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Research Paper

Resting-State Electroencephalogram (EEG) Coherence Over Frontal Regions in Paranormal Beliefs

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ABSTRACT

Introduction: Paranormal beliefs are defined as the belief in extrasensory perception, precognition, witchcraft, and telekinesis, magical thinking, psychokinesis, superstitions. Previous studies corroborate that executive brain functions underpin paranormal beliefs. To test this hypotheses, neurophysiological studies of brain activity are required.

Methods: A sample of 20 students (10 girls, Mean±SD age: 22.50±4.07 years) were included in the current study. The absolute power of resting-state electroencephalogram (EEG) was analyzed in intra-hemispheric and inter-hemispheric coherence with eyes open. The paranormal beliefs were determined based on the total score of the revised paranormal belief scale (RPBS).

Results: The results of this study demonstrated a significant negative relationship between paranormal beliefs and resting-state EEG in alpha band activity in the frontal lobe (left hemisphere), EEG coherence of alpha and β1, β2, and gamma band activities in the frontal lobe (right hemisphere) and coherence of alpha and β1, β2 and gamma band activities between frontal regions (two hemispheres). In addition, the results showed that coherence of α, α1, β, and β2 band activities between the frontal lobe (right hemispheres) and the EEG coherence of Δ, α1, and beta band activities in the frontal lobe (two hemispheres) predict paranormal beliefs.

Conclusion: This study confirms the connection of executive brain functions to paranormal beliefs and determines that frontal brain function may contribute to paranormal beliefs.

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Highlights

- Paranormal beliefs were negatively related to the EEG coherence.
- Paranormal beliefs were associated with EEG coherence in the right frontal lobe.
- We found a negative correlation between paranormal beliefs and the EEG coherence in the frontal lobes.
- EEG coherence the frontal lobes predicted paranormal beliefs.

Plain Language Summary

Paranormal beliefs were negatively related to the EEG coherence. They were associated with EEG coherence in the right frontal lobe. In this study, we found a negative correlation between paranormal beliefs and the EEG coherence in the frontal lobes. EEG coherence the frontal lobes predicted paranormal beliefs.

1. Introduction

Paranormal belief is described as a belief in psychological, biological, or physical phenomena assuming the existence of core/basic ontological characteristics of other ontological categories. Thus, physical and biological phenomena may have psychological core characteristics (such as intentionality, desires, and beliefs) (Betsch, Jäckel, Hammes, & Brinkmann, 2021). It is also likely that physical and mental phenomena have the main characteristics of biological organisms (such as contamination, healing, and living). Also, mental phenomena can have the main characteristics of physical phenomenon, such as independent presence and energy (or force) and the ability to touch objects (Betsch, Aßmann, & Glöckner, 2020; Drinkwater, Denovan, Dagnall, & Parker, 2020; Lindeman & Aarnio, 2007; Lindeman & Saher, 2007; Wellman & Gelman, 1998). Paranormal beliefs are beliefs, entities, practices, and processes that contradict the basic limiting principles of science (FioRito, Abeyta, & Routledge., 2020) and include belief in traditional religion, extrasensory perception, witchcraft, superstition, telekinesis, spiritualism, magical thinking, and precognition (Wilson, 2018). Cognitive neuroscience research on paranormal ideas has proposed the paranormal belief executive inhibition hypothesis (Narmashiri, Hatami, Khosrowabadi, & Sohrabi, 2017, 2019, 2021; Cristofori et al., 2016; Wain & Spinella, 2007).

