Title: Brain in Transition: Linking Intelligence and Personality to Default Mode Network Dynamics During Rest-to-Task Switching

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To appear in: **Basic and Clinical Neuroscience**

Received date: 2026/02/12

Revised date: 2026/04/26

Accepted date: 2026/04/29

Please cite this article as:

Akbari, S., Hajizadegan, M., Samanian, A. (In Press). Brain in Transition: Linking Intelligence and Personality to Default Mode Network Dynam-ics During Rest-to-Task Switching. Basic and Clinical Neuroscience. Just Accepted publication Jul. 10, 2026. Doi: http://dx.doi.org/10.32598/bcn.2026.8548.1

DOI: http://dx.doi.org/10.32598/bcn.2026.8548.1

Highlights

- Right precuneus and left inferior parietal activity during rest-to-task transition predict Performance and Full-Scale IQ.
- Left inferior parietal changes negatively correlate with Agreeableness and Extraversion.
- Personality does not moderate intelligence–brain relationships.
- Personality masked the link between verbal IQ and inferior parietal activity (suppressor effect).
- Frontal DMN hubs showed no task-related change, indicating task-dependent specificity.

Plain language summary

We all have times when our mind wanders and times when we focus on a task. Our brain has special networks for these different states. One important network, called the Default Mode Network, is active when we daydream and quiets down when we concentrate. But what happens during the switch from resting to focusing?

In this study, we asked 36 university students to rest for six minutes and then play Tetris for six minutes while we recorded their brain activity. We wanted to know if smarter people or people with different personalities show different brain changes when they switch from rest to play.

We found that two brain regions—the right precuneus and left inferior parietal lobule—increased their activity during Tetris. People with higher IQ scores showed bigger increases in these areas. Specifically, brain activity in these regions predicted nearly half of the differences in people's performance IQ.

We also found that personality matters, but in a different way. People who scored high on Agreeableness and Extraversion showed smaller increases in the left inferior parietal region. Importantly, personality and intelligence affect brain activity independently—they don't interfere with each other.

Our results suggest that how your brain transitions from resting to working is not just about the task itself. It reflects who you are—how smart you are and, to some degree, your personality.

Abstract

Background: The brain's rest-to-task transition requires dynamic Default Mode Network (DMN) reconfiguration. Although DMN activity reflects individual differences, whether intelligence and personality influence the *magnitude of DMN change* during this transition remains unclear. This study investigated associations between IQ, Big Five traits, and EEG power changes in DMN hubs during visuospatial task engagement.

Method: 36 university students underwent 6-minute resting-state EEG followed by 6-minute Tetris gameplay. Source localization (sLORETA) was performed on 12 DMN regions defined by the Desikan-Killiany atlas. Relative power changes (task–rest) were computed across eight frequency bands. Participants completed the WAIS-IV and NEO-FFI. Partial correlations and regression models examined associations between DMN activity changes, IQ, personality, and game performance.

Results: Among DMN regions showing significant rest-to-task power increases, only the right precuneus and left inferior parietal lobe were associated with intelligence. Right precuneus (Alpha2) and left inferior parietal (Beta1, Beta3) changes showed positive associations with Performance and Full-Scale IQ, with the regression models accounting for 46% and 38% of the variance, respectively (adjusted R^2). Left inferior parietal changes (Alpha2, Beta2, Beta3) were negatively correlated with Agreeableness and Extraversion. Personality did not moderate IQ–brain relationships but acted as a suppressor for verbal IQ

Conclusion: Frequency-specific DMN modulation during rest-to-task transition serves as a sensitive neural marker for individual differences in cognitive ability, particularly visuospatial intelligence. Personality traits are independently reflected in DMN dynamics but contribute less to predictive models. Findings highlight the task-dependent specificity of DMN functional reconfiguration and its potential for individualized neuroscience.

Keywords: Default Mode Network, Rest-to-task transition, Intelligence, Big Five personality, EEG source imaging

Introduction

The brain is a dynamic and complex system that continuously and dynamically oscillates between different functional states. One of the most fundamental and critical of these transitions is the shift of the brain from a resting baseline state to a state engaged in a goal-oriented cognitive task. A precise examination of this transition opens a unique window into fundamental issues in neuroscience: for example, understanding the mechanism through which the brain mobilizes its processing resources to initiate a cognitive activity while simultaneously deactivating unrelated parts of its circuitry is a prominent research area in neuroscience (de Dreu et al., 2019; Lin et al., 2022; Zou et al., 2013). The efficiency and integrity of this dynamic regulatory process are considered the cornerstone of optimal cognitive function, and any impairment in it can lead to a wide range of cognitive and psychological problems (Anticevic et al., 2012; Fox et al., 2005; Zhou et al., 2016). Therefore, understanding the neural mechanisms governing this transition not only deepens our knowledge of normal brain function but also serves as an essential and initial step toward discovering diagnostic neuromarkers for disorders rooted in the dysregulation of brain states.

However, another key point in this context is the influence of individual factors on this process. Growing evidence indicates that neural activity patterns during rest differ between individuals. These individual differences in the brain's intrinsic architecture mean that an individual's brain function at rest is considered a unique "neuro-signature." Among brain networks, the **Default Mode Network (DMN)**, due to its central role in self-referential processing and information internalization, its core activity during rest, and its distinctive characteristics across individuals(Whitfield-Gabrieli & Ford, 2012), has garnered particular attention as a promising neural marker (neuromarker) for individual differences.

Basic research has shown that intra-network connectivity patterns of the DMN during rest can predict the level of brain activity during cognitive tasks across different individuals (Mennes et al., 2010). On the other hand, how and to what extent DMN activity is modulated when the brain engages with an external task can serve as a sensitive index of cognitive flexibility, network efficiency, and neural resource allocation mechanisms (Douw et al., 2016). The importance of the DMN transition from rest to activity is such that studies have shown any abnormality in this phase is associated with impaired cognitive function, and this issue has been confirmed in disorders such as autism (Chien et al., 2016), Alzheimer's (Lai et al., 2025), and schizophrenia (Buckner et al., 2008; Whitfield-Gabrieli & Ford, 2012; Zhou et al., 2016). These findings introduce the DMN as an ideal candidate for studying how brain function changes during the dynamic mechanism of state transition from rest to activity. But here this question is raised that: Is the change in this network's activity during the transition from rest to task also influenced by individual differences? In other words, do internal factors of the individual affect this functional change, and can the differential functioning of this network during transitional states be used as a neural signature to examine individual characteristics?

