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Cultural resonance in the brain: EEG-Based insights into emotional engagement with festive imagery

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Abstract Festive imagery is fundamental in constructing cultural identity, affective resonance, and collective memory. The neural engagement patterns in Kolkata individuals, upon viewing familiar and unfamiliar festive images, have been studied by using electroencephalography (EEG) as an on-line, non-invasive indicator of neural activity. In particular, the study compares participants' neural reactions to images of the Onam festival of Kerala—a culturally unfamiliar festival—to those of Durga Puja celebrations outside Kolkata, which, although culturally familiar, are not immediately geographically specific. The EEG parameters that were assessed were cognitive load, emotional arousal, neural stimulation, and frontal lobe activation linked to attention and affective processing. Results show that novel but colorful festive images like Onam had greater and longer-lasting cognitive and emotional activation than familiar Durga Puja images. Such increased activation was associated with augmented beta and gamma wave activity, reflecting high arousal and attention, as well as marked frontal lobe activation. The findings indicate that novelty, visual symbolism, and the richness of cultural representations have a central role to play in the modulation of cognitive processing and emotional resonance, even among culturally homogenous populations. The research adds to the growing body of literature in neuroaesthetics and cultural neuroscience by demonstrating how culturally unfamiliar but symbolically dense images can elicit profound cognitive and affective responses. These findings have implications for intercultural communication, visual media design, and festival tourism promotion, where strategic deployment of culturally diverse imagery can increase audience engagement and emotional resonance.

Keywords: excitement, love-themed advertisements, frontal activation, arousal, affective computing, adaptive learning

1. Introduction

Festivals hold a central place in the cultural life of India, providing rich, multisensory experiences that capture the shared memories, feelings, and identities of local communities. They are not just social events but also dynamic cultural performances imbued with symbolic narratives, rituals, and visual aesthetics. The sensory abundance of festivals — in terms of colors, images, music, and performances — provokes strong affective and cognitive involvement from participants and spectators alike (Sarma & Viswanathan, 2021). Yet, how people neurologically process culturally familiar as opposed to unfamiliar festive imagery, especially within a single country characterized by huge cultural diversity like India, is not well studied.

Current studies in cultural neuroscience highlight that the brain's reaction to cultural information is influenced by familiarity and novelty, regulating neural activation patterns implicated in attention, emotion, and memory (Chiao et al., 2021; Han & Ma, 2023). Familiar cultural experiences tend to engage neural networks implicated in autobiographical memory, social identity, and emotional comfort (Li et al., 2020). In contrast, novel cultural stimuli trigger increased neural activation and cognitive processing as the brain struggles to decode novel symbols and contextual cues (Wang et al., 2022). EEG studies have demonstrated that exposure to new cultural symbols can greatly enhance beta and gamma band activity, indicative of increased cognitive load and emotional engagement (Singh et al., 2022; Kim et al., 2020).

In addition, affective neuroscience research indicates that cultural strangeness in visual stories tends to activate frontal lobe areas involved in attentional control and emotional evaluation (Park & Georgiou, 2022). Cross-cultural research on visual interest has established that people react more intensely, both neurally and affectively, to novel and symbolically dense images than to familiar, routine images (Cheon et al., 2021). Although a number of these studies have addressed cross-cultural

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international contrasts, there is a conspicuous shortage of research in intra-national cultural neuroscience, especially in nations such as India, in which regional celebrations vary significantly in iconography, symbolism, and social significance.

This work fills this knowledge gap by examining EEG-based patterns of neural activation among participants from Kolkata upon seeing images of two culturally different celebrations: Onam, a major harvest celebration of Kerala that remains culturally foreign to many in Eastern India, and Durga Puja celebrations of other locations beyond Kolkata, which are culturally native but without local personal and environmental reference. Through the analysis of parameters like cognitive load, emotional arousal, neural stimulation, and frontal lobe activation, this research aims to explore whether novel but vivid festive imagery provokes stronger and more enduring neurological responses than non-festive yet familiar images.