As a reaction to authoritative propositions, executive down-regulation is theorized to underpin paranormal beliefs (Deeley, 2003). Since structural networks in frontal brain areas support executive functions, neuropsychological research has focused on the hypothesis of frontal executive inhibition, particularly dorsolateral prefrontal cortex (dlPFC) (Newberg, Wintering, Morgan, & Waldman, 2006). A theory was proposed for reducing cognitive resources in the monitoring of errors in religious rituals in the form of a paranormal phenomenon by Schjoedt and Sørensen (Schjoedt et al., 2013). Supporting the executive inhibition hypothesis, an activity reduction in dlPFC was found within paranormal experiences (Newberg et al., 2006). Participants were recently found to reduce dlPFC regions as a reaction to a charismatic speaker's prayers (Schjoedt et al., 2011). Also, dlPFC was demonstrated to be substantially more activated among skeptics than among paranormal believers (Lindeman et al., 2013).

Nonetheless, a large cortical network with dorsal cingulate, ventrolateral prefrontal cortex, parietal cortex, and dlPFC was demonstrated to support cognitive control (Aron et al., 2004; Corbetta & Shulman, 2002). Research has viewed the dlPFC as a key brain structure for inhibition imposition, specifically concerning paranormal beliefs (Schjoedt, Stødkilde-Jørgensen, Geertz, Lund, & Roepstorff, 2011). Cognitive control involves the dlPFC (Koechlin, Ody, & Kouneiher, 2003); the explanation for such a reduction is based on the reduction of cognitive resources in religious rituals in monitoring errors (Schjoedt et al., 2013). This may induce a belief in the mysticalness of specific sensorial experiences on account of a supernatural phenomenon - or partially on account of improper inhibitory control (Hood Jr, Hill, & Spilka, 2018). Lesions of the essential networks in cognitive control (e.g., dlPFC) may affect the human belief system and thus raise paranormal beliefs.

Research has recently focused on how such psychological properties are neurophysiologically correlated. In the electroencephalogram (EEG) method, alternations in the time of cerebral cortex electrical activity arising from postsynaptic potentials of numerous neurons with the similarity of spatial orientation are recorded (Cassani, Estarellas, San-Martin, Fraga, & Falk, 2018). Such electric potentials are measured by scalp-positioned electrodes. EEG spatial resolution associates with the number of electrodes and position (arrangement) on the scalp. The international 10-20 system is the most used positioning; it involves twenty-one electrode locations. Other variants of this system with larger density are also employed, which involve 64 and 128 electrodes; the former is known as the international 10-10 system, while the latter is referred to as the 10-5 system (Jurcak, Tsuzuki, & Dan, 2007). Other positioning systems include the Maudsley (Seeck et al., 2017) and Geodesics (Hu, Lai, Valdes-Sosa, Bringas-Vega, M. L., & Yao, 2018) layouts. Research has recently demonstrated that quantitative EEG (qEEG) is a valid clinical instrument to diagnose and investigate diseases, mental states, and cortical disorders (Boersma et al., 2011; Jeong, Kim, Song, Chung, & Jeong, 2016; Sponheim, Clementz, Iacono, & Beiser, 2000; Wang et al., 2013). The power/amplitude and network connectivity (including phase delay, asymmetry, and coherence) indices are two categories of EEG variables. They represent the correlation extent of various brain regions (Thatcher, North, & Biver, 2005).

The EEG measures of coherence can be employed to effectively estimate the connectivity of the cortical brain region (Rippon, Brock, Brown, & Boucher, 2007). The EEG coherence measurement approximates the synchronization of two regions in the brain based on EEG signal records in various scalp sites (Nunez & Srinivasan, 2006). Large EEG coherence stands for the high synchronization of brain regions, while small coherence represents poor synchronization (Murias, Webb, Greenson, & Dawson, 2007). Apart from the synchronicity degree, research has demonstrated that various EEG frequencies are correlated with various cognitive processes. It is possible to use event-associated neural oscillations to analyze neural responses via several frequency bands (such as alpha, theta, gamma, beta, and delta) (Nguyen et al., 2017). Each frequency band transfers distinct information on basic brain processes within paranormal beliefs. Furthermore, several resting-state EEG works demonstrated that the activities of the alpha (Ishii et al., 1999; Nigbur, Ivanova, & Stürmer, 2011; Yamanaka & Yamamoto, 2010), beta (Bresnahan & Barry, 2002; Choi et al., 2013; Kühn et al., 2004; Lee et al., 2017), and gamma (Barry et al., 2010; Benasich, Gou, Choudhury, & Harris, 2008; Han et al., 2020; Harmony, Alba, Marroquín, & González-Frankenberger, 2009; van Wingerden, Vinck, Lankelma, & Pennartz, 2010) bands are related to the frontal region. They suggested that the frontal region could be related to the activities of the gamma, β, and α bands.

