Southeast Asia Psychology Journal
Volume 13, Issue 1 (2025), 190 – 211
e-ISSN 2710-544X

A CULTURAL NEUROSCIENCE PERSPECTIVE IN THE PROCESS OF EMOTION: A MALAYSIAN CONTEXT

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Received date: 13 December 2024; Accepted date: 04 April 2025

DOI: https://doi.org/10.51200/sapj.v13i1.5767

Abstract: Cultural factor plays a crucial role in shaping how emotions are experienced, expressed, regulated, and physiologically manifested during emotional arousal. This study examines electrophysiological evidence related to emotional arousal, using culturally relevant visual stimuli featuring Malaysian-oriented images. The research was conducted in two parts. In part one, 47 participants self-rated their emotional responses to a series of Malaysian-oriented images using the Self-Assessment Manikin (SAM), which ranged from 1 (calm) to 9 (excited). This process aimed to classify the images into low, moderate, and high arousal categories before programming them into E-Prime for electroencephalogram (EEG) recording. In part two, during an Event-Related Potential (ERP) session conducted in the Neuroscience Laboratory, participants (N=30) viewed the categorized images, which elicited varying levels of emotional intensity, while electroencephalography (EEG) was recorded using a 128-channel HydroCel GSN connected to a high-input impedance Net Amps 300 amplifier. Notable shifts in emotional arousal, particularly in the mid-frontal (Fz) and frontal polar regions (Fp1, Fp2), were reflected by the N200 amplitude. **However, no difference was observed in latency across all electrodes.** These results underscore the role of cultural context in shaping brain activity during emotional processing, highlighting the importance of incorporating cultural perspectives when examining the neural mechanisms of emotion and behavior.

Keywords: Electrophysiology, Emotion Processing, ERP N200 Component, Cultural Emotion

INTRODUCTION

Culture significantly influences emotion processing, shaping how individuals perceive, express, and regulate emotions. This effect is rooted in the shared norms, values, and beliefs of a cultural group, which drive emotional experiences and behaviors in various ways (Kwon & Kim, 2019). Cultural norms affect how emotions are interpreted and understood. In collectivist cultures (e.g., East Asian societies), these cultures emphasize group harmony and interdependence. As a result, individuals might focus more on context and the emotions of surrounding people when interpreting facial expressions. Emotions may be perceived in a way that considers social implications and group dynamics. Meanwhile in individualist cultures, such as western societies, personal goals and independence are prioritized. For example, people may focus more directly on the individual's facial expression to interpret emotions without heavily weighing contextual or group cues (Chua et al., 2022).

Culture also influences how emotions are expressed. Different cultures have specific rules governing the appropriateness of emotional expressions. In many East Asian cultures, overt expressions of strong emotions (such as anger or exuberant joy) may be restrained to maintain social harmony. On the other hand, Western cultures often encourage more open and direct emotional expressions (Kuppens et al., 2017). Culture, in addition, influences strategies used for regulating emotions. In cognitive reappraisal, collectivist cultures may emphasize strategies that promote reappraisal in a way that enhances group cohesion (e.g., reframing a situation to maintain peace). In some cultures, suppressing outward emotional displays is common to uphold social norms (Chen et al., 2017). Other than that, studies have found that East Asian individuals may use suppression more frequently without the same negative psychological impacts seen in Western cultures, due to cultural normalization of this strategy (Kwon & Kim, 2019).

Another dimension of cultures is that it shapes which emotions are valued or emphasized. Positive emotions like excitement and elation may be highly valued in Western, individualistic societies because they align with ideals of personal achievement and self-expression. Conversely, more subdued and calm positive states, like contentment and harmony, may be valued in collectivist cultures that prioritize balance and interdependence (Eliot & Kim, 2022; Kim et al., 1994). In terms of arousal preferences, cultural differences exist in preferences for high versus low arousal positive emotions. For example, Americans may seek high-arousal emotions like excitement, while Chinese people may prefer low-arousal positive states like calmness and serenity (Lim, 2016; Oya & Tanaka, 2023).

Culture also impacts the brain's emotional processing pathways. Neuroscience research like Functional Magnetic Resonance Imaging (fMRI) and Electroencephalogram (EEG) has shown that cultural context can modulate neural responses to emotional stimuli (Chiao, 2015; Pughet et al., 2022). The amygdala (associated with emotion processing) may react differently to emotional faces or images depending on whether the person comes from a culture that views emotional expressions as socially acceptable or not (Derntl et al., 2012; Malik & Marwaha, 2024). In the Event Related Potential (ERP) approach, cultural differences have been noted, where early components like N200 and P300 might show variation in response to culturally congruent versus incongruent stimuli, indicating differing levels of attention and emotional relevance (Chen et al., 2002; Fields, 2023; Spencer et al., 2018).

The cultural neuroscience perspective is a theoretical approach that examines how culture and biology interact to shape the human mind, brain, and behavior. It is grounded in the understanding that both cultural contexts and neural mechanisms influence each other dynamically and that this interaction is essential for understanding human diversity and universality (Chiao et al., 2020). In the cultural neuroscience perspective, the N200 component serves as a neurophysiological biomarker, providing valuable insights into the neuro-culture interaction in the human brain. The N200 (or N2) is an event-related potential (ERP) component that appears as a negative deflection in the electroencephalogram (EEG) waveform, typically occurring around 200 to 350 milliseconds after a stimulus is presented. It is most prominent at central and frontal scalp locations and plays an important role in various cognitive and emotional processes (Konig et al., 2021; Luck, 2005).

