. The presentation of each stimulus was prefaced by the presentation of a fixation mark (+) on the center of the computer screen. The fixation mark was presented for 500 ms at the beginning of each trial to orient subjects to the center of the computer screen. The IAPS images appeared 2000 ms after the offset of the fixation mark. The interval between the offset of the IAPS images and the following fixation mark was 800 ms. Each image was presented in three blocks, making a total of 90 test trials. All photos were reconfigured automatically by E-Prime to a resolution of 640 pixels x 480 pixels, and were positioned at the centre of the screen against a black background. A schematic illustration of the experimental procedure is depicted in Fig 1.

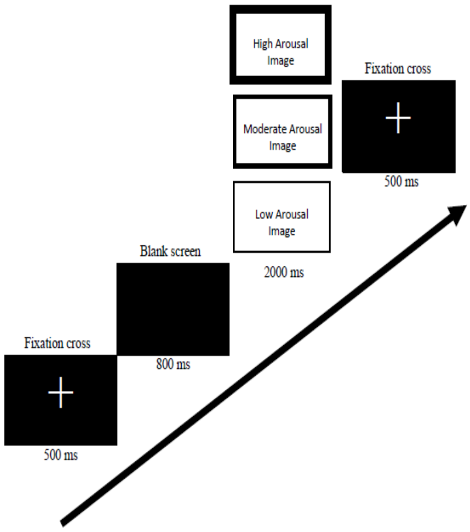

Fig 1: Schematic illustration of the experimental procedure

2.3 Analysis

Several steps were taken to extract the ERP components (P300 and N200) using the EGI Net Station 5.3 software. The raw EEG recordings were subjected to 0.30-50.00Hz bandpass filter, and a 50Hz Notch filter was applied. Segmentation was locked to 100ms before stimulus onset and 1000ms after stimulus onset, with 17ms offset. Ocular artefacts (eye blinks and eye movements) and other movement artefacts were removed. Eye blink artefacts were recognized when an amplitude difference of 200µV or larger was found within the first 640ms of a segment. In the case of eye movements (i.e., when participants looked away from the intended stimulus), the difference was set to 70µV instead for detection. In the meantime, bad channels were recognized once an amplitude difference of 400µV or larger were identified in a segment and it was considered unreliable when the bad channels were found in about 20% of the EEG recordings in all segments. Interpolation (by using the signals recorded by nearby good electrodes) was performed to replace bad channels in order to eliminate noisy data. Separate averaging of the data took place to increase the signal-to-noise ratio followed by converting the data, which would then subject to baseline correction, into the 10-20 EEG montage. In the last step, data was combined and averaged together to mask subject variability. Next, the raw data of amplitudes and latencies of N200 and P300 was extracted. Electrode sites in main regions (Pz, Cz and Fz) was selected for the statistical analysis of the N200 and P300 components as these electrodes indicated strong evidence of the effect of visualization on emotional processing (e.g., 41,60).
In the next step, data was further analyzed with the Statistical Package for the Social Sciences (SPSS) Version 23. The analysis of two-way mixed design was employed to determine the combine effect of personality (three levels of the between-subjects effect: Extraversion, Ambiversion, Introversion) and arousal intensities (three levels of the within-subject effect: high, moderate, low) on the amplitude and latency of the ERP components (P300, N200) related to emotional arousal processing. Sphericity Assumed was determined and the degree of freedom of the F ratio was corrected according to the Huynh-Feldt method. In addition, the Multivariate Tests of Pillai's Trace was employed, where appropriate.

