Contribution ID: **181** Type: **Symposium**

Correlation of cognitive variables with brain activity measured by EEG and fRMI

Abstract

Introduction

Recent investigations point to a link between intelligence and more efficient neural processing, suggesting that people with higher cognitive performance tend to have stronger integration among key brain areas and reduced redundant activity (Jung & Haier, 2007). Grounded in this concept of neural efficiency, the current study examines resting-state functional activity and connectivity in individuals with above-average cognitive abilities compared to those with average IQ, aiming to shed light on how brain organization differs according to intelligence level.

Objective

To explore whether resting-state brain activity, as measured by amplitude of low-frequency fluctuations (ALFF) and functional connectivity, differs according to intelligence levels. Specifically, the study examines differences in brain connectivity between individuals with high cognitive abilities and those with an average IQ.

Participants

The sample consists of 10 women and 10 men, with an average age of 20.1 years. All of them students of the ULL

Method

Resting-state functional magnetic resonance imaging (rs-fMRI) was used to analyze brain activity and connectivity. Participants were classified into two groups based on their IQ scores:

- High cognitive ability group (IQ ≥ 120)
- Average cognitive ability group (IQ 90–119)

The sample consisted of 10 participants per group,all university students from Universidad de La Laguna. ALFF was measured in key brain regions, including the ACC, left frontal pole (lFP), and subcallosal cortex, to assess spontaneous neural activity. Functional connectivity analyses were conducted to examine relationships between these regions and other cortical and subcortical structures.

Results

The study revealed differences in brain activity and connectivity between individuals with high and average intelligence.

- Higher intelligence was associated with increased ALFF in key brain areas, indicating greater neural efficiency.
- Differences in connectivity patterns were observed, suggesting variations in the way brain networks communicate and integrate information.
- Regions linked to executive functioning and emotional regulation showed notable distinctions between the groups, reinforcing the idea that intelligence influences brain organization.

Conclusion

The findings highlight key differences in spontaneous brain activity and connectivity between individuals with different intelligence levels.

- Higher IQ individuals exhibited stronger brain activity in cognitive control regions.
- They demonstrated more efficient functional connectivity, particularly in prefrontal networks.
- The results support the neural efficiency hypothesis, suggesting that intelligence is associated with optimized brain function.

These findings contribute to a better understanding of how intelligence shapes brain organization, emphasizing that intelligence is not simply about higher activity in specific areas but about the efficient integration of multiple networks. Future research could further explore how these neural differences relate to cognitive performance in complex tasks.

Keywords

Intelligence, rs-fMRI, high abilies

Communication 5

Study of Brain Activity at Resting State by Functional Magnetic Resonance Imaging in People with High and Low Sensitivity.

Authors

Michelle Padrón, Julio Manuel Plata Bello, África Borges del Rosal

Affiliation

University of La Laguna

Symposium title

Correlation of cognitive variables with brain activity measured by EEG and fRMI

Coordinator

Elena Rodríguez-Naveiras

Affiliation

University of La Laguna

Abstract

Currently, in the field of psychology and neurosciences, brain activity study techniques are correlated with performance measures of cognitive tasks or with scores obtained in questionnaires to find out which performances or traits are related to brain activity, whether measured with metabolic activations (oxygenation or glucose) or electroencephalographic frequencies. Thus, the aim of the present symposium is to describe the techniques of brain signal acquisition by means of encephalography and functional magnetic resonance imaging in relation to cognitive tasks or personality traits, emphasizing the methodological details of the recording technique, data analysis and tasks or tests used. Five papers are included, three with electroencephalography and two with fRMI. The first one Theory of mind and high abilities, EEG analysis is about theory of mind and highlights the use of an abbreviated version of the Yoni task, which has good reliability indicators. The second, Emotional Synergy in Music-Color Combinations: A Neurophysiological Study, explores whether there is synergy in the emotional categorization of auditory (music) and visual (color) stimuli presented simultaneously. At the same time, electroencephalographic activity was recorded and differences in the theta band were found. The third work Electroencephalography as a Recording Method in Visual Photosensitivity, analyzes a scarcely studied phenomenon, the visual photosensitivity that refers to the triggering of epileptiform activity caused by specific visual stimuli and one of its main contributions is the design of 5 patterns with specific characteristics that are compared, in addition, its second contribution is the proposal of EEG analysis since it compares a clinical method with an automated quantitative one. The following two works were carried out with functional brain images (fMRI), highlighting in them the analysis of the signal calculating the Fractional Amplitude of the Low Frequency Fluctuations signal (fALFF). In addition, both studies study such brain activity in relation to the characteristics of the participants: sensitivity or intelligence. In Study of Brain Activity at Resting State by Functional Magnetic Resonance Imaging in People with High and Low Sensitivity, it was found that specific brain regions are differentially activated when high sensitivity is present or not. While in Resting-State Brain Activity and Connectivity in Individuals with High Cognitive Abilities the fALFF technique is employed for resting-state analysis, but also to analyze connectivity, finding that people with higher intellectual capacity present more efficient neuronal connectivity. These works reflect on the importance of neuroscience studies having a robust methodological review both in the analysis of brain activity and in the use of valid tasks or questionnaires to study specific cognitive processes or characteristics.