It seems that a significant part of the individual differences contributing to this neural signature should be sought in intra-individual psychological characteristics. Factors such as intelligence (DeSerisy et al., 2021) and personality traits (Li et al., 2017; Li et al., 2022; Wu et al., 2019), which themselves are stable foundations of differences among individuals, have been extensively associated with brain activity patterns during rest. For example, previous EEG studies have shown that the pattern of alpha waves in the resting state, which indicates the level of arousal in individuals (Golan & Neufeld, 1996; Schmidtke & Heller, 2004; Tran et al., 2006), suggests a difference in arousal levels between extroverted and introverted individuals. Specifically, extroverted individuals show lower levels of arousal compared to introverted individuals (Tran et al., 2001). In another attempt to investigate the relationship between personality traits and EEG, Knyazev (2006) estimated individuals' resilience by examining the balance between alpha and delta waves (Knyazev, 2006) Additionally, some studies confirm the relationship between EEG and intelligence, with some pointing to the association between high alpha power and intelligence (Jausovec & Jausovec, 2001), while others have acknowledged that neural efficiency and brain complexity are related to intelligence (Thatcher et al., 2005). Some researchers have even addressed the significant relationship between EEG in early life and individual characteristics in adulthood (Tan et al., 2023). On the other side of this spectrum, the majority of research today in the field of the relationship between EEG and individual characteristics is task-based, examining the relationship between brain activity and these characteristics during the performance of a cognitive task (Firooz & Setarehdan, 2019; Friedman et al., 2019; Haaf et al., 2024). However, research on the extent to which these stable characteristics influence the degree and pattern of changes in brain activity, particularly in a sensitive network like the DMN, at the moment of encountering a cognitive challenge, is limited and scattered (Kilpatrick et al., 2015; Knyazev, 2012; Li et al., 2022). In fact, the question remains whether individuals with different cognitive and personality profiles exhibit distinct patterns of DMN network resource mobilization and regulation during the transition to a task.

In this study, we aim to answer the main question of whether individual differences in intelligence and the Big Five personality traits are associated with the pattern of activity changes in the Default Mode Network (DMN) during the transition from a resting state to a complex visuospatial task (game). This study addresses the following questions:

1. In which key DMN regions and frequency bands does brain electrical activity change significantly during a visuospatial task (game) compared to the resting state?
2. Is there a relationship between the magnitude of activity change in these nodes and the participants' levels of intelligence (performance, verbal, and full-scale IQ)?
3. Is there a relationship between the magnitude of activity change in these nodes and the Big Five personality dimensions?
4. Is the individual's performance on the visuospatial task (game score) related to the pattern of DMN activity changes?

Different resources have defined the DMN across various hubs; therefore, after reviewing the literature, we selected nodes for this study that most sources agreed upon. Another consideration in selecting these regions was that they were all located in the cortex or near the cortical surface, in order to be less susceptible to errors arising from the inverse problem. In most studies, the following regions have been identified as the core hubs of the DMN:

Precuneus and posterior cingulate cortex (Bowman et al., 2017; Cavanna & Trimble, 2006; Greicius et al., 2003; Menon, 2023), *medial orbitofrontal cortex* (Bowman et al., 2017; Kang-Min Choi, 2021; Menon, 2023) ,*superior frontal gyrus* (Aiken-Morgan et al., 2012; Ma et al., 2016; Xia et al., 2022), *angular gyrus* (Kong et al., 2010; Petit et al., 2023; Seghier, 2013), *anterior cingulate cortex* (Bowman et al., 2017; Kang-Min Choi, 2021; Mohan et al., 2016; Sandhu et al., 2021; Tu et al., 2021), *inferior parietal lobe* (Bowman et al., 2017; Menon, 2023; Raichle, 2015; Sharaev et al., 2016; R. Wang et al., 2021).

In this study, we used the Desikan-Killiany atlas for source estimation and selected the following 12 regions, which, according to this atlas, corresponded as closely as possible to the aforementioned areas: Left and right orbitofrontal cortex, left and right rostral anterior cingulate cortex, left and right caudal anterior cingulate cortex, left and right supramarginal gyrus, left and right precuneus, left and right inferior parietal lobe (Figure 1).

To investigate the aforementioned question, we examined the changes in DMN hub activity from the resting state to engagement in a visuospatial task. The rationale for selecting this cognitive domain is that visuospatial skills not only play a vital role in everyday functions (such as navigation and understanding spatial relationships), but also serve as a foundation for many higher-order executive functions, including planning, reasoning, and problem-solving (Brock et al., 2017; Michel et al., 2020; Miyake et al., 2001). Therefore, understanding the mechanism of DMN function in such activities contributes to a better comprehension of this network's role in supporting higher-level and more complex cognitive functions. Moreover, despite the high importance of this category of cognitive skills, the DMN has rarely been studied in task-based fMRI/PET research within this cognitive domain (Chung et al., 2017; Lai et al., 2025; Suri et al., 2017; Tomasi et al., 2009).

Adopting an integrative approach, this study seeks to bridge the gap between the understanding of individual differences at baseline and the dynamics of these differences in the moment of action. The findings of this research can provide deeper insights into the neurocognitive underpinnings of personality and intelligence, offer a framework for developing objective indicators of flexible brain function, and ultimately open new avenues in the fields of assessment, personalized education, and understanding disorders related to cognitive regulation.

Method

Participants

Following a public recruitment call at the university, 40 volunteers met the inclusion criteria and participated in the study. After data collection and quality control, four participants were excluded due to incomplete or artifact-contaminated EEG data (excessive movement, ocular artifacts, or incomplete task performance). The final sample therefore consisted of 36 participants. *A post-hoc sensitivity power analysis using G*Power (Faul et al., 2009) indicated that with our final sample size of 36 participants, $\alpha = 0.05$, and power = 0.70, the minimum detectable effect size (f^2) ranged from 0.19 (for models with 2 predictors) to 0.39 (for models with 8 predictors). According to Cohen's (1988) conventions (Cohen, 1992), this corresponds to medium-to-large effects, respectively. . The inclusion criteria were: a) aged between 18-30 years, b) no history of psychiatric or neurological disorders, as confirmed by a preliminary interview and self-report, c) not taking any medication affecting the CNS, and d) participants refrained from drinking coffee and smoking for at least 2 hours before the EEG recording session e) no prior experience in our cognitive task (Tetris game). All procedures of the study were in accordance with the latest revision of the Declaration of Helsinki and were approved by the ethics committee at the University of Tehran (Approval ID: IR.UT.PSYEDU.REC.1403.083).

Procedure

Participants were informed about the study's goal and signed a written consent form. After filling the personality questionnaire, first, a 6-minute resting-state electroencephalography (EEG) recording was taken from the participants. Then, they played Tetris for 6 minutes, while EEG was specifically recorded again during their play. The total scores of the participants during the 6 minutes of the game was recorded as a measure of their performance in the gaming task.

Behavioral Measures

Cognitive Task: Tetris Gameplay

The cognitive task employed in this study was the classic video game Tetris. In this visuospatial puzzle game, geometrically shaped blocks (tetrominoes) descend from the top of the screen one at a time. The participant's objective was to mentally rotate and translate these falling shapes in real-time to create complete horizontal lines without gaps. Upon forming a complete line, it is cleared from the screen, and the player earns points. The game's difficulty inherently escalates as the levels progress due to an increase in the descent speed of the tetrominoes. This structure makes Tetris an ideal paradigm for cognitive neuroscience research, as it places continuous and escalating demands on key cognitive functions including visuospatial processing (Agren et al., 2021; GomezRomero-Borquez et al., 2024; Lau-Zhu et al., 2017; Nouchi et al., 2013)**,** mental rotation, working memory (for planning and previewing shapes), decision-making (GomezRomero-Borquez et al., 2024; Lau-Zhu et al., 2017; Nouchi et al., 2013) under time pressure, and fine motor coordination for input execution. The task was administered on a standard desktop computer, with participants using the keyboard arrow keys for control (left/right for translation, up for rotation). Participants played the game for a continuous duration of 6 minutes. Their primary performance metric was the total score achieved during this period, which served as the behavioral outcome measure for subsequent predictive modeling. The use of Tetris provides a high degree of ecological validity compared to more abstract laboratory tasks, while still allowing for precise control and measurement of performance.