3. Results

3.1. P300 Component

3.1.1 P300 Amplitude at Main Electrode – Frontal (Fz), Central (Cz) And Parietal (Pz)

The Fz electrode indicated non-significant results for the main effect [F(2,86)=1.10, ns], interaction effect [F(4,174)=0.21, ns], as well as the between-subjects effects [F(2,87)=2.96, ns].
At Pz electrode, significant result was found for the main effect [F(1.82,158.26)=5.95, p<0.01)], but not for the interaction effect [F(3.64,158.26)=0.36, ns] and between-subjects effects [F(2,87)=0.15, ns]. Pairwise comparison for the main effect of Pz revealed the significant differences between high (4.71±0.27) and low intensity (3.70±0.26) – (high-low: Mean difference=1.02; 95%CI=0.25-1.79; p<0.01), and between moderate (4.36±0.31) and low intensity (3.70±0.26) – (moderate-low: Mean difference=0.66; 95%CI=0.08-1.24; p<0.05).
Similar to Pz, the significant main effect was observed at the Cz electrode [F(2,86)=17.70, p<0.001)]. However, the interaction effect [F(4,174)=0.42, ns] and the between-subjects effects [F(2,87)=0.34, ns) were non-significant. Pairwise comparison for the main effect of Cz indicated highly significant difference between each levels of arousal with high intensity (mean=2.90±0.19) being rated higher than moderate (mean=2.04±0.16) and low intensity (1.71±0.15) – (high-moderate: Mean difference=0.86; 95%CI=0.38-1.33; p<0.001), (high-low: Mean difference=1.19; 95%CI=0.70-1.69; p<0.001).

3.1.2 P300 latency at main electrode – Frontal (Fz), Central (Cz) and Parietal (Pz)

Non-significant results of the latency of Fz electrode was found at all parameters – main effect [F(2,86)=1.97, ns; interaction effect [F(4,174)=0.46, ns] and between-subjects effects [F(2,87)=0.09, ns].
However, the results were different for the latency of Cz and Pz electrodes. Both electrodes indicated significant results for main effect – [F(2,86)=4.37, p<0.05] and [F(2,86)=5.45, p<0.01] respectively. Conversely, the significant interaction effect and between-subjects effects were not seen in both electrodes – Cz [Interaction effect: F(4,174)=0.63, ns; between-subjects effects: F(2,87)=1.69, ns] and Pz [Interaction effect: F(4,174)=0.39, ns; between-subjects effects: F(2,87)=0.53, ns].
Pairwise comparisons for the main effects of Cz and Pz were further explored. At Cz electrode, the significant mean difference was observed between high intensity (mean=584.93±SD98.84) and low intensity (mean=544.09±111.01) – (high-low: mean difference=40.84; 95%CI=6.75-74.94; p<0.05). Similarly, at Pz electrode, the significant mean difference was observed between high intensity (mean=475.78±SD115.77) and low intensity (mean=426.67±108.36) – (high-low: mean difference=49.11; 95%CI=12.66-85.57; p<0.05).

3.2. N200 Component

3.2.1. N200 amplitude at main electrode – Frontal (Fz), Central (Cz) and Parietal (Pz)

The Fz electrode indicated non-significant main effect [F(2,86)=0.82, ns] and interaction effect [F(4,174)=0.09, ns). The result of the between-subjects effects was also found to be non-significant [F(2,87)=0.21, ns].
Similarly, at the Cz electrode, the main effect [F(2,86)=1.67, ns], interaction effect [F(4,174)=2.05, ns] and between-subjects effects were found to be non-significant [F(2,87)=0.19, ns].
The electrode of Pz indicated similar pattern with Fz and Cz in which the main effect [F(1.92,166.74)=2.18, ns], interaction effect

[F(3.83,166.74)=0.49, ns] and between-subjects effects [F(2,87)=0.03, ns], all appeared to be non-significant.

N200 Latency at Main Electrode – Frontal (Fz), Central (Cz) And Parietal (Pz)

The main effect [F(2,83)=0.45, ns] and between-subjects effects [F(2,48)=0.25, ns] at Fz electrode revealed non-significant results. However, surprisingly, significant interaction effect was detected [F(4,174)=4.01, p<0.01)].
As depicted in Fig 2, it is seen that, the latency epoch in responding to high arousal intensity was indeed shorter (between 279.47 ms and 283.47 ms; time epoch=4) in extraverts, relative to ambiverts (between 281.20 ms and 294.41 ms; time epoch=13.21) and introverts (between 243.60 ms and 284.67 ms; time epoch=41.07).