In emotion processing, the N200 is associated with the brain's initial stages of evaluating and responding to emotional stimuli (Gao et al., 2023). Specifically, the N200 reflects processes related to attention allocation, conflict detection, and stimulus discrimination. When processing emotional content, such as emotionally arousing images or sounds, the N200 can indicate the brain's early effort to distinguish between emotionally significant and neutral stimuli.

Research on emotion processing using electrophysiological evidence, such as EEG and ERP studies, has expanded our understanding of how different cultures experience and react to emotions. However, significant gaps remain, particularly concerning eastern populations like Malaysians as well as the limited cross-cultural electrophysiological studies that has to be paid attention. Most emotion processing studies with electrophysiological methods have been conducted in Western contexts (e.g. Vitolo et al., 2022). These studies have provided valuable insights but may not fully capture the unique cultural, social, and cognitive factors influencing emotion processing in eastern populations. Another point is that there is a scarcity of comparative EEG/ERP research that directly contrasts eastern populations, such as Malaysians, with western counterparts. This limits our understanding of how cultural norms shape neural responses to emotional stimuli differently across cultures. The lack of culturally relevant stimuli is another significant bias. Many studies use standardized emotional stimuli (e.g., the International Affective Picture System, IAPS), which are often designed with Western populations in mind. These may not elicit the same emotional responses or levels of arousal in Eastern populations due to cultural differences in the perception of emotional content. Therefore, the need for culturally tailored emotional stimuli that resonates with Eastern contexts is critical to ensure that findings are culturally valid and reflective of real-world experiences. While some theoretical models propose that cultural differences impact brain activity, empirical evidence from EEG and ERP studies on Eastern populations is lacking. This creates a need for integrated neuro-cultural models that combine electrophysiological evidence with cultural and psychological insights to offer a holistic understanding of emotion processing. Therefore, this study was conducted to examine the Malaysian emotional processes, as indexed by the neural correlates of the N200 brainwave component, evoked by visual affective stimuli aligned with the local culture of Malaysia.

METHODOLOGY

The study was carried out in two parts. In Part One, participants rated the arousal levels of Malaysian-oriented images using the Self-Assessment Manikin (SAM) scale, which ranged from one (calm) to nine (excited). The aim of Part One is to determine the emotional properties, specifically the arousal level, of the images for further classification into high, low and moderate categories. In different sample i.e., Part Two, participants viewed the selected images while their brain activity was captured using electroencephalography (EEG) to assess emotional arousal processing at different levels – high, moderate, low.

Part One: Categorization of Malaysian-Oriented Images into Different Arousal Levels

Population and Sample

For this cross-sectional study, we recruited undergraduate students from Universiti Sains Malaysia's Health Campus in Kubang Kerian, Kelantan. Initially, through the convenient sampling, 50 volunteers were selected, but three were excluded due to incomplete responses, resulting in a final sample of 47 participants who completed the task. Inclusion and exclusion criteria were defined for participant selection. Eligible participants were healthy young adults aged 18–35 years with no history of affective disorders. Individuals were excluded if they had uncorrected vision problems that impaired their ability to clearly view the images.

Majority of the participants in this Part One were female (91%, n=43), while males accounted for 9% (n=4). All participants were Malaysian (100%). The majority were bachelor's degree students (98%, n=46), with only one participant enrolled in a Diploma program (2%). No participants were pursuing master's or PhD programs. The age range of participants was between 19 and 22 years, with a mean age of 20 years (SD = 0.64). This distribution reflects a predominantly young, undergraduate sample.

Participants were asked to evaluate Malaysian-oriented images and classify their arousal levels as low, moderate, or high using the Self-Assessment Manikin (SAM) (Lang et al., 1997).

Study Procedure

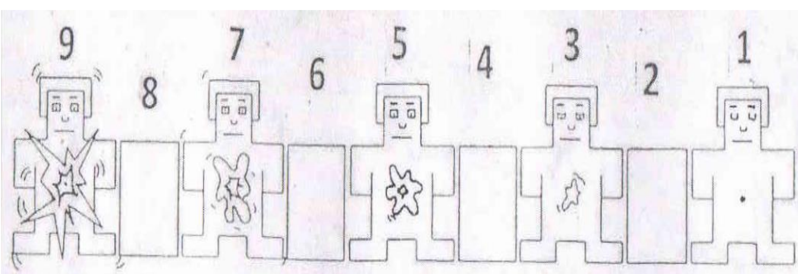
The study received ethical approval from the Human Ethical Committee of Universiti Sains Malaysia Health Campus (USM/JePeM/15040127). Participants were selected using convenience sampling, with recruitment facilitated through advertisements placed across the USM Health Campus.

Only volunteers who satisfied the established inclusion and exclusion criteria were eligible to participate.

Sixty Malaysian affective images, free of copyright restrictions, were purposefully selected from online sources. These images covered various genres, including physical objects (e.g., food, traditional games, and buildings), human activities, and culturally significant events. All images were chosen based on their alignment with the Malaysian Nusantara identity. For instance, objects like *ketupat palas* and *wau bulan*, declared as tangible Malay cultural heritage by the Department of National Heritage Malaysia (2020), were included. Meanwhile, images depicting human activities and culturally relevant events were specifically chosen to reflect situations unique to Malaysia, avoiding representations from other cultural backgrounds. Examples include scenes of cow slaughtering during *Eid al-Adha*, feasts (*kenduri*), and similar activities. For these images depicting human activities and culturally relevant events, we sought the opinion and approval of an academic expert in an area of culture and community within the Malaysian population.