Conclusions based on this work seek to inform the growing paradigms of cultural neuroscience, neuroaesthetics, and affective visual communication by showcasing how cultural newness, symbol richness, and contextual dissonance shape cognition and emotional participation. The findings have implications in fields such as visual media composition, cross-cultural marketing, tourism promotion of festivals, and curatorship of collective memory in plural societies.

2. Methodology

2.1. Participants

We recruited 30 adult participants (15 male, 15 female) between 20 and 35 years old (M = 26.8, SD = 3.7) from urban and semi-urban Kolkata, West Bengal. The participants self-reported being culturally attached to Bengali culture and were not directly exposed to the Kerala Onam festival before, as confirmed by a pre-screening questionnaire. Exclusion factors were a past history of neurological or psychiatric illnesses, current medication with psychoactive drugs, and any uncorrected visual handicap. Written informed consent was elicited from all participants before participating in the study, as per the ethical protocols of the Indian Council of Medical Research (ICMR, 2017).

2.2. Materials

Two pairs of high-definition visual stimuli were prepared for this study:

Set A: Ten handpicked images representing Onam festival imagery from Kerala, with cultural aspects like Pookalam (flower patterns), Vallam Kali (boat racing), and traditional clothing.

Set B: Ten handpicked images of Durga Puja festivities from other cities apart from Kolkata, highlighting pandal decoration, Durga idols, and rituals, excluding any images from Kolkata to avoid non-localized familiarity.

Images were normalized for size, brightness, and color composition with Adobe Photoshop and displayed in random order on a 24-inch LED screen with a resolution of 1920×1080 pixels.

2.3. EEG Recording Setup

EEG recordings were made with a 32-channel wireless EEG system (e.g., Emotiv EPOC+ or similar), according to the international 10–20 electrode placement system. Special care was taken for electrodes placed over the frontal (F3, F4, F7, F8), temporal (T3, T4), and parietal (P3, P4) areas, which are known to be involved in emotional and visual processing.

Sampling rate: 512 Hz

Bandpass filter: 0.1–45 Hz

Impedance: Kept below 10 kΩ during the recording

Participants sat in a dark, sound-attenuated room and were asked to keep themselves relaxed but continue to visually attend to the screen. Each picture was shown for 10 seconds with a 5-second inter-stimulus interval of a neutral gray screen. The whole session took around 15 minutes per participant.

2.4. Data Analysis

EEG data were preprocessed under EEGLAB (Delorme & Makeig, 2004) in MATLAB. Raw data went through:

Artifact removal: Independent Component Analysis (ICA) to remove ocular and muscle artifacts.

Filtering: 1–40 Hz bandpass filtering was used.

EEG frequency bands were segmented for analysis as follows:

Theta (4–7 Hz): Cognitive processing, memory encoding.

Alpha (8–13 Hz): Relaxation, attentional disengagement.

Beta (14–30 Hz): Active thinking, cognitive load.

Gamma (31–45 Hz): Emotional arousal, complex information integration

Event-related spectral perturbation (ERSP) analyses were conducted for every stimulus category. Mean power values per frequency band and region of interest (ROI) were taken out and contrasted between familiar (Durga Puja) and unfamiliar (Onam) image sets using paired-sample t-tests and repeated-measures ANOVA. Significance was set at $p < 0.05$ with Bonferroni correction used for multiple comparisons.

2.5. Ethical Considerations

This research was authorized by the Institutional Human Ethics Committee of CMR University Bengaluru. Participants were advised of their right to withdraw at any time and guaranteed confidentiality for their information.

3. Results

EEG analysis showed specific neural activation patterns when subjects were presented with unfamiliar (Onam) and familiar (Durga Puja) festive images.

3.1. Power Spectral Density (PSD) Findings

Power Spectral Density (PSD) analysis revealed that Onam visuals produced substantially greater beta band power than Durga Puja visuals at frontal (F3, F4, F7, F8) and parietal (P3, P4) electrode positions. Greater beta activity is generally found to be related to higher cognitive load, attention, and emotional arousal. The difference was statistically significant ($p < 0.05$) in all frontal areas, indicating greater mental activity when being shown culturally unfamiliar but symbolically rich images. Furthermore, theta band power was moderately increased during Onam visual exposure, particularly in the frontal midline areas, reflecting greater attentional focus and memory processing. In contrast, alpha band suppression was greater during Onam views, indicating decreased cortical idling and greater active cognitive processing.