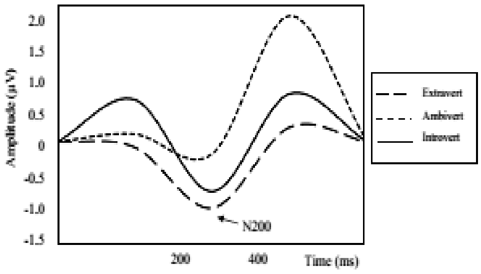

Fig 2: Emotional arousal substrate of N200 latency in extravert, ambivert and introvert

This pattern, however, was not seen in Cz and Pz electrodes. Both Cz and Pz electrodes indicated significant main effect [Cz: F(1.96,170.15)=12.35, p<0.001 and Pz: F(2,83)=3.68, p<0.01]. Nonetheless, they failed to indicate significant interaction effects – [Cz: F(3.91,170.15)=0.43, ns; and Pz: F(4,168)=0.61, ns], as well as for the between-subjects effects [Cz: F(2,87)=0.17, ns and Pz: F(2,87)=0.68, ns].
The main effects of Cz and Pz were further analyzed with pairwise comparisons. Significant mean difference was observed between high intensity (313.82±50.98) and moderate intensity (293.91±51.04) at Cz electrode (Mean difference=19.91; 95%CI=4.07-35.74; p<0.01). Cz electrode also indicated significant mean difference between high intensity (313.82±50.98) and low intensity (284.09±49.56) – (Mean difference=29.73, 95%CI=13.92-45.55; p<0.001). Meanwhile, Pz electrode exhibited a significant mean difference between high (301.96±60.00) and low intensity (281.33±60.31) – (Mean difference=20.62, 95%CI=3.35-37.90; p<0.05).

4. Discussion

In this study, two major findings are discussed – (1) the combination effect of personality (extraversion vs non-extraversion) and arousal intensity on the arousal emotional processing, as reflected by the frontal region of the N200 latency; and (2) the main effect of arousal intensity, as reflected by the amplitude of P300 (in the middle of central and parietal regions) and the latency of P300 and N200 (in the middle of central and parietal regions).
The first finding might explain the tendency of extraverts to experience a higher level of subjective well-being than non-extraverts, as suggested by previous findings (e.g., [2-3,41]). The clear picture of the mechanism that underlies the subjective well-being of the extraverts, in fact, remains elusive and controversial. Even though Eysenck's theory proposed that arousal is lower in extraverts as compared to introverts,[1] these two groups of personality, in some conditions, indicated similar responses to emotional stimuli.[41] Findings on brain sensitivity to reward [10,34,61] may not fully elucidate the phenomenon of brain mechanisms that lie beneath the higher levels of subjective well-being of extraverts. It is also uncertain whether extraverts are less responsive to punishment.[33,62] In contrast, extraversion was said to be a personality trait that is sensitive to the emotional intensity change of the stimuli [34] and it was seen as a significant factor that interacts with emotion, as reflected by well-known emotional substrates such as N200.[41] This scenario may associate with the reality that extraverts are superior at regulating emotions which is crucial for mood balancing and can lead to higher level of subjective well-being.[45-47] Perhaps, this is also why the extraverts are perceived as less susceptible towards punishment and more disposed to signals of rewards,[13] as well as tending to avoid harmful circumstances.[62-63]
Similarity with previous findings was noticeable, in terms of the effect of arousal intensity on the underlying neural substrates of emotion. In our study, we found the effect of arousal intensity at the amplitude of P300 (in the mid central and parietal regions) and the latency of P300 and N200 (both in the mid central and parietal regions). Stimulations from the pictures with moderate arousal intensity (IAPS mean strength of 4-6) revealed robust effect, in which the significantly lower amplitude in comparison to high arousal intensity (in mid central region) and significantly higher amplitude in comparison to low arousal intensity (in mid parietal region) were detected. This pattern was almost seen in other previous studies as well.[17,37] However, some conflicting findings were reported. For example, Conroy and Polich [17] found that P300 amplitude from negative relative to neutral stimuli was smaller over frontal areas, whereas amplitude from positive relative to neutral stimuli did not show any difference. Similarly, inconsistent findings were observed in several studies in which smaller P3 amplitudes were seen for emotional stimuli and neutral stimuli [41] and this was not parallel to other findings.[25,32,64-65] Since we used passive viewing technique of ERP with three target stimuli (high, moderate and low arousal) in order to cater to the equal range of emotion flow (regulation/modulation of the emotion) between categories of arousal intensity, the strength of IAPS means of 4-6 (which was the 'moderate' category) in our study, in fact, corresponded to the strength of IAPS mean of 5 (which was the 'neutral' category) in other previous studies (e.g., [22,66]). Emotional self-regulation in fact, is related to the human capacity to influence the electrochemical dynamics in the brain.[67] It was found that the processes of emotion and attention occurred differently according to specific processing stages, in which the interaction of emotion and attention indicated their effect mostly during the later stages of processing.[68] Since pictures were taken from the large pool of IAPS collection in which the selection of pictures was done by stratified randomization based on the standard means from IAPS, in order to include the various natures of universal emotional pictures (i.e., nature, people activity, tragedy and object), the emotional strength of the pictures was controlled by classifying pictures into different categories of arousal intensity (high, moderate and low). Moreover, the pleasantness (valence dimension) of pictures was also controlled as much as we can in which almost 75% of the pictures (N=22 from 30 pictures) were unpleasant images with normative mean of IAPS of less than 7 (high arousal = average mean valence of 3.7; moderate arousal = average mean valence of 5.2; low arousal = average mean valence of 6.1). Another point to be highlighted is that, the emotional components of P300 from the present finding indicated significant higher amplitude from the high arousal images in comparison to low arousal images (in the mid parietal area), a similarity that was almost found in Rozenkrants and Polich [24]. Negotiation of emotion is suggested to be influenced by attentional habituation – a feature of the interaction between cognitive and emotional processes which is associated with growing resistance to the image as a result of decreased responses to a stimulus after repeated presentations.[69] The robust effect of the arousal intensity has been reported earlier in hemodynamic and electrophysiological areas of studies,[19,70] with high arousal stimuli being recognized to elicit larger implication on the related neural substrates of emotion.[25] This fact was supported by Functional Magnetic Resonance Imaging (fMRI) finding as well, that pointed out the greater functional activity in emotional stimuli as com-