To ensure the images were categorized according to their emotional properties (i.e., level of arousal), 47 participants were invited to evaluate them using the paper-based Self-Assessment Manikin (SAM) scale, which ranges from 1 (calm) to 9 (excited). Out of the 60 images, 15 were randomly selected and categorized into three arousal levels based on their SAM ratings: 5 low-arousal images (scores of 1–3), 5 moderate-arousal images (scores of 4–6), and 5 high-arousal images (scores of 7–9) (Figure 1).

Figure 1: Emotional continuum of Self-Assessment Manikin (SAM) for arousal domain – 1 (Calm) to 9 (Excited)



To ensure effective stimulation, the selected images were of high quality and vividly represented human activities or culturally significant Malaysian events. Participants evaluated their emotional responses to each image using a 9-point scale. The images were subsequently uploaded into the E-Prime system for further measurement in Part two i.e., EEG recording. The internal consistency of the 15 chosen images demonstrating excellent reliability with a Cronbach's alpha of 0.92

For the next part of the study i.e Part Two, different participants were recruited, as below.

Part Two: Electroencephalography (EEG) Recording – An Event-Related Potential (ERP) Technique at the Neuroscience Laboratory

Population and Sample

In Part two, 30 participants aged 18-35 were recruited from Universiti Sains Malaysia's Health Campus through convenience sampling, with informed consent obtained from all participants. The inclusion criteria specified that participants must be right-handed young adults with normal or corrected vision, no family history of psychiatric disorders, and no current use of psychiatric medications. Exclusion criteria ruled out individuals with alcohol or drug dependence, major medical conditions, visual impairments, a history of seizures or loss of consciousness, chronic smoking habits, or a history of alcohol abuse.

Majority of the participants were female (87%, n=26), while males made up 13% (n=4). In terms of ocular dominance, most participants were right-eye dominant (77%, n=23), with the remaining 23% (n=7) being left-eye dominant. Regarding the level of study, 60% of participants (n=18) were bachelor’s degree students, while 3% (n=1) were enrolled in a Diploma program. Missing data accounted for 23% (n=7) of participants. All participants were Malaysian (100%). The age range was between 21 and 28 years, with a mean age of 23 years (SD = 1.6), representing a slightly older group compared to typical undergraduate samples.

Procedures

EEG recordings were conducted in the ERP laboratory at the Universiti Sains Malaysia Specialist Hospital, located in Kubang Kerian, Kelantan. Participants received thorough instructions both in advance and on the day of the experiment to reduce potential errors and disruptions. Before an EEG recording, subjects were reminded to avoid several factors that could introduce artifacts or affect brain activity, including lack of sleep and certain dietary habits (such as consuming caffeine, nicotine, alcohol, and recreational drugs). Subjects were also reminded to avoid using hair products, such as gels, oils, and sprays, as these may interfere with electrode contact and signal quality. After the study procedures were explained, participants gave written consent and completed an ocular dominance test before the recording session began.

Participants were fitted with the EEG net in the ERP recording room (Figure 2). To ensure high-quality recordings, the scalp impedance was adjusted before each session, improving the electrical connection between the electrodes and the scalp. Both verbal and written briefings were provided to explain the study procedures, highlighting the voluntary nature of participation and the right to withdraw at any time. Participants were also encouraged to ask questions about the study and its processes before continuing.

EEG data were collected using a 128-channel HydroCel Geodesic Sensor Net. The sensor net was meticulously positioned on each participant's head following standard electrode placement protocols to ensure precise positioning and high-quality data acquisition. Additionally, participants completed basic demographic and medical questionnaires to provide essential background information.

Figure 2: Application of 128 HydroCel Geodesic Sensor Net on participant head

The study consisted of 45 trials, divided into three repeated blocks, with stimuli presented in equal proportions across three arousal levels: high, moderate, and low (1:1:1). The E-Prime system automatically adjusted all Malaysian affective images to a resolution of 640 x 480 pixels, displayed centrally against a black background (Figures 3a & 3b). Each trial followed a randomized sequence generated by the E-Prime system, beginning with a black screen, followed by a 500-ms white fixation point, a 500-ms blank black screen, and a 1500-ms display of a Malaysian affective image. The next trial started immediately after the completion of the previous one. The timing sequence in the Event-Related Potential (ERP) paradigm is carefully designed to ensure reliable and interpretable data. The black screen at the beginning serves as a baseline period, providing a neutral reference for analyzing brain activity. The 500-ms white fixation point that follows focuses the participant's attention on the screen and standardizes their gaze, ensuring they are prepared for the stimulus. A 500-ms blank black screen acts as a buffer, minimizing potential overlap of brain responses from the fixation point and the upcoming stimulus. The Malaysian affective image is displayed for 1500 ms to allow sufficient time for the participant to process the emotional and cognitive content of the image, which involves both immediate sensory perception and subsequent evaluations. Finally, the next trial starts immediately after the previous one to maintain engagement and experimental flow while optimizing data collection. This sequence effectively isolates specific neural responses, reduces variability, and aligns with standard ERP methodologies for studying emotional and cognitive processing.

EEG data were recorded using a 128-channel HydroCel Geodesic Sensor Net (Electrical Geodesics Inc., Eugene), connected to a high-input impedance Net Amps 200 amplifier. EEG signals were recorded from 19 electrode sites: C3, Cz, C4, Fp1, F7, F3, Fz, Fp2, F4, F8, T3, T5, T4, T6, P3, Pz, P4, O1, and O2.