Keywords

EEG, fRMI, cognitive tasks

Number of communicatios

5

Communication 1

Theory of mind and high abilities, EEG analysis

Authors

Jesús del Pino Relwani Moreno, Ernesto Pereda de Pablo, África Borges del Rosal

Affiliation

University of La Laguna

Abstract

Introduction
Theory of Mind (ToM) refers to the ability to understand and represent both one's own mental states and those of others, enabling the process of mentalizing (Happé et al., 2017). This study posits that individuals with high cognitive abilities may exhibit distinct neural processing patterns during ToM tasks, reflecting a potentially more efficient or elaborate engagement of brain regions associated with social cognition. By employing electroencephalography (EEG) to examine brain activity in individuals with varying intelligence levels during a ToM task, this research aims to shed light on the neural correlates of intelligence-related differences in social cognitive processing, contributing to a more nuanced understanding of the intersection between cognitive ability and social understanding.
Objective
To explore whether brain processing, measured through electroencephalography (EEG), differs according to intelligence levels during Theory of Mind (ToM) tasks. The study compares individuals with high cognitive abilities and those with a normal IQ.
Method
EEG measures were used to analyze brain processing. Participants were classified into two groups using the MATRICES-TAI test: 36 university students, 18 with high cognitive abilities and 18 with normal IQ, aged between 18 and 55 years. EEG data were obtained through a reduced version of the Yoni Task to measure responses to ToM stimuli. A time-frequency analysis has been carried out
Results
The study identified differences in brain activity across cognitive, affective, and physical conditions. Cognitive Condition: Differences were observed in beta and gamma frequency bands (23-32 Hz, 36-40 Hz) in prefrontal and frontocentral regions, particularly around 100-300 ms. Affective Condition: Theta (6-7 Hz) and beta (16-29 Hz) frequency differences were detected in anterior regions, particularly around 100-200 ms. Physical Condition: Differences were present in gamma (36-40 Hz) and alpha (9-12 Hz) activity, particularly at 250-550 ms.
Conclusions
The findings highlight differences in brain activity and connectivity across cognitive, affective, and physical conditions.
- Differences in high-frequency activity were found in cognitive tasks.
- Differences in theta and beta frequencies were observed in affective conditions.
- Variability in gamma and alpha activity was present in physical conditions.

Keywords

ToM, high abilities, EEG

Communication 2

Emotional Synergy in Music-Color Combinations: A Neurophysiological Study

Authors

Pablo Valdés-Alemán; Bernarda Téllez-Alanís; Diana Platas-Neri; Bruma Palacios-Hernández

Affiliation

Center for Transdisciplinary Research in Psychology (CITPsi), Autonomous University of the State of Morelos (UAEM), Mexico.

Abstract

This study investigated whether combining musical and chromatic stimuli with congruent emotions produces a synergistic effect on emotional responses, measured through subjective self-reports and electroencephalography (EEG). The sample consisted of 33 participants (20 females; M = 20.3 years, SD = 2.4), all free of moderate to severe depressive symptoms (BDI-II: M = 5.5, SD = 5). Professional musicians were excluded to avoid potential biases in neurophysiological responses. Emotionally validated stimuli (n = 32) were selected, including light cyan (positive) and dark yellow (negative) from the Berkeley Color Project, along with musical excerpts with high and low emotional valence and arousal, based on prior evaluations (n = 85). Stimuli were presented in randomized order, either individually or as music-color combinations. EEG data were recorded using electrodes placed at F3, F4, P3, and P4 according to the 10/20 system, maintaining impedance levels below 5 kΩ. Preprocessing included bandpass filtering (1–30 Hz), independent component analysis (ICA) to remove ocular artifacts, and normalization of absolute power (μV^2) in theta (4–8 Hz) and alpha (8–13 Hz) bands, subtracting resting-state activity and applying natural logarithmic transformations to enhance signal-to-noise ratio. Subjective responses were collected using continuous slider scales to assess valence, arousal, pleasure, and stimulus predominance. Repeated-measures ANOVAs and nonparametric tests (W of Kendall) analyzed emotional and neurophysiological differences across experimental conditions, with corrections applied for sphericity (Greenhouse-Geisser) and effect sizes calculated (η^2 and Cohen's d). Results showed no synergistic effect between congruent music-color pairs. Subjective data indicated music as the dominant emotional stimulus, independent of its combination with congruent or incongruent colors, likely due to its greater perceptual and emotional complexity. EEG findings corroborated this, with the sad color evoking lower theta activity in the parietal region compared to more emotionally activating stimuli. This highlights the influence of stimulus complexity on emotional processing. Methodologically, this research underscores the value of integrating subjective reports with neurophysiological measures to investigate multimodal interactions. These findings have implications for affective neuroscience, virtual environments, and therapeutic applications, providing a framework for developing tools that leverage multisensory integration for emotional regulation and engagement.