Personality Assessment: NEO Five-Factor Inventory (NEO-FFI)

To assess stable dispositional traits, all participants completed the **NEO Five-Factor Inventory (NEO-FFI)**, a well-validated and widely used 60-item self-report questionnaire (Costa Jr, 1985; Costa & McCrae, 1992). The NEO-FFI provides a comprehensive measure of the five major domains of normal personality, known as the Big Five:

- **Neuroticism (N):** Contrasts emotional stability with a tendency to experience negative affect such as anxiety, anger, and depression.
- **Extraversion (E):** Characterizes the quantity and intensity of interpersonal interaction, activity level, need for stimulation, and capacity for joy.
- **Openness to Experience (O):** Describes the proactive seeking and appreciation of experience for its own sake, as well as tolerance for and exploration of the unfamiliar.
- **Agreeableness (A):** Reflects the quality of one's interpersonal orientation along a continuum from compassion and prosociality to antagonism.
- **Conscientiousness (C):** Measures the degree of organization, persistence, control, and motivation in goal-directed behavior.

The psychometric properties of this questionnaire have been examined and confirmed in several studies conducted on the Iranian population. Based on the findings of a comprehensive study of 2,669 Iranian adults, the five-factor structure of this instrument was confirmed using advanced statistical methods, specifically Exploratory Structural Equation Modeling (ESEM), with model fit indices ranging from good to excellent (CFI = 0.99, RMSEA = 0.03). Furthermore, the reliability coefficients (Cronbach's alpha) calculated for this questionnaire in the Iranian population indicated acceptable internal consistency (reliability range: 0.68 to 0.92)(Komasi, 2026).

Evaluation of Intelligence

All participants were administered the Wechsler Adult Intelligence Test. The Wechsler Adult Intelligence Scale, Fourth Edition (WAIS-IV), is a widely recognized and comprehensive intelligence test designed for individuals aged 16 and above (Wechsler, 2008). Developed by David Wechsler and first released in 2008, the WAIS-IV represents the latest version of a test that has evolved significantly to incorporate modern psychometric advances and address contemporary clinical needs (Wechsler, 2008). It is considered a "gold standard" in clinical and research practice, used for various applications such as clinical diagnosis, educational assessment, neuropsychological evaluation, and occupational screening (Wechsler, 2008). The WAIS-IV demonstrates strong psychometric properties, including high internal consistency with reliability coefficients ranging from .90 to .98 for composite scores, strong test-retest stability over 2-12 week intervals, and comprehensive normative data based on 2,200 individuals aged 16-90. Validity has been evaluated extensively, with factor analytic studies demonstrating it to be a good measure of general intelligence and various cognitive abilities (Collinson et al., 2016).

From this test, performance IQ, verbal IQ, and full-scale IQ scores were ultimately extracted and used as variables related to intelligence.

Electroencephalography recording and preprocessing

EEG recording was performed via a Mitsar-31 channel electroencephalography (EEG) amplifier (Mitsar Company), from 31 electrodes arranged according to the international 10–20 system

(Mecarelli, 2019) with an averaged Linked-ear reference. The impedance was kept below 10 kΩ (P. Wang et al., 2021; Zaehle et al., 2010). Data were digitized at 250 Hz and an online band-pass filter (0.01 to 70 Hz) using WinEEG software was applied. Six minutes of electrical activity in the brain were recorded at rest, after which participants played a Tetris game for 6 minutes, while their brain activity was recorded by EEG. The online reference was linked-ear and it was changed to common average reference for analysis (offline reference). EEG signals were filtered offline, using a band-pass filter of 0.1–45 Hz. Bad EEG segments (those exceeding ± 100 μV in any channel) were rejected (Ilvonen et al., 2004; Maurer et al., 2003). Eye blinks and eye-movements artifacts were corrected using Independent Component Analysis approach (Stone, 2002), applying RunICA function. Visual inspection was carried out after the bad segment rejection and ICA correction to assure quality of the data. Those data with less than 65% of total time remaining after artifact rejection were excluded from further analysis (Picton et al., 2003). After this preprocessing EEG signals were divided into 3 second segments for further analysis. Preprocessing and data analysis was performed with Brainstorm (Tadel et al., 2011), which is documented and freely available for download online under the GNU general public license (http:// neuro image. usc. edu/ brain storm).

Data analysis

Following preprocessing, source localization was performed using Brainstorm (Tadel et al., 2011) via standardized low-resolution brain electromagnetic tomography (sLORETA) (R.D. Pascual-Marqui, 2002). The cortex was then parcellated into 12 regions of interest based on the Desikan–Killiany atlas, selected to correspond with the core and most consistently reported hubs of the DMN (see Introduction section). Subsequently, Welch's power spectral density (PSD) was computed from the sLORETA solutions across eight frequency bands: Delta (1–4 Hz), Theta (4–

8 Hz), Alpha1 (8–10 Hz), Alpha2 (10–12 Hz), Beta1 (12–15 Hz), Beta2 (15–20 Hz), Beta3 (20–30 Hz), and Gamma1 (30–45 Hz). This procedure yielded power spectra for each of the 12 brain regions under both resting and gaming conditions. To identify significant differences between the two conditions, a permutation-based paired t-test was conducted across all regions and frequency bands.

This analysis of power differences was performed on relative power values. The resulting p and t values from this test were then extracted, and to avoid errors due to multiple comparisons, p-values were corrected within each frequency band using the FDR method. Regions that remained significantly different after FDR correction are presented in Table 1.

In the next step, the difference in relative power between the two conditions was calculated for each significant region across the eight frequency bands, yielding numerical values representing the change in activity for these regions at different frequencies. These values were normalized using z-score transformation and were then statistically analyzed in SPSS (version 27) to address the research questions. Pearson correlation and partial correlation tests were employed in these analyses. It should be noted that after removing outliers from the dataset, the normality of the distribution was examined using the Kolmogorov–Smirnov test. To ensure robustness, extreme values were excluded using a Z-score threshold ($Z > 3$).

Results

The study included 36 participants (22 female), ranging in age from 19 to 28 years. Descriptive statistics for the Wechsler test scores and game scores are presented in Table 2.After screening for outliers, 69 data cells out of a total of 1,044 extracted cells were removed, equivalent to 6.6% of the entire dataset. The results of the Kolmogorov–Smirnov test indicated that the data were normally distributed ($p > 0.05$). The results of the permutation paired t-test (Table 1) were extracted as region-frequency complexes and were used in subsequent analyses. As can be observed, the following regions showed no significant differences in activity between the two conditions:

medial orbitofrontal cortex, *right inferior parietal* and *caudal anterior cingulate cortex*

Is the task-related changes in DMN activity associated with intelligence?

To address this question, we first considered the possibility that interactions between personality, intelligence, and brain activity might influence the relationship between DMN activity and intelligence. Therefore, partial correlation was used to examine this relationship (Table 3). To reduce the likelihood of error due to multiple comparisons, the confidence level was increased to 99% ($p < 0.01$). The results of this analysis showed that only in three frequency bands—Alpha2, Beta1, and Beta3—activity changes in the right precuneus and left inferior parietal regions were associated with intelligence.

To examine the predictive power of selected Default Mode Network (DMN) regions on performance IQ, two regression models were conducted using the enter method. In the first model, three significant neural regions identified from the correlation analysis (Table 3) —A2-precuneus R, B1-inferiorparietal L, and B3-precuneus R—were entered as predictors. In the second model, the Big Five personality traits were additionally entered to assess their control effect on the neuro-cognitive relationship.