ERP Component extraction and analysis

Before conducting the statistical analysis, raw ERP data i.e. the amplitudes and latencies at 19 electrode sites (Cz, C3, C4, Fp1, F7, F3, Fz, Fp2, F4, F8, T3, T5, T4, T6, P3, Pz, P4, O1, and O2) were processed through a series of standardized steps, including filtering, segmentation, artifact detection, bad channel replacement, averaging separately, montage operation, baseline correction, data combination, and final averaging, followed by statistical extraction. Given its relevance to information processing and visual cognition, the N200 ERP component was the primary focus of this study. Further data analysis was carried out using IBM SPSS software version 24, with a 95% confidence level and an alpha value set to less than 0.05 for statistical significance. All ERP data were checked for any violations of assumptions and distribution. We then performed repeated measures ANOVA to analyze peak amplitudes and latency across the three levels of emotional arousal: low, moderate, and high. Mauchly's test of sphericity was used to test for sphericity assumptions, and when necessary, the Huynh-Feldt correction was applied to adjust the degrees of freedom for the F-ratio.

Figure 3a: Schematic diagram of Event Related Potential technique

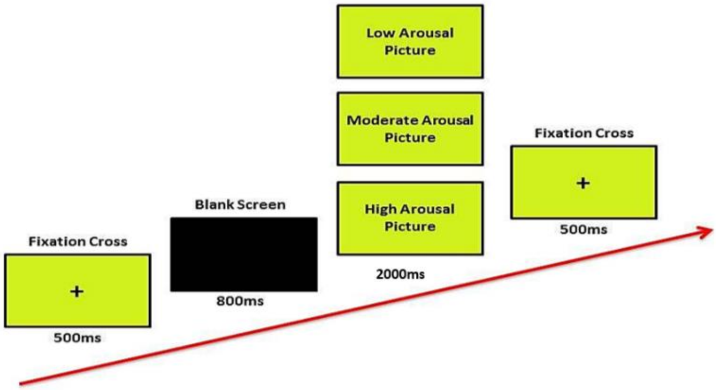


Figure 3b: An example of various arousal levels of Malaysian-oriented images used as visual stimuli in ERP

RESULTS

Electrophysiological data of N200

The analysis of N200 latencies across different levels of arousal showed no significant trends in any of the frontal regions (Fp1, Fp2, F7, F3, Fz, F4, and F8). For the Fp1 electrode, the sphericity test indicated no violation (X^2 (2) = 1.004, p = .605), suggesting no significant difference in arousal levels: low (mean = 298.13, SD = 78.03), moderate (mean = 273.73, SD = 82.10), or high (mean = 272.53, SD = 81.18). Likewise, Fp2 showed no assumption violations (X^2 (2) = 1.104, p = .576), and the repeated measures ANOVA confirmed that the Malaysian images did not evoke significant emotional arousal (F (2, 58) = .750, p > .05, η^2 = .025).

Although emotional arousal was slightly higher at the moderate level (mean = 280.00, SD = 76.71) compared to the high (mean = 273.60, SD = 76.58) and low (mean = 260.93, SD = 78.68) arousal levels, these differences were not statistically significant. The F3 electrode also showed no violation of assumptions (X^2 (2) = 2.466, p = .291). A one-way within-subjects ANOVA revealed no significant effect of arousal level on N200 latencies (F (2, 58) = 2.769, p > .05, η^2 = .087) across the low (mean = 291.87, SD = 66.46), moderate (mean = 265.33, SD = 68.51), and high (mean = 262.00, SD = 70.11) arousal levels.

For the F7 electrode, the results showed no significant differences in arousal levels (X^2 (2) = .688, p = .709), with mean latencies of 290.67 (SD = 69.48) for low, 267.47 (SD = 71.98) for moderate, and 258.00 (SD = 62.94) for high arousal. The repeated measures ANOVA revealed a small effect size (F (2, 58) = 2.062, p > .05, η^2 = .066), further confirming the lack of significant differences.

Similarly, the midline frontal electrode Fz showed no significant differences in arousal levels (X^2 (2) = 1.037, p = .595). The ANOVA results indicated no substantial effect of arousal on N200 latencies across low (mean = 290.00, SD = 74.25), moderate (mean = 276.67, SD = 65.64), and high (mean = 268.93, SD = 69.48) arousal levels. This pattern was consistent with the F4 electrode, where the sphericity test showed no significant effect (X^2 (2) = .332, p = .847; F(2, 58) = .069, p > .05, η^2 = .002) across low (mean = 261.87, SD = 78.82), moderate (mean = 267.47, SD = 61.61), and high (mean = 263.87, SD = 68.58) arousal levels.

Lastly, electrode F8 showed no significant differences in arousal levels (X^2(2) = .688, p = .709). The within-subject ANOVA confirmed that the Malaysian images did not significantly affect emotional arousal at low (mean = 254.27, SD = 68.24), moderate (mean = 266.13, SD = 60.84), or high (mean = 282.00, SD = 70.96) levels. Overall, the N200 latency analysis for the frontal electrodes showed no significant relationship between emotional arousal levels and the Malaysian affective images. Table 1 summarizes the main findings for latencies at these frontal electrodes.