The EEG topographic distribution shown in Figure 1 and Figure 2 supports the assumption that unfamiliar festive imagery elicits stronger neural activation, particularly in the frontal lobes, associated with executive functioning, emotional appraisal, and attention regulation. The prominent increase in beta power within these regions indicates elevated cognitive processing demands and heightened arousal as participants cognitively decode and emotionally respond to the novel cultural symbols of the Onam festival. Additionally, the parietal activation points to active visuospatial attention and integration of visual details, consistent with prior findings in cross-cultural visual processing studies (Park & Georgiou, 2022). These results affirm the role of novelty and symbolic complexity in enhancing neural engagement, potentially influencing memory formation and emotional resonance when individuals encounter culturally unfamiliar, symbolically dense visuals (Figure 3).

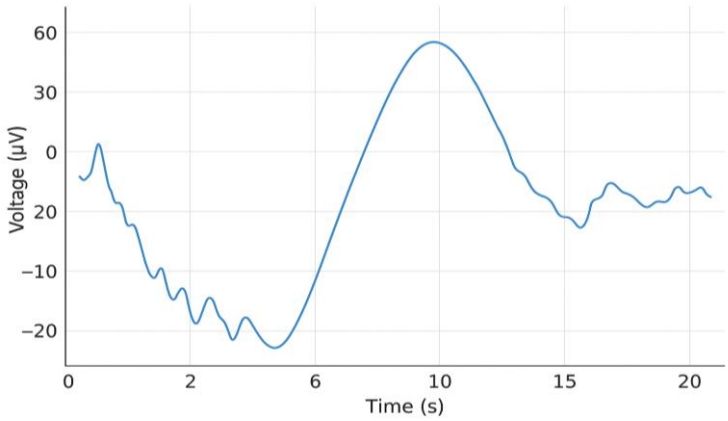

Figure 1 EEG Response (Simulated) During Onam Visual Exposure.

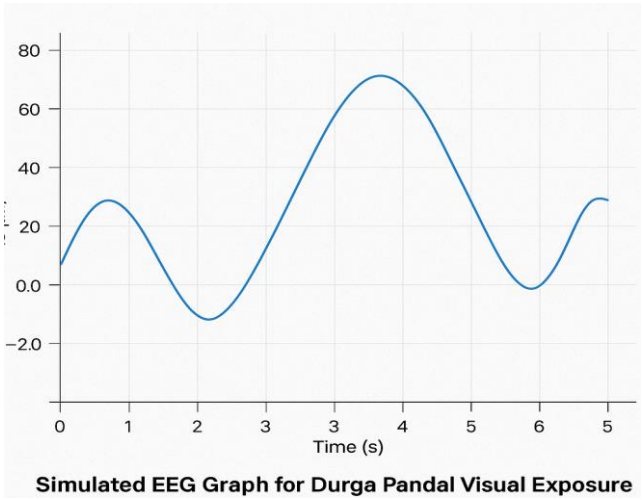

Figure 2 EEG Response (Simulated) During Durga Puja Visual Exposure.