ANOVA results indicated that both models were statistically significant [Model 1: $F(3, 24) = 8.168$, $p = 0.001$; Model 2: $F(8, 19) = 3.529$, $p = 0.011$].

Based on the model fit indices, the first model explained 50.5% of the variance in performance IQ ($R^2 = 0.505$). After adjusting for the number of predictors, this value decreased to 44.3% (Adjusted $R^2 = 0.443$). When personality variables were added in the second model, the coefficient of determination increased to 59.8% ($R^2 = 0.598$), but the Adjusted R^2—a more conservative estimate—decreased slightly to 42.8%. This reduction suggests that adding the five personality traits did not provide significant incremental utility and may have led to overfitting. The change in R^2 resulting from the inclusion of personality variables was not significant [R^2 Change = 0.092, F (5, 19) = 0.874, $p = 0.517$]. Therefore, the first model was retained, and adding personality variables to improve predictive power is not recommended. The Durbin-Watson statistic for the final model was 1.64, indicating independence of residuals.

None of the standardized coefficients (Beta) in either model were individually significant at the $p < 0.05$ level. Therefore, considering the possibility that multicollinearity among DMN regions might account for this issue, a backward linear regression approach was employed for prediction. The results of the backward elimination analysis revealed that the optimal model for predicting performance IQ included only two neural regions: the *left inferior parietal lobe* (in the Beta1 band) and the *right precuneus* (in the Beta3 band). The improvement in Adjusted R^2 from 0.447 to 0.459, along with the significant coefficient for the inferior parietal region ($p = 0.041$) after removing the redundant variable, indicates the higher efficiency of this simplified model. This finding suggests that among DMN regions recruited during task transition, activity changes in the left inferior parietal lobe and right precuneus are more strongly influenced by performance IQ (Table 4 and Figure 2). VIF values for all variables were below 5, indicating no serious multicollinearity in the model. Residual analysis also confirmed normal distribution and homoscedasticity ($p > 0.01$).

To examine the predictive power of neural activity for full-scale IQ, two multiple linear regression models were conducted using the enter method. In the first model, two neural regions that were significant in the initial correlation analysis—B3-inferiorparietal L and B3-precuneus R—were entered as predictors. In the second model, the Big Five personality traits were additionally entered.

ANOVA results indicated that both models were statistically significant [Model 1: $F(2, 25) = 8.006$, $p = 0.002$; Model 2: $F(7, 20) = 3.377$, $p = 0.015$].

Based on the model fit indices, the first model (neural variables only) explained 39.0% of the variance in full-scale IQ ($R^2 = 0.390$). After adjusting for the number of predictors, this value decreased to 34.2% (Adjusted $R^2 = 0.342$). With the addition of personality variables (Model 2), the coefficient of determination increased to 54.2% ($R^2 = 0.542$), but Adjusted R^2 decreased to 38.1%. This reduction indicates that adding the five personality traits did not provide significant incremental utility to the model in this sample. The change in R^2 resulting from the inclusion of personality variables was not significant ($\Delta R^2 = 0.151$, $F(5, 20) = 1.320$, $p = 0.296$). The Durbin-Watson statistic for the final model was 1.55, indicating independence of residuals.

None of the standardized coefficients (Beta) in either model were individually significant at the $p < 0.05$ level. Therefore, to reduce the possibility of multicollinearity among the network variables, a multiple regression model using the backward elimination approach was employed.

In the first model, in which both variables were present, the model was overall significant [$F(2,26) = 8.536$, $p < 0.01$]. This model explained 39.6% of the variance in full-scale IQ ($R^2 = 0.396$). However, examination of the coefficients revealed that only the left inferior parietal variable showed a marginally significant association with full-scale IQ ($t = 1.901$, $p = 0.068$), while the right precuneus variable was not statistically significant [t = 0.801, p = 0.430]. Evidence of multicollinearity between the two variables was also observed (VIF = 2.57 for both variables).

Based on the established criterion, the variable *B3-right Precuneus* was removed from the model due to its significance level substantially exceeding the threshold ($p > 0.05$). The second model retained only the variable *B3-inferiorparietal lobe*.

The second model was highly statistically significant [F(1,27) = 16.651, $p < 0.001$] and explained 38.1% of the variance in full-scale IQ ($R^2 = 0.381$) (Figure 3). The slight reduction in the coefficient of determination (1.5%) compared to the first model indicates that removing the non-significant variable did not substantially affect the overall predictive power of the model however, in this model, the multicollinearity issue was resolved (VIF = 1.000).

Based on the standardized coefficients in the final model, the variable *B3-left inferior parietal* showed a significant positive relationship with full-scale IQ [$\beta = 0.618$, $t = 4.081$, $p < 0.001$]. This indicates that a one standard deviation increase in activity in this brain region is associated with a 0.618 standard deviation increase in full-scale IQ scores. The model constant was also significant ($p < 0.001$). Residual analysis further confirmed normal distribution and homoscedasticity ($p > 0.01$).

Is the task-related changes in DMN activity associated with personality?

To address this question, Pearson and partial correlation analysis was again employed, this time with intelligence variables (verbal, performance, and full-scale IQ) entered as covariates. A 99% confidence level ($p < 0.01$) was also applied here. The results indicated that activity in the inferior parietal region across three frequency bands—Alpha2, Beta2, and Beta3—was correlated with the Agreeableness (A) and Extraversion (E) traits from the personality questionnaire (Table 5).

It should be noted that in both partial correlation analyses, no substantial differences were observed between the results of the zero-order and partial correlations. The only exception was in the examination of the relationship with intelligence, where after controlling for the effect of personality, the correlation between verbal IQ and left inferior parietal activity in the Beta3 band showed a notable change (Table 4).

Here, to examine the predictive power of the two personality traits—Agreeableness and Extraversion—two multiple linear regression models were conducted using the backward elimination method. The linear model was not able to predict Extraversion ($p > 0.05$). The final model showed that the variable *A2- left inferior parietal* alone explained 25.1% of the variance in the dependent variable Agreeableness ($R^2 = 0.251$). Figure 4 displays the scatterplot of predicted versus observed Agreeableness values, confirming adequate model fit ($R^2 = 0.220$ for the linear trend). The standardized coefficient ($\beta = -0.501$) indicated a moderate to strong inverse relationship, meaning that as electrical activity in the left inferior parietal region in the Alpha-2 frequency band increased, Agreeableness scores decreased. The model was statistically significant ($F = 9.739$, $p = 0.004$). Interestingly, none of the three intelligence variables (verbal IQ, performance IQ, full-scale IQ) were significant in the model and were removed at various stages of the analysis. These variables showed severe multicollinearity in the initial model (VIF ranging from 59 to 181), indicating that they provided redundant information. Even with this multicollinearity, none of the intelligence variables were independently significant either ($p > 0.4$ in all cases). Residual analysis also confirmed normal distribution and constant variance (homoscedasticity) of the residuals ($p > 0.01$).

Is there a relationship between the degree of change in DMN regional activity and game scores?

Partial correlation was again used here, with intelligence entered as a covariate. The results indicated no correlation between game scores and the magnitude of activity change in these regions across the two conditions. However, when personality variables were additionally entered as covariates alongside intelligence, a borderline significant correlation was observed for the left inferior parietal region in the B3 frequency band [r = -0.439; p = 0.03], prior to FDR correction.