Table 1: Difference in N200 Latencies at Frontal Brain Area

	Level	Mean (SD)	95% CI	F	p-value	ηp2
Fp1	High	272.53 (81.176)	242.22-302.85	1.682	0.195	0.055
	Moderate	273.73 (82.101)	243.08-304.40	(SA)		
	Low	298.13 (78.029)	269.00-327.28			
Fp2	High	273.60 (76.579)	245.01-302.20	0.750	0.477	0.025
	Moderate	280.00 (76.705)	251.36-308.64	(SA)		
	Low	260.93 (78.684)	231.55-290.31			
F3	High	262.00 (70.111)	235.82-288.18	2.769	0.071	0.087
	Moderate	265.33 (68.508)	239.75-290.92	(SA)		
	Low	291.87 (66.457)	267.05-316.68			
F7	High	258.00 (62.937)	232.26-282.94	2.062	0.136	0.066
	Moderate	267.47 (71.975)	240.60-294.34	(SA)		
	Low	290.67 (69.483)	264.72-316.61			
Fz	High	268.93 (69.478)	242.99-294.88	0.986	0.379	0.033

	Moderate	276.67 (65.635)	252.16-301.18	(SA)		
	Low	290.00 (74.247)	262.28-317.72			
F4	High	263.87 (68.582)	238.26-289.48	0.069	0.933	0.002
	Moderate	267.47 (61.608)	244.46-290.47	(SA)		
	Low	261.87 (78.824)	232.43-291.30			
F8	High	282.00 (70.964)	255.50-308.50	1.937	0.153	0.063
	Moderate	266.13 (60.842)	243.41-288.85	(SA)		
	Low	254.27 (68.236)	228.79-279.75			

Note: SD= standard deviation, 95% CI = 95% confidence interval, SA – Sphericity Assumed (Mauchly's test non-significant), SNA-HF - Sphericity not assumed (Huynh- Feldt correction), $\eta p2$= partial eta-squared
* Significant at <.05

We recorded the peak amplitude of the N200 component in the frontal region (Fp1, Fp2, F7, F3, Fz, F4, and F8). For the left frontal polar electrode (Fp1), the analysis revealed no significant differences in arousal levels (X^2 (2) = .688, p = .709). However, a significant interaction was observed between amplitude and arousal levels (F (2, 58) = 3.273, p < .05, η^2 = .101). Specifically, moderate arousal (mean = 4.211, SD = 3.561) differed significantly from both high (mean = 2.676, SD = 2.283) and low arousal (mean = 3.818, SD = 3.660). Pairwise comparisons confirmed significant differences between moderate and high arousal (p < .05), indicating that the Fp1 electrode region experienced moderate stimulation evoked by Malaysian images.

For the right frontal polar electrode (Fp2), the assumption of sphericity was met (X^2 (2) = 3.061, p = .216). A one-way ANOVA revealed a significant effect of emotional arousal on amplitude (F (2, 58) = 4.361, p < .05). Arousal was higher at the moderate level (mean = 4.361, SD = 2.668) compared to low (mean = 3.611, SD = 2.962) and high (mean = 2.693, SD = 2.741), with pairwise comparisons showing significant differences between moderate and high arousal (p < .05).

For the F3 electrode, sphericity was maintained (X^2 (2) = 1.569, p = .456), but there was no significant interaction between amplitude and arousal levels (F (2, 58) = 1.447, p > .05, η^2 = .048). Arousal levels did not differ significantly across the low (mean = 2.541, SD = 2.290), moderate (mean = 2.005, SD = 1.601), and high (mean = 2.054, SD = 1.613) levels.

Finally, the F7 electrode violated the assumption of sphericity (X^2 (2) = 30.079, p = .000), necessitating the use of the Huynh-Feldt correction. The analysis indicated no significant effect of Malaysian images on arousal (F (1.513, 43.875) = .452, p > .05, η^2 = .027), with no significant differences observed for low (mean = 2.999, SD = 4.473), moderate (mean = 1.995, SD = 1.841), or high (mean = 2.182, SD = 2.114) levels of arousal.

At the midline frontal electrode (Fz), sphericity was not violated (X^2 (2) = .051, p = .975), and a significant effect of arousal on amplitude was observed (F (2, 58) = 3.518, $p < .05$, $\eta^2 = .108$). Moderate arousal (mean = 3.094, SD = 2.131) differed significantly from both high (mean = 2.084, SD = 1.590) and low arousal (mean = 2.617, SD = 2.291). Pairwise comparisons confirmed significant differences between moderate-to-high and low-to-moderate arousal ($p < .05$), indicating moderate stimulation at the Fz electrode evoked by the Malaysian pictures.

For the F4 electrode, sphericity was maintained ($X^2(2) = .484$, p = .785), but no significant differences were found in arousal levels (F(2, 58) = .807, $p > .05$, $\eta^2 = .027$) across low (mean = 1.804, SD = 1.637), moderate (mean = 2.278, SD = 2.087), and high arousal (mean = 2.271, SD = 2.854).

Lastly, the F8 electrode violated the sphericity assumption (X^2 (2) = 13.109, p = .001), necessitating a Huynh-Feldt correction. The analysis revealed no significant effect of emotional arousal (F (1.513, 43.875) = .452, $p > .05$, $\eta^2 = .027$), with mean values of 1.876 (SD = 1.941) for low, 1.992 (SD = 1.859) for moderate, and 2.326 (SD = 3.537) for high arousal levels.