Keywords

Emotional; Music-color; Multisensory; EEG

Communication 3

Electroencephalography as a Recording Method in Visual Photosensitivity.

Authors

María Graciela Cano Celestino, Ma. de la Cruz Bernarda Téllez Alanís

Affiliation

Research Center in Cognitive Sciences (CINCCO), Autonomous University of the State of Morelos, Mexico. Transdisciplinary Research Center in Psychology (CITPSI), Autonomous University of the State of Morelos, Mexico.

Abstract

Electroencephalography is a harmless recording technique (Rivera et al., 2023) employed in both clinical and research settings to obtain an electroencephalogram (EEG). It has been recognized as a gold method of brain electrical activity to discover structural or functional damage in people with or without a diagnosis of neurological disease such as epilepsy (Guerrero Aranda, 2020). As a result, methodologies for EEG recording are periodically updated and reviewed to ensure best practices (Kasteleijn-Nolst Trenité, 2012). Addressing the demands of emerging interdisciplinary research, this study details the methodology employed and the data analysis processes used to examine a group of young university students without epilepsy, aiming to identify brain activation responses triggered by graphic images in visual photosensitivity which is mainly related to a high perceptual sensitivity to lights (Fisher, 2022). The international 10-20 system for EEG electrode placement was used to record brain electrical activity from 21 electrodes, incorporating a Vision Test, Baseline Recording (BR), and Pattern Sensitivity Test (PST). Changes in brain electrical activity were analyzed using clinical and psychological approaches, focusing on detecting biomarkers of abnormalities during the recording process (BR, PST). Additionally, frequency analysis (Hz) and band power ($\mu V^2/Hz$) were evaluated, with special attention to delta (0.2-3.5 Hz), alpha (8-12.5 Hz), and gamma (30 90 Hz) bands following the PST period. The fast Fourier transform method was employed for this analysis. This work hypothesizes that graphic images with specific structural features may modify the normal brain electrical activity in young people with undiagnosed visual photosensitivity.

Keywords

electroencephalography, brain, visual photosensitivity

Communication 4

Resting-State Brain Activity and Connectivity in Individuals with High Cognitive Abilities

Authors

Jesús del Pino Relwani Moreno, Dante Noah Jorge Sálamo, África Borges del Rosal, Julio Manuel Plata Bello

Affiliation

University of La Laguna

Abstract

Introduction: Sensory processing sensitivity (SPS) is an inherited personality trait that determines people to feel, think and interact with others differently from others. Several research studies have shown these differences through studies on brain processing. Objective: To analyse the differences in resting brain activity, as determined by functional magnetic resonance imaging, between people with high and low sensitivity, in order to test their neural processing. Method: Two study groups of 10 participants were selected by sensitivity condition (with a mean of 78.3 in high sensitivity and 39.3 in low sensitivity) according to their response to the Spanish version of the HSC (Higly Sensitive Child) scale developed by Pluess, where the mean age of the participants was 23.8 years, with 13 women and 7 men, in order to subsequently record the basal functional image of the brain, through fMRI, calculating the Fractional Amplitude of the Low Frequency Fluctuations signal (fALFF). Results: In a first analysis, the results showed a positive relationship between fALFF and PAS levels (high and low) at the level of the left parietal lobe and the left cerebellar hemisphere, corresponding to the posterior lobe, and a negative relationship at the level of the left thalamus, bilateral medial frontal lobe (including the anterior cingulum) and the left superior temporal lobe. In a second analysis, a study was conducted between each subject's fALFF and their individual score on each of the PAS factors (AES, EOE, LST). In the AES analyses, negative relationships were only observed for both hemispheres located in the right temporal lobe (medial temporal gyrus, fusiform and parahippocampal), left temporal lobe (left superior temporal gyrus) and at the level of the cuneus. In the correlation analysis between fALFF and the EOE factor, a positive relationship was observed at the level of the left parietal lobe (including the postcentral gyrus, supramarginal and inferior parietal lobe), and a negative relationship in the left thalamus and bilateral medial regions at both parietal (cuneus and precuneus) and frontal levels. Finally, correlation analysis between fALFF and LST showed a positive relationship at the left parietal level and with the posterior lobe of the left

cerebellum, and a negative relationship in the left thalamus, some regions of the left temporal lobe (medial and superior temporal gyri), medial frontal and parietal regions. Discussion: It has been observed that most of the regions that show some kind of significant result belong to regions related to the somatosensory system, such as the regions that form part of the parietal lobe, as well as the left postcentral gyrus, which correspond to the somatosensory cortex. On the other hand, the thalamus is considered one of the most important sensory neural regions, being the main intermediary, together with the cerebral cortex, in the processing of emotional stimuli, with the exception of olfaction. Research has also shown that the prefrontal and temporal cortex and some limbic structures, such as the cingulate, play a fundamental role in the development of empathic quality.

Keywords

SPS, fMRI, personality

Primary author: RODRÍGUEZ NAVEIRAS, Elena (Universidad de La Laguna)

Session Classification: Symposium : "Correlation of cognitive variables with brain activity measured by EEG and fRMI"

Track Classification: Measurement: Measurement