Discussion

Previous studies have emphasized the influence of individual factors such as psychological factors and cognitive performance on DMN activity (Azarias et al., 2025; Raichle, 2015; Yeshurun et al., 2021); However, the effect of these factors on how DMN activity changes during the transition from rest to task has not yet been investigated. In other words, do individuals with different cognitive and psychological profiles exhibit different patterns of DMN recruitment (and consequently, different degrees of for example self-referential processing) while performing a visuospatial task? Answering this question can deepen our understanding of how stable individual traits interact with brain dynamics during everyday cognitive demands. The present study examined the effects of two individual difference factors—intelligence and personality—on the magnitude of activity changes across different DMN regions. Our findings indicate that personality traits do not play a strong moderating role in the relationship between intelligence and DMN activity changes during the rest-to-task transition. Nevertheless, the analyses revealed that the pattern of DMN modulation during engagement in a complex cognitive task is associated with individual characteristics, including intelligence and certain personality dimensions. In the following sections, the findings related to each research question are discussed separately.

Changes in Key DMN hubs During Rest-to-Task Transition

The results showed that performing the Tetris task led to significant changes in electrical activity across several DMN regions in different frequency bands (Table 1). As the data indicate, no significant differences were observed in the delta and alpha1 frequency bands. This pattern is consistent with previous findings demonstrating that engagement in demanding cognitive tasks is typically associated with modulation of activity in higher frequency bands, likely reflecting increased information processing and cognitive resource allocation (Gaona et al., 2011; Gruenwald et al., 2023; Lachaux et al., 2012). Examination of t-values revealed that significant changes in the hubs specified in Table 1 were consistently positive, indicating that performing the cognitive task led to increased activity in all of these regions. Additionally, the following regions showed no significant differences in activity during the transition from rest to task:

Right and left caudal anterior cingulate cortex, *right inferior parietal lobe*, *right and left medial orbitofrontal cortex.*

As can be observed, the hubs located in the frontal regions remained unchanged without significant differences. In explaining these findings, it should first be noted that our variable of interest was the magnitude of change in activity between the two conditions, not the absolute activity level of each hub. Therefore, the absence of significant change in these specific hubs does not indicate a lack of activity in these regions during the cognitive task.

To account for this lack of difference, it should be pointed out that the caudal anterior cingulate cortex (cACC) is primarily involved in conflict and error detection (Ursu et al., 2009). Although

Tetris is a visuospatial cognitive task, its mild nature and the absence of frequent feedback—due to the game's design—do not elicit substantial conflict perception and a heavy cognitive challenge, and consequently, no significant increase in activity occurs in this region (Sklar et al., 2017). Moreover, the design and style of the game do not tend to provoke emotional responses either.

On the other hand, as previously mentioned, the frontal regions of the default mode network—particularly the medial orbitofrontal cortex (mOFC) and the cACC—play key roles in self-referential processing, affective decision-making, and conflict detection (Gusnard et al., 2001; Jackson et al., 2020; Knyazev, 2013; Menon, 2023). The lack of significant change in these regions supports the notion that individuals remained engaged in internal and self-referential processing during the task. This observation also helps explain the absence of significant changes in the delta and alpha1 frequency bands (Knyazev, 2013).

More generally, the inferior parietal lobe is involved in sensory information processing, attention, spatial perception, and higher-order cognitive functions such as calculation and language (Numssen et al., 2021; Singh-Curry & Husain, 2009). Given this region's role in integrating and transforming visuospatial sensory information into motor commands (Clower et al., 2001; Fogassi & Luppino, 2005), and considering that all participants were right-handed, the observed significant difference in the left inferior parietal lobe—alongside the lack of significant change in the right hemisphere—is theoretically justifiable.

Overall, these findings support the notion that the DMN is not a static network, but rather a dynamic system that is flexibly reconfigured in accordance with task demands.

Relationship Between Changes in Activity of Significant DMN Regions and Intelligence Levels

Correlation and regression analyses revealed that activity changes in several DMN regions—particularly the right precuneus (in the alpha2 and beta3 bands) and the left inferior parietal lobe (in the beta1 band)—were significantly associated with performance IQ and full-scale IQ scores. Specifically, increased activity in the right precuneus within the beta3 band was the strongest neural predictor of performance IQ. That is, the higher an individual's performance IQ, the greater the increase in beta3 activity in this region (Table 3). Notably, performance IQ measured by Weschler intelligence scale, primarily encompasses cognitive skills in which visuospatial perception plays a key role, and Tetris is a game whose core cognitive component relies precisely on such abilities. Thus, this association is not only plausible but also serves to validate the robustness of the study's findings. Moreover, this result is consistent with previous studies reporting increased precuneus activity during Tetris gameplay (Haier et al., 1992; Nouchi et al., 2020).

Given the well-established role of this region in mental rotation and spatial skills (Cavanna & Trimble, 2006), increased Beta3 activity during tasks requiring spatial planning and mental rotation—such as Tetris—is theoretically coherent. Meanwhile, increased Alpha2 activity has been associated with enhanced spatial attention (Cruz et al., 2025), enabling more efficient mobilization of neural resources. Therefore, individuals who are able to achieve this frequency balance in the precuneus during Tetris are precisely those with higher performance IQ—in other words, superior visuospatial abilities.

Furthermore, the emergence of the left inferior parietal lobe as a region associated with intelligence likely reflects its involvement in spatial processing and multisensory integration (Bouyssi-Kobar et al., 2019). Bzdok and colleagues (2016) have noted that this region is engaged during cognitive processes that require understanding relationships among elements. Together, these findings suggest that **the pattern of DMN activity change during task performance may serve as a sensitive neural marker for predicting individual differences in specific cognitive abilities**.

Changes in DMN Regional Activity and the Big Five Personality Dimensions

Findings revealed that activity changes in the left inferior parietal lobe across the Alpha2, Beta2, and Beta3 frequency bands were associated with two personality dimensions: Agreeableness and Extraversion (Table 5). The observed negative correlation between activity changes in this region and Agreeableness scores may reflect distinct patterns of neural resource mobilization in individuals with higher levels of Agreeableness. This relationship was negative, indicating that individuals with higher Agreeableness and/or Extraversion showed less tendency to increase activity in this region within alpha and beta bands. the role of this area in social cognition is already established (Numssen et al., 2021; Wang et al., 2017), Perhaps this finding suggests that in individuals with high agreeableness, this region already exhibits high activity during rest, and performing the Tetris task induces little change—or even a decrease—in its activity. In any case, commenting on this issue requires examining the activity of this hub under resting conditions. Nevertheless, some studies have confirmed elevated beta activity in posterior parietal regions in this group of individuals (Jach et al., 2020). These results underscore the idea that **personality differences are rooted not only in the resting-state architecture of the brain, but also in the dynamics of its response to cognitive tasks**.

As outlined in the analysis section, when examining the correlations of both intelligence and personality with changes in DMN hub activity, we also investigated the potential confounding effects of these two variables on one another, employing partial correlations alongside Pearson correlations. Results showed that correlation coefficients between DMN regional activity and intelligence scores remained largely unchanged even after controlling for the Big Five personality traits (Tables 3 and 5), with one exception: while the zero-order correlation between verbal IQ and left inferior parietal activity in the Beta3 band was borderline (r = 0.344, p = 0.054), after controlling for personality variables, this correlation increased markedly and reached statistical significance (r = 0.566, p = 0.002). This substantial change—a 65% increase in effect size—indicates that **personality acts as a suppressor variable** in this relationship. In other words, individual differences in personality traits had been masking a portion of the shared variance between verbal IQ and neural activity. This finding is conceptually coherent. The left inferior parietal region plays a key role in social cognition and interpersonal information processing. Verbal IQ, meanwhile, is not merely a measure of lexical ability but also entails social communication skills (Wieczorek et al., 2025). Thus, it is reasonable that activity in this region is associated with verbal IQ. Controlling for personality variables—themselves linked to social cognition and communicative patterns—serves to unveil this intrinsic relationship more clearly.