In conclusion, the amplitude analysis for frontal electrodes showed that Malaysian affective images significantly evoked emotional arousal at the Fp1, Fp2, and Fz electrode sites. However, no significant effects were observed at F3, F4, F7, and F8. Table 2 summarizes the main findings for amplitudes at these frontal electrodes.

Table 2: Differences in N200 Amplitudes at Frontal Brain Area

	Level	Mean (SD)	95% CI	F	p-value	ηp2
Fp1	High	2.676 (2.283)	1.823-3.528	3.273	0.045*	0.101
	Moderate	4.211 (3.561)	2.881-5.541	(SA)		
	Low	3.818 (3.660)	2.451-5.184			
Fp2	High	2.693 (2.741)	1.670-3.717	3.832	0.027*	0.117
	Moderate	4.361 (2.668)	3.364-5.357	(SA)		
	Low	3.611 (2.962)	2.505-4.717			
F3	High	2.054 (1.613)	1.452-2.656	1.447	0.244	0.048
	Moderate	2.005 (1.601)	1.407-2.603	(SA)		
	Low	2.541 (2.290)	1.687-3.397			
F7	High	2.182 (2.114)	1.393-2.972	1.678	0.205	0.055

	Moderate	1.995 (1.841)	1.308-2.683	(SNA-		
	Low	2.999 (4.473)	1.328-4.669	HF)		
Fz	High	2.084 (1.590)	1.491-2.678	3.518	0.036*	0.108
	Moderate	3.094 (2.131)	2.298-3.890	(SA)		
	Low	2.617 (2.291)	1.761-3.473			
F4	High	2.271 (2.854)	1.205-3.336	0.807	0.451	0.027
	Moderate	2.278 (2.087)	1.499-3.057	(SA)		
	Low	1.804 (1.637)	1.193-2.416			
F8	High	2.326 (3.537)	1.005-3.646	0.452	0.585	0.015
	Moderate	1.992 (1.859)	1.298-2.687	(SA)		
	Low	1.876 (1.941)	1.151-2.601			

Note: SD= standard deviation, 95% CI = 95% confidence interval, SA – Sphericity Assumed (Mauchly's test non-significant), SNA-HF - Sphericity not assumed (Huynh-Feldt correction), ηp2= partial eta-squared, *Significant at <.05

DISCUSSION

These findings highlight the importance of considering culture as a dimension in emotion processing studies. The significance of N200 amplitude changes in response to emotional arousal suggests that cultural values shape the underlying neural mechanisms.

The heightened N200 amplitude in areas like the mid-frontal (Fz) and frontal polar (Fp1, Fp2) may reflect culturally influenced attention to emotional stimuli that align with social values. It points to a deep interconnection between neural processing and cultural factors. These changes could reflect the brain's adaptation to cultural values surrounding emotion, cognition and attention. These current findings have a connection with Malaysian population trait (i.e. collectivist culture trait) - stronger neural responses to emotional cues that signify social approval or disapproval, as these are more pertinent to maintaining group harmony.

As no other studies have specifically highlighted the significant role of N200 amplitude at the mid-frontal and frontal polar regions, our findings represent a novel contribution to the neuroscience field concerning cultural emotion. Several studies within cross-cultural psychology have provided evidence that supports this argument.

Errasti et al (2018) suggested variations between eastern (Thailand participants) and western (Spanish participants) samples at various cultural level. The Thai sample had higher scores in affective empathy but lower scores in cognitive empathy, engaged in more emotional and empathic expression. The different behavioral intentions of collectivists and individualists in response to social exclusion was highlighted by Pfundmair et al. (2015). In this study, participants with more individualistic orientation indicated more antisocial behavioral intentions in response to exclusion (a complex and multifaceted phenomenon that refers to the denial or limitation of people's participation in the economic, social, and cultural life) society than in response to inclusion (The concept that is closely tied to equality, social cohesion, and human rights, aiming to address barriers that prevent meaningful societal participation); however, participants with more collectivistic orientation did not differ in their behavioral intentions between exclusion and inclusion. Building on this, Vishkin et al (2023) suggest that adherence to emotion norms would be greater in individualist than in collectivist cultures. In line with their prediction, they found that in countries higher in individualism, emotional experiences of individuals were more homogenous and more concordant with the emotions of others in their culture. Furthermore, in more individualist countries, deviation from the mean emotional experience was linked to lower life satisfaction, a phenomenon that may be influenced by heightened attentional sensitivity to social or emotional discrepancies. This aligns with the role of the N200 component, which is associated with attentional processes such as detecting conflicts or unexpected stimuli (Shaharum et al., 2024).

In a culture where social norms and emotional cues are highly valued, there might be an enhanced N200 response when individuals process emotional information that aligns or conflicts with these norms. In Malaysian culture, emotions that signify respect, humility, or social conformity might evoke a more pronounced N200 response due to their importance in daily social interactions. This suggests that cultural context primes individuals to pay more attention to certain emotional cues, influencing how the brain allocates attention and processes these emotions.

The mid-frontal and frontal polar areas are associated with higher cognitive functions, including emotion regulation and the integration of emotional and social information (e.g. Ku et al., 2022). In a culture where maintaining emotional control is valued, an enhanced N200 amplitude in these areas may indicate an increased cognitive effort to process and regulate emotional arousal in line with cultural expectations. If certain levels of emotional arousal are perceived differently within a cultural framework, this could manifest in distinct neural signatures. Low-arousal emotions may be seen as more acceptable or desirable in some Eastern cultures, while high-arousal states might trigger stronger regulatory responses as they are less socially favored.