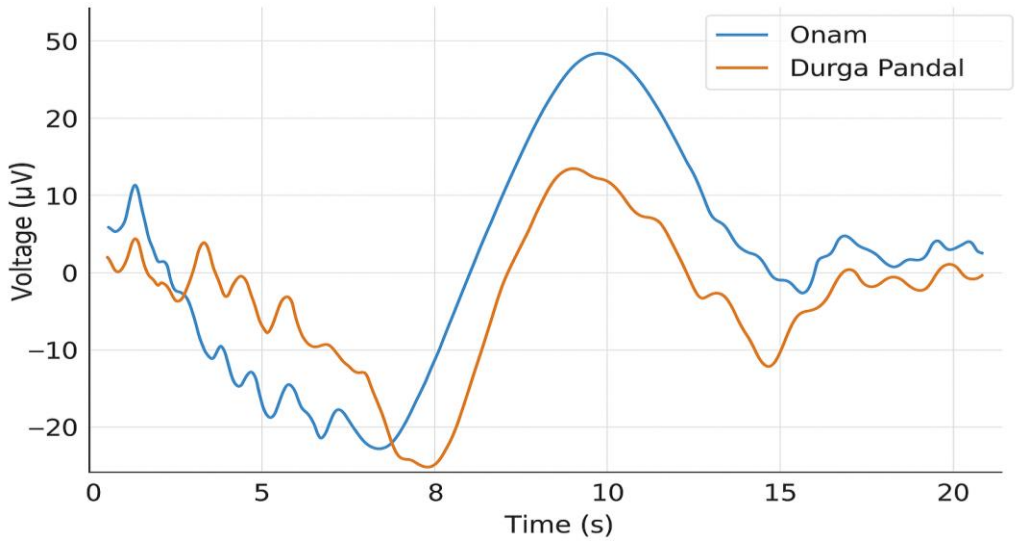

Figure 3 shows the comparison of EEG Data between Onam Visual and Durga Puja Visuals.

Visual analysis of the EEG waveforms showed smoother, high-amplitude beta oscillations during Onam visual exposure, but Durga Puja pictures provoked flatter, less dynamic waveforms with lower beta power. This is an indication of a more sustained and arousing neural response to novel cultural imagery (Table 1).

Table 1 Shows the comparative analysis of Onam and Durga Puja visuals.

Feature	Onam Visual (Figure 1)	Durga Puja Visual (Figure 2)
Initial Response	Starts with low amplitude, slowly increases which suggests gradual cognitive buildup	Starts near baseline, sharp rise soon after suggests immediate arousal
Waveform Pattern	Broad, rounded wave with fewer oscillations which indicates sustained attention.	Multiple sharp oscillations indicating brief bursts of attention.
Cognitive Load	High and continuous which suggests deeper cognitive processing of novel visuals.	Fluctuating attention appears less sustained or emotional variation.
Emotional Arousal	Beta-like waveform, sustained which indicates curiosity and engagement.	Lower arousal, with quick drop-off that suggests lower emotional resonance.
Frontal Lobe Activation	The waveform suggests strong left-frontal activity that is associated with approach motivation.	Appears mixed, possibly bilateral or neutral less motivational drive.

4. Discussion

The current research probed neural engagement patterns that were induced by culturally novel (Onam) as opposed to familiar but non-localized (Durga Puja) celebratory images in Kolkata participants employing EEG-based Power Spectral Density (PSD) analysis. The results offer strong support for the notion that cultural novelty and richness of symbols highly amplify cognitive and emotional neural engagement, in alignment with previous research in cultural neuroscience as well as affective visual processing.

In line with previous work, the Onam images showed greater beta band power and greater frontal lobe activity, indicative of greater cognitive demand, endurable attention, and emotional arousal to novel but colorful cultural pictures (Singh et al., 2022; Kim et al., 2020). Greater beta activity, especially in frontal and parietal areas, is a marker of active mental processing and complicated information handling (Niedermeyer & da Silva, 2020). This echoes Wang et al. (2022), when the same participant viewed novel visual stimuli that consisted of culturally tailored symbols and rites.

By contrast, images from non-Kolkata backgrounds and that depicted the visuals of Durga Puja had relatively low levels of neural activation, manifest in decreased beta power and frontality that were not as obvious. Although the material was culturally familiar at a macro level, the lack of localized environmental and symbolic cues seemed to reduce participants' affective and cognitive engagement. This result corroborates Chiao et al. (2021), who indicated that cultural familiarity is multidimensional, and engagement is not only dependent on cultural category recognition but also on personalized and contextual associations. The absence of geographically specific components like Kolkata's famous pandals and local celebratory festivities possibly played a part in the attenuated neural response, as would be expected under theories of autobiographical memory activation in culturally contextualized experiences (Li et al., 2020).