These findings also held true for the relationship between personality factors and DMN hub activity, and removing the effect of intelligence did not significantly impact the observed associations. Overall, this pattern suggests the relative independence of this neurocognitive relationship from personality variables. Indeed, the relative stability of the correlation coefficients in partial correlation analyses highlights two important points: First, the relationship between DMN activity and intelligence cannot be attributed to a third factor such as personality. Second, the neural mechanisms underlying intelligence and personality appear to operate partially independently of one another. This finding is consistent with recent perspectives in cognitive neuroscience emphasizing the relative dissociation of neural circuits related to cognition and emotion (Barbey et al., 2014; Kennis et al., 2013; Woods et al., 2019).

Performance on the Visuospatial Tetris Task and Changes in DMN Activity Patterns

No significant direct relationship was found between Tetris game scores and the magnitude of activity changes in key DMN regions after controlling for the effect of intelligence. This result suggests that performance on this particular task is more influenced by other factors—such as processing speed, motor skills, or the efficiency of more specialized attentional and executive networks—than by DMN modulation directly. However, the observation of a borderline negative correlation between activity changes in the left inferior parietal lobe (beta3) and game scores after simultaneously controlling for intelligence and personality indicates a more complex interaction between individual characteristics and neural activity in determining behavioral performance. In other words, the relationship between DMN activity and performance may not be simply linear and may instead be moderated by the individual's cognitive-personality profile.

Neural Correlates of Intelligence and Personality in DMN Hub Changes

The findings of this study indicate that patterns of activity change in key regions of the default mode network (DMN) may be associated with individual differences in intelligence. A regression model based on two neural regions—the left inferior parietal lobe in the Beta1 band and the right precuneus in the Beta3 band—accounted for 46% of the variance in performance IQ in this sample (based on Adjusted R^2). For full-scale IQ, a univariate model including the left inferior parietal lobe in the beta3 band explained nearly 38% of the variance. These values indicate that frequency-specific changes in these regions are related to cognitive abilities; however, given the modest sample size and the exploratory nature of the study, these findings require replication in larger independent samples before drawing firm conclusions..

Regarding personality traits, although significant correlations were observed between left inferior parietal lobe activity (in the Alpha2, Beta2, and Beta3 bands) and the dimensions of Agreeableness and Extraversion, the observed effect sizes of these relationships were smaller in multivariate models. For instance, the final model explained only 25% of the variance in Agreeableness based on activity in this region within the alpha2 band. These results tentatively suggest that while personality may also be associated with DMN dynamics, its contribution to variance explanation appears to be more limited in the present study and is potentially influenced by other moderating variables.

In summary, models based on task-related DMN activity demonstrate substantial capacity for correlation with intelligence, whereas their contribution to predicting personality traits is more modest. This distinction likely reflects differences in the neurocognitive nature of these two categories of psychological constructs.

Conclusion

The present study demonstrated that changes in Default Mode Network (DMN) activity during the transition from rest to a cognitive task not only reflect task demands but may also interact with stable individual characteristics such as intelligence and personality dimensions. Findings from correlation analyses and multiple regression confirmed that:

1. It is noteworthy that none of the significant DMN activity changes observed in anterior brain regions showed any correlation with individual differences in intelligence or

personality traits. This finding is likely attributable to the visuospatial nature of the task employed. Given that the DMN's anterior hubs—particularly the medial prefrontal and orbitofrontal cortices—are primarily involved in self-referential, affective, and socially oriented processing, a visuospatial task such as Tetris may not sufficiently engage these regions to reveal individual differences related to higher-order cognitive or personality characteristics. This absence of association further underscores the task-dependent specificity of DMN functional dynamics and suggests that individual differences in anterior DMN modulation may only emerge under tasks that recruit socio-affective or introspective processes.

2. The pattern of DMN activity change during task engagement can serve as a potential sensitive neural marker for predicting specific cognitive abilities (e.g., performance and full-scale IQ). In particular, increased activity in the right precuneus (Beta3 band) and left inferior parietal lobe (Beta1 band) were among the neural correlates of performance IQ.
3. Although personality looks to be independently associated with activity changes in certain DMN regions, it did not appear to play a strong moderating role in the relationship between intelligence and neural activity. This suggests a relative dissociation between the neurocognitive substrates underlying intelligence and personality.
4. Performance on the visuospatial task (Tetris) did not show a direct association with DMN modulation, indicating that behavioral performance in such tasks is likely influenced by other factors, including processing speed, motor skills, and the efficiency of more specialized attentional and executive networks.

5. Regression models based on DMN activity accounted for variance in cognitive abilities in the present sample; however, adding personality variables to these models did not appear to improve their accuracy.

Collectively, these findings emphasize the complexity and dynamic nature of brain state regulation and open new avenues for future research in the field of individualized neuroscience and the neural underpinnings of cognitive and personality differences. Future studies are recommended to investigate functional connectivity within the DMN and its changes during the rest-to-task transition. Moreover, given that age was controlled in the present sample, similar studies across different age groups are warranted to examine the effects of development and aging.

Limitations

Although the present study represents an effort to investigate DMN activity during both rest and task states, it is limited by its relatively small sample size. The sample of 36 participants, while adequate for preliminary analyses, may restrict statistical power to detect smaller effects and limit the generalizability of findings to broader populations. Additionally, the following limitations in the design and execution of the study should be noted and we suggest to be considered for further research:

1. **Limited task variety:** This study employed only one visuospatial task (Tetris) to induce the rest-to-task transition. Therefore, generalizing these findings to other cognitive domains (e.g., verbal memory, abstract reasoning, or affective tasks) requires examination using more diverse paradigms.

2. **Limitations of neural recording method:** Despite the advantages of EEG, including high temporal resolution and the use of sLORETA for source localization, this method offers lower spatial resolution compared to techniques such as fMRI. In particular, accurate localization of deep brain structures (e.g., deep regions of the anterior cingulate cortex or insula) remains challenging.

3. **Limitations in personality and intelligence assessment:** While the NEO-FFI is a well-validated instrument for assessing the Big Five personality traits, it relies on self-report and may be subject to response biases. Furthermore, although the intelligence test used is valid, it does not cover other dimensions of intelligence such as emotional intelligence or creativity.

4. **Limitations in statistical analysis and multiple comparison correction:** Despite employing methods such as FDR to correct for multiple comparisons, the large number of comparisons (12 regions × 8 frequency bands) may increase the risk of Type II error (i.e., missing true effects). In addition, some regression analyses exhibited moderate multicollinearity among predictor variables, which—although not severe—complicates the interpretation of coefficients.

Taken together, these limitations indicate that while the present findings represent an important step toward understanding the neural dynamics associated with individual differences, they require replication in larger samples, with more diverse tasks, and using multimodal approaches to confirm and generalize the results.