The observed changes in N200 amplitude support the idea that cultural contexts influence how emotional information is processed at the neural level. Developing neuro-cultural models that integrate cultural psychology, and neuroscience can provide deeper insights into these mechanisms. Such insights emphasize the need for culturally nuanced interpretations of neuroscientific data and suggest that cultural influences are integral to how emotional information is processed at the neural level. This fact can inform clinical practices, such as designing culturally sensitive interventions for emotional and psychological disorders.

While N200 amplitude showed significant activation in the mid-frontal (Fz) and frontal polar regions (Fp1, Fp2), N200 latency did not show any significant differences across electrodes. It should be noted that latency reflects processing speed, while amplitude reflects processing intensity. Thus, this pattern indicates that the processing of cultural images required greater neural engagement but did not take additional time. The increased N200 amplitude in frontal regions suggests heightened cognitive control, attention allocation, or conflict monitoring when processing culturally relevant images. Since the latency remained unchanged, this implies that all images were processed within a similar time frame, suggesting that recognizing or categorizing these cultural images did not require extra processing time

These findings can be situated within the broader framework of cross-cultural neuroscience, which examines how cultural values and practices shape neural and psychological processes. In collectivist cultures, such as those prevalent in many Eastern societies like Malaysia, social harmony, interdependence, and emotional regulation are prioritized (Liu et al., 2021). This emphasis on group cohesion often requires individuals to adapt their emotional expressions to align with social norms, fostering a heightened sensitivity to emotional cues. The observed enhancement of N200 amplitude in certain brain regions aligns with this pattern, reflecting increased cognitive effort to monitor, integrate, and regulate emotional arousal in line with societal expectations.

The current findings open up several potential avenues for future research. It is suggested that researchers implement cross-cultural neuroscience studies (such as ERP) using standardized emotional stimuli and culturally tailored stimuli to assess the generalizability of the findings. Future research should give more attention to the impact of social and environmental contexts i.e., how social context (e.g., viewing images alone vs. in a group) and environmental cues affect N200 amplitude related to emotional arousal. The rationale is that eastern cultures often emphasize group dynamics and social harmony; testing how social settings influence emotional processing could reveal context-dependent neural responses. The potential methods that can be integrated are to include experimental conditions where participants are exposed to emotional stimuli in different social settings and record EEG data to capture variations. Future research can also delve further into clinical applications and psychological interventions with the aim of exploring how findings on N200 amplitude in emotion processing can be applied to clinical interventions for mood and anxiety disorders within specific cultural settings. The combination method in neuroscience and clinical psychology is suggested to investigate how therapeutic approaches (e.g., mindfulness, cognitive behavioral therapy) affect N200 responses during emotional arousal.

One possible limitation of this study is about the generalizability of the results. The significant changes in emotional arousal marked by the N200 amplitude in the mid-frontal (Fz) and frontal polar (Fp1, Fp2) areas might be culturally specific and influenced by factors unique to the Malaysian context. This could limit the broader applicability of the findings to other cultural settings. Additionally, consider whether the sample and demographic characteristics (e.g., a young age group living in a specific geographic area, such as Kota Bharu, Kelantan, and predominantly female participants) could impact the robustness and replicability of these findings across different populations. Another potential limitation could involve the specificity of the emotional stimuli used and whether they are equally representative or impactful for diverse cultural groups.

CONCLUSION

The current research on the neural substrate of the emotion process in the Malaysian context, using a cultural neuroscience approach, has revealed significant insights into how emotional arousal manifests in brain activity. The significant changes in the N200 amplitude suggest that certain parts of the brain regions play a critical role in the early processing of emotional stimuli, within the cultural context. This highlights the importance of considering cultural factors when examining the neural basis of emotional processing, as they may influence the activation patterns in specific brain areas. These findings could be expanded by incorporating diverse stimuli or comparing results with data from other cultural groups to better understand the universality and specificity of these neural patterns.

Informed Consent Statement

All participants provided written informed consent prior to their involvement in the study, in accordance with the Declaration of Helsinki.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this paper.

Ethics Statement

This study was conducted in accordance with the ethical guidelines and approved by the Human Research Ethic Committee (HREC), Universiti xx (xx/xx/15040127).

Author Contributions

TR conceptualized and designed the study, as well as conducted data collection and analysis. NY provided supervision throughout the research process. All authors contributed to the drafting, critical revision, and final approval of the manuscript.

Funding

No

Acknowledgement

Universiti xx for research facilities.

Data Availability Statement

The data presented in this study are available upon request from the corresponding author.

REFERENCES

Chen, T. J., Yu, Y. W., Chen, J. Y., Wang, Y. C., Chen, M. C., Hong, C. J., & Tsai, S. J. (2002). Association analysis of two dopamine D2 receptor gene polymorphisms and P300 event-related potential in depressive patients. *Neuropsychobiology, 46*(3), 141–144.

Chen, S., Deng, Z., Xu, Y., Long, Q., Yang, J., & Yuan, J. (2017). Individual differences in spontaneous expressive suppression predict amygdala responses to fearful stimuli: The role of suppression priming. *Frontiers in Psychology, 8,* 1.

Chiao, J. Y. (2015). Current emotion research in cultural neuroscience. *Emotion Review, 7*(3), 280–293.

Chiao, J. Y., Li, S. C., Turner, R., & Lee-Tauler, S. Y. (2020). Cultural neuroscience and the research domain criteria: Implications for global mental health. *Neuroscience & Biobehavioral Reviews, 116,* 109–119.