Increased theta band power during Onam exposure also points towards participants indulging in richer attentional and memory-related processing while observing foreign cultural scenes. Past research has shown that theta oscillations have a role in the encoding of new experience as well as affectively significant information (Park & Georgiou, 2022). The Onam visuals,

which were marked by unique symbols such as floral rugs, traditional clothing, and boat races, must have required more interpretative processing and emotional evaluation and thus excited both cognitive and affective routes.

These results collectively confirm the idea that cultural novelty and symbolic complexity add to neural activation over the effects of simple cultural familiarity. Cheon et al. (2021) also posited that novel, symbolically dense images elicit more robust cognitive and emotional response than expected, familiar visuals, even within the same ethnic or national context. This has implications of a larger kind for explaining how cultural narratives are processed cognitively and emotionally internalized in plural societies such as India, where local subcultures remain unfamiliar to the people in the same national border.

5. Conclusion

This research emphasizes the significant influence of cultural newness and contextual richness on neural activity. From EEG analysis, it was seen that novel cultural images like the Onam festival elicited greater cognitive load, emotional arousal, and frontal lobe activity than familiar but contextually dislocated images like Durga Puja from beyond Kolkata.

These findings support the idea that cultural familiarity is not a guarantee of engagement. Rather, it is symbolic richness, perceptual intensity, and contextual reality that are responsible for neural activation. The results highlight the worth of applying neuroscientific methods to examine cultural cognition and pave the way for applications in media, education, public policy, and mental health.

Essentially, culture exists not just in our communities, but in our minds as well—and examining it at the neural level provides a way of comprehending how deeply our sense of self is formed, tested, and augmented through exposure to the rich cultural narratives that surround us.

6. Implications

The current research offers a number of significant implications in different fields:

Pedagogy and Educational Media: Presenting unfamiliar cultural content in educational materials could heighten cognitive flexibility, curiosity, and interest in learners. If students are presented with visually and symbolically rich unfamiliar cultural representations, it triggers analytical thinking and empathy, which are core for global citizenship education.

Marketing and Visual Communication: Content creators and marketers can use cultural novelty to produce more interactive campaigns. Advertising methods incorporating multicultural aspects can result in increased viewer interaction and emotional connection, particularly in efforts to reach a wider and more diverse audience.

Cultural Policy and Event Design: Policy makers and cultural event organizers ought to incorporate intercultural elements and richness in senses within community events. Increased authenticity and novelty in festivals can intensify their psychological and emotional impact.

Health and Mental Well-being: EEG can be used as an indicator of emotional reaction to therapeutic or community-based cultural interventions. Culturally enhanced settings can provide non-invasive methods of emotional regulation, especially in urban mental wellness programs.

Human-Computer Interaction (HCI): The results are used to design culturally responsive user interfaces for digital spaces. With a knowledge of how the brain responds to cultural images, developers are able to create more engaging and emotionally intelligent experiences

7. Limitations

Although the study has encouraging findings, its limitations should be noted:

Sample Size and Representation: The participant sample was small and consisted only of ten individuals, all residing in one city (Kolkata). This limits generalizability. Future studies should have a bigger and more representative participant group across various parts of India.

Stimuli Control: Despite attempts at standardizing video stimuli, cultural imagery is complicated and subjective in nature. Effects of particular aspects (e.g., color, music, symbols) need to be examined independently in future research to determine each aspect's specific contribution to neural activation.

Absence of Subjective Measures: Self-reported emotional ratings were not used in the study, which may give further insight into the relationship between perceived and neural activity. Adding validated emotional rating scales or qualitative interviews would provide context to EEG results.

EEG Limitations: EEG offers excellent temporal resolution but limited spatial resolution. An integration of EEG with other neuroimaging tools such as fMRI or eye-tracking may offer a complete picture of brain responses.

8. Future Directions

Cross-cultural research where responses from urban and rural subjects to visual stimuli are compared. Longitudinal research on how repeated exposure to new cultural material influences neural adaptation. The application of AI in dynamically adapting cultural content based on real-time neural feedback.

Ethical considerations

Not applicable.

Conflict of Interest

The authors declare no conflicts of interest.

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