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Figures

Fig. 1

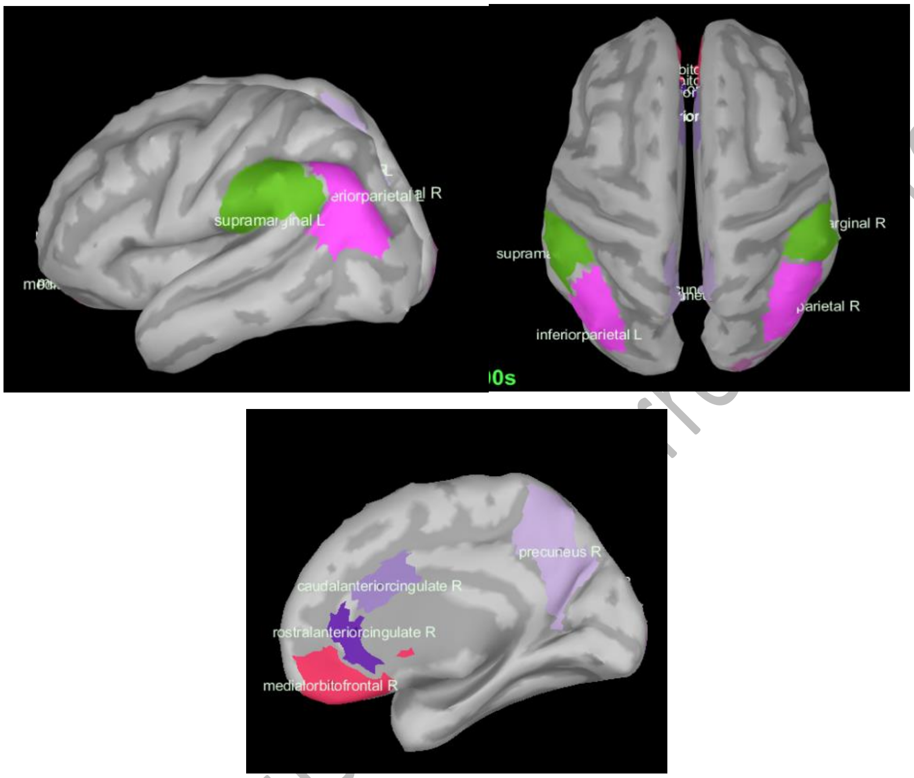

Figure 1. Cortical representation of selected hubs from the Desikan-Killiany atlas.

Fig. 2

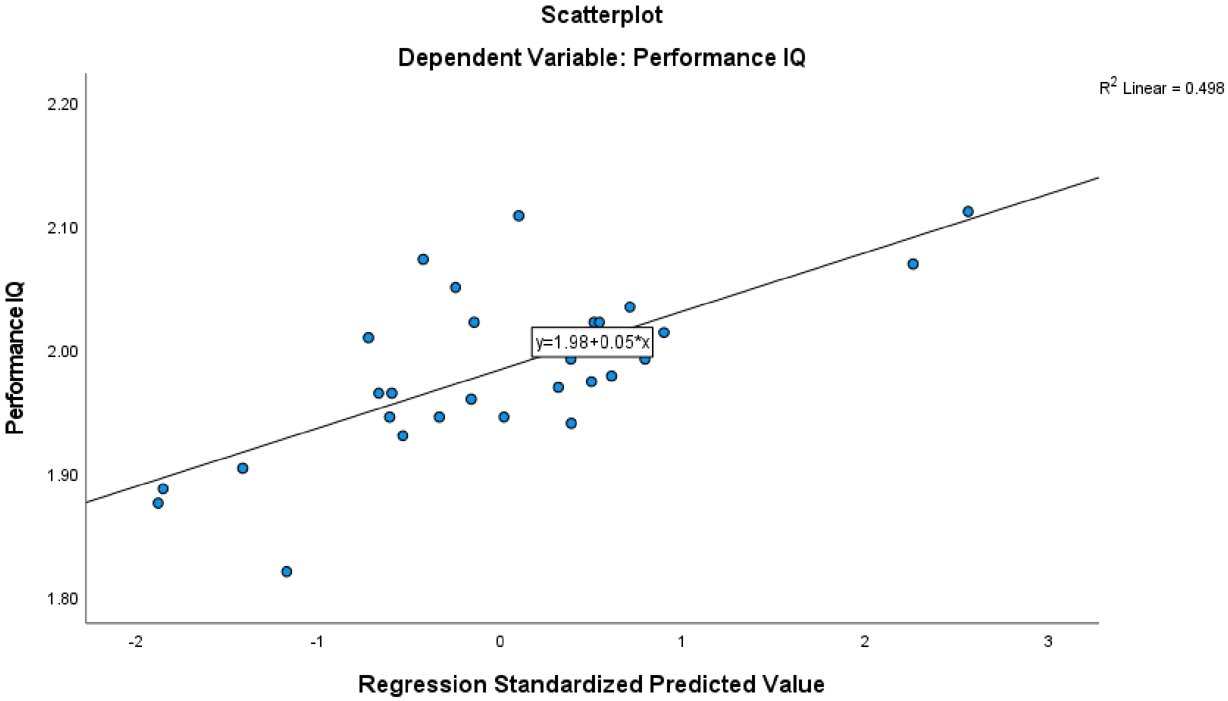

Figure 2. Multiple linear regression scatterplot showing the relationship between normalized relative power in the left inferior parietal lobe (Beta1 band) and right precuneus (Beta3 band) against Performance IQ scores. The trend line, indicates a positive linear association ($R^2 = 0.498,\ Adjusted\ R^2 = 0.459$).

Fig. 3

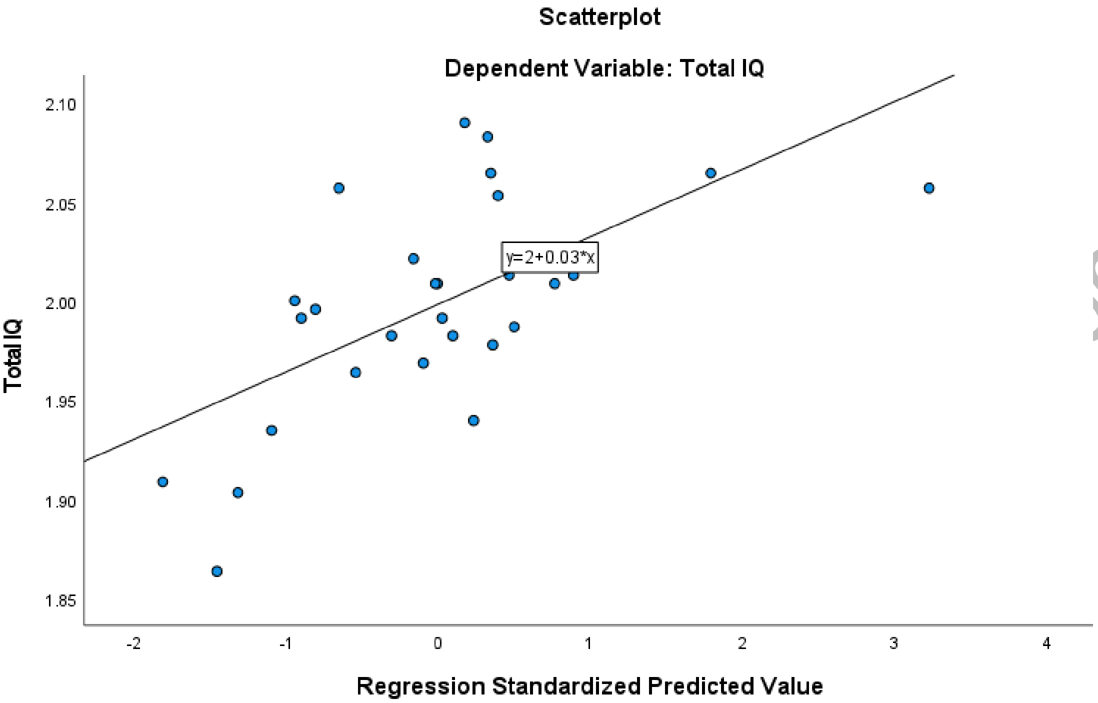

Figure 3. Multiple linear regression scatterplot showing the relationship between normalized relative power in the left inferior parietal lobe (Beta3 band) against Total IQ scores. The trend line, indicates a positive linear association ($R^2 = 0.381$).