pared to neutral stimuli.[71] In line with this, biological psychology perspective has pointed the affective processing from the covariation of autonomic arousal intensity in affective response.[18] Another study, likewise, reported higher cortical positivity of the emotional than non-emotional stimuli.[72]

For the latency parameter, the effect of different arousal intensities was obvious, especially in the mid central and parietal regions of the P300 and N200 components, in which the significant longer latency was exhibited by high arousal images in comparison with low arousal images. This is perhaps parallel to some other findings that similarly showed the difference of duration taken to respond to positive and negative stimuli, between high and low arousal images.[20] In relation to this, it was seen that the fundamental mechanism of arousal indicated some lengthening effect on the perception of the duration of the process of emotion.[21]

Through the present findings, the Eysenck Theory on the connection between personality and the experience of subjective well-being, indeed, almost supported. Future research is suggested to further investigate the mechanism of the process of emotion from a more holistic perspective – cultural, biological and psychological.

5. Conclusions

The combination effect of three types of personality (extravert, ambivert and introvert) and intensity of emotional arousal (low, moderate, high) on the neural substrate of the emotional arousal process was examined in this study by using ERP technique with the emotional visual stimulation of IAPS to discover the spatio-temporal features of the effect of emotion. Emotional arousal, acting as a specifically targeted stimulus, stimulates the mid frontal region in extraverts, which is reflected by the latency of N200 component. The arousal emotional process in the mid frontal region was more stimulated in extraverts, than non-extraverts, pointing to the tendency of extraverts to experience higher subjective well-being which perhaps is associated with the superiority of extraverts in regulating emotions that in turn leads to higher experience of subjective well-being. Such findings almost go in line with the Eysenck Theory on the connection between extraversion and the experience of well-being.

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