Chua, S. Y. P., Rentzelas, P., Frangou, P., Kourtzi, Z., Lintern, M., & Mavritsaki, E. (2022). Cultural differences in visual perceptual learning. *International Journal of Psychology, 57*(3), 377–386.

Department of National Heritage Malaysia. (2020). *Perisytiharan warisan kebangsaan [Declaration of national heritage 2015]*. https://www.hrdnet.com.my/department-of-national-heritage.html

Derntl, B., Habel, U., Robinson, S., Windischberger, C., Kryspin-Exner, I., Gur, R. C., & Moser, E. (2012). Culture but not gender modulates amygdala activation during explicit emotion recognition. *BMC Neuroscience, 29*(13), 54.

Eliot, C. W., & Kim, D. (2022). *The conflict between individualism and collectivism in a democracy*. New York, NY: SAGE Publications, Inc.

Errasti, J. M., Amigo Vázquez, I., Villadangos, M., & Morís, J. (2018). Differences between individualist and collectivist cultures in emotional Facebook usage: Relationship with empathy, self-esteem, and narcissism. *Psicothema, 30*(4), 376–381.

Fields, E. C. (2023). The P300, the LPP, context updating, and memory: What is the functional significance of the emotion-related late positive potential? *International Journal of Psychophysiology, 192,* 43–52.

Gao, C., Uchitomi, H., & Miyake, Y. (2023). Influence of multimodal emotional stimulations on brain activity: An electroencephalographic study. *Sensors (Basel), 23*(10), 4801.

Kim, U., Triandis, H. C., Kagitcibasi, C., Choi, S. C., & Yoon, G. (1994). *Individualism and collectivism: Theory, method, and applications*

(Cross cultural research and methodology). New York, NY: SAGE Publications, Inc.

Konig, N., Steber, S., Borowski, A., Bliem, H. R., & Rossi, S. (2021). Neural processing of cognitive control in an emotionally neutral context in anxiety patients. *Brain Sciences, 11*(5), 543.

Ku, L. C., Allen, J. J. B., & Lai, V. T. (2022). Attention and regulation during emotional word comprehension in older adults: Evidence from event-related potentials and brain oscillations. *Brain and Language, 227*, 105086.

Kuppens, P., Tuerlinckx, F., Yik, M., Koval, P., Coosemans, J., Zeng, K. J., & Russell, J. A. (2017). The relation between valence and arousal in subjective experience varies with personality and culture. *Journal of Personality, 85*(4), 530–542.

Kwon, H., & Kim, Y. H. (2019). Perceived emotion suppression and culture: Effects on psychological well-being. *International Journal of Psychology, 54*(4), 448–453.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). *International Affective Picture System (IAPS): Technical manual and affective ratings*. Gainesville, FL: NIMH Center for the Study of Emotion and Attention.

Lim, N. (2016). Cultural differences in emotion: Differences in emotional arousal level between the East and the West. *Integrative Medicine Research, 5*(2), 105–109.

Liu, S. S., Shteynberg, G., Morris, M. W., Yang, Q., & Galinsky, A. D. (2021). How does collectivism affect social interactions? A test of two competing accounts. *Personality and Social Psychology Bulletin, 47*(3), 362–376.

Luck, S. (2005). *An introduction to the event-related potential technique*. Cambridge, MA: MIT Press.

Malik, F., & Marwaha, R. (2024). Developmental stages of social emotional development in children. Cambridge: StatPearls Publishing.

Oya, R., & Tanaka, A. (2023). Cross-cultural similarity and cultural specificity in the emotion perception from touch. *Emotion, 23*(5), 1400–1409.

Pfundmair, M., Graupmann, M., Frey, D., & Aydin, N. (2015). The different behavioral intentions of collectivists and individualists in response to social exclusion. *Personality and Social Psychology Bulletin, 41*(3), 363–378.

Pugh, Z. H., Choo, S., Leshin, J. C., Lindquist, K. A., & Nam, C. S. (2022). Emotion depends on context, culture and their interaction: Evidence from effective connectivity. *Social Cognitive and Affective Neuroscience, 17*(2), 206–217.

Shaharum, M. H., Yusoff, N., Reza, F., Ismail, R., Kueh, Y. C., & Azman, A. (2024). Moral internalization influences the attentional bias to smoking and non-smoking stimuli in Malaysian youth. *Medicine & Health, 19*(1), 173–191.

Sims, T., Koopmann-Holm, B., Young, H. R., Jiang, D., Fung, H., & Tsai, J. L. (2018). Asian Americans respond less favorably to excitement (vs. calm)-focused physicians compared to European Americans. *Cultural Diversity and Ethnic Minority Psychology, 24*(1), 1–14.

Spencer, H., Heitland, I., Montoya, E. R., Branje, S. J. T., & Bos, P. A. (2018). Ethnic effects when facing children: An ERP study. *Biological Psychology, 138*, 56–62.

Vishkin, A., Kitayama, S., Berg, M. K., Diener, E., Gross-Manos, D., Ben-Arieh, A., & Tamir, M. (2023). Adherence to emotion norms is greater in individualist cultures than in collectivist cultures. *Journal of Personality and Social Psychology, 124*(6), 1256–1276.

Vitolo, E., Diano, M., Giromini, L., & Zennaro, A. (2022). Markers of emotion regulation processes: A neuroimaging and behavioral study of reappraising abilities. *Biological Psychology, 171*, 108349.