Fig. 4

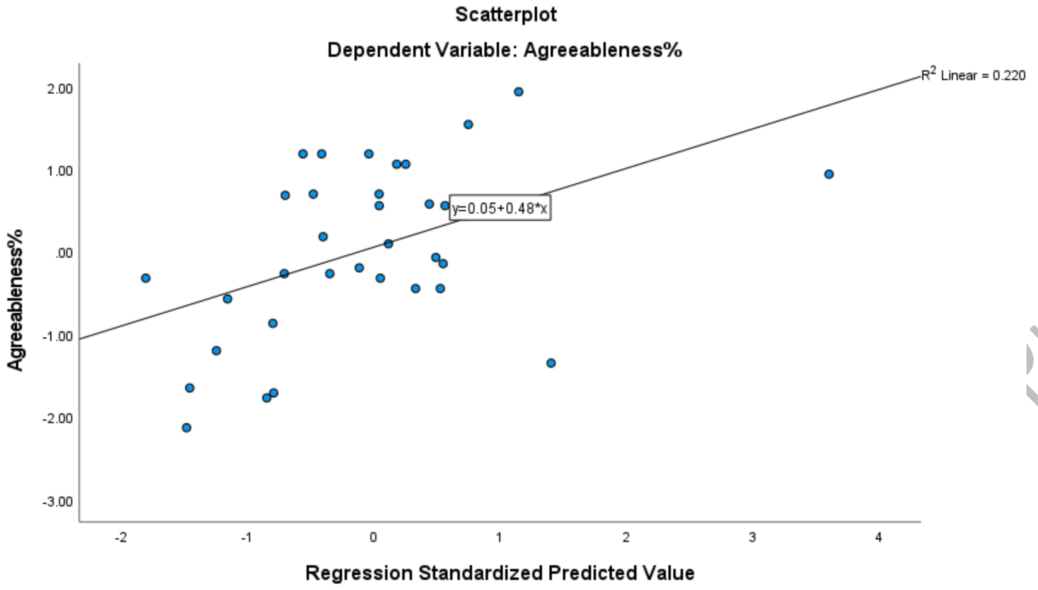

Figure 4. Multiple linear regression scatterplot showing the relationship between normalized relative power in the left inferior parietal lobe (Alpha2 band) against Agreeableness scores. The trend line, indicates a positive linear association ($R^2 = 0.22$).

Tables

Table 1. t-values for significant differences in electrical activity of Default Mode Network (DMN) regions between resting state and visuospatial task (Tetris) performance across different frequency bands (p<0.05)

Row Labels	Left Precuneus	Right Precuneus	Left Rostral ant. Cingulate	Right Rostral ant. Cingulate	Left Supramarginal	Right Supramarginal	Left Inferiorparietal
theta			2.2389	2.6435	1.5932		4.7978
alpha2		2.56		2.5521	1.4075		1.5087
beta1				2.5181	1.3254		1.4485
beta2		2.935		2.6232	1.2874		1.5095
beta3	2.7634	3.2655	2.6259	2.9215	1.6334	4.5824	1.7845
gamma1	3.0251	3.8299		2.5014	3.9781	3.1687	5.1865

Table 2-. Descriptive statistics of Wechsler Intelligence test and Tetris scores.

	N	Minimum	Maximum	Mean	Std. Deviation
age	36	19.00	28.00	22.3548	2.58906
verbal IQ	36	10.00	131.00	97.6471	23.54092
Practical IQ	36	35.00	129.00	93.8529	19.65634
total IQ	36	73.00	123.00	100.0294	11.48777
Game score	36	542	2720	1156.14	526.30

Table 3. Significant correlations between Default Mode Network (DMN) regional activity and intelligence scores.

area		**Partial correlation**			**Pearson correlation**		
		verbal IQ	Performance IQ	total IQ	verbal IQ	Performance IQ	total IQ
A2- Right precuneus	Correlation	0.008	**0.526**	0.370	0.029	0.465	0.329
	Significance (2-tailed)	0.968	**0.005**	0.053	0.871	0.007	0.062
B1- Left inferior parietal	Correlation	-0.194	**0.504**	0.269	-0.237	0.484	0.227
	Significance (2-tailed)	0.322	**0.007**	0.166	0.184	0.005	0.204
B3-Left inferior parietal	Correlation	**0.566**	0.448	**0.573**	0.344	0.413	0.461
	Significance (2-tailed)	**0.002**	0.019	**0.002**	0.054	0.019	0.008
B3-Right precuneus	Correlation	0.354	**0.668**	**0.600**	0.293	0.640	0.559
	Significance (2-tailed)	0.089	**0.000**	**0.002**	0.122	0.000	0.002

$p<0.01$

Table 4. Standardized regression coefficients (β) for the final model predicting Performance IQ

Model	Predictor	Beta	SE	t	p	VIF	R2	Adj_R2
1	A2_precuneus_R	0.109	0.015	0.648	0.523	1.426	0.506	0.447
1	B1_inferiorparietal_L	0.367	0.139	1.849	0.076	1.990		
1	B3_precuneus_R	0.340	0.028	1.743	0.094	1.926		
2	**B1_inferiorparietal_L**	**0.403**	**0.132**	**2.145**	**0.041**	**1.829**	0.498	0.459
2	B3_precuneus_R	0.368	0.027	1.960	0.061	1.829		

Table 5. Significant correlations between Default Mode Network (DMN) regional activity and the Big Five personality factors.

area		Partial Correlation					Pearson Correlation				
		N	**E**	**O**	**A**	**C**	**N**	**E**	**O**	**A**	**C**
A2-inferiorparietal left	Correlation	-0.148	-0.338	-0.317	**-0.476**	-0.171	-0.120	**-0.344**	-0.256	**-0.469**	-0.150
	Significance (2-tailed)	0.443	0.073	0.093	**0.009**	0.376	0.498	**0.046**	0.144	**0.005**	0.396
B2-inferiorparietal left	Correlation	0.045	-0.337	-0.211	**-0.497**	-0.220	0.078	-0.314	-0.079	**-0.433**	-0.139
	Significance (2-tailed)	0.818	0.074	0.273	**0.006**	0.251	0.662	0.070	0.659	**0.011**	0.434
B3-inferiorparietal left	Correlation	0.091	**-0.476**	-0.239	**-0.534**	-0.159	-0.020	-0.430	-0.207	**-0.504**	-0.250
	Significance (2-tailed)	0.638	**0.009**	0.211	**0.003**	0.411	0.912	0.012	0.248	**0.003**	0.160

N: Neuroticism ; E: Extroversion; O: Openness; A: Agreeableness; C: Conscientiousness.

P<0.01