Although paranormal beliefs have not been related to frontal regions in the literature, research has provided electrophysiological findings concerning paranormal beliefs; previous works focused more on the lateralization of the brain in such findings. The source locations of skeptics and paranormal believers were shown to substantially differ in the beta, gamma, and delta bands (Gianotti, Faber, & Lehmann, 2002; Narmashiri, Sohrabi, & Hatami, 2020). Also, right-localizing gamma-band activity was demonstrated to support previous observations of beta-band activity. Several studies argued paranormal believers have greater right-hemisphere activity and lower or irregular asymmetry of the hemispheres (Pizzagalli et al., 2000). In paranormal believers and non-believers, significant beta (excitatory) activity was located to the right and left hemispheres, respectively. Furthermore, compared to those who have low transliminality, high-transliminality people have smaller beta and alpha bands in the right superior temporal cortex and the left occipital/parietal region (Fleck et al., 2008). High transliminality people were reported to have high gamma bands within the media-frontal cortex and low gamma bands within the right temporal lobe and left temporal/occipital region.

Given that, some band activities, such as the alpha, beta, and gamma in the frontal lobe were associated with cognitive function; therefore, we concentrated on alpha, beta, and gamma bands activity in the present study. Previous studies have shown dysfunction in the frontal lobe in supernatural beliefs and paranormal phenomena (Cristofori et al., 2016; Wain & Spinella, 2007). Therefore, according to the executive inhibition hypothesis, we expected that dysfunction of the frontal lobe would be associated with increased paranormal beliefs due to the frontal cortex (FC) role in regulating inhibition and evidence showing FC regions deactivation in paranormal experiences. Based on this hypothesis, we hypothesized that paranormal beliefs are regulated by key regions in the frontal lobe. We sought to find the characteristics of the resting-state EEG activity to identify frontal region activities in paranormal believers. Due to the lack of resting-state EEG studies, especially in the frontal lobe in paranormal beliefs, we predict that reduction in frontal activity in the alpha, beta, and gamma band (left and right hemispheres) was related to the rise in paranormal beliefs.

2. Methods

Participants

A total of 20 (10 girls, Mean±SD age: 22.50±4.07 years, the age range of 19-34 years) healthy right-handed psychology students (Edinburgh handedness inventory) were selected for the study. The participants were recruited from classrooms at the University of Tehran City, Iran. Based on the self-report questionnaire, the participants had no history of mental, neurological, or personality disorders, no acute or chronic diseases, and no history of alcohol or substance abuse, epilepsy, psychosis, head injury, and other mental disorders.

Behavioral measure

The revised paranormal belief scale (RPBS) has 26 items. These items are classified into 7 groups, including Psi, traditional religious beliefs, superstition, witchcraft, precognition, extraordinary life forms, and spiritualism. The seven-point Likert scale was used to rate the items, where 1 represented "highly disagree," while 7 stood for "highly agree" (Tobacyk, 2004). Moreover, to measure reliability, Cronbach's alpha was employed and calculated to be 0.92.

Electroencephalogram (EEG) recording

The participants were given seats and rested in a place connected to the recording room. A 5-minute EEG recording was performed with open eyes (Mitsar Medical, Petersburg, Russia). The standard 10-20 layout was applied to seven sites, including Fz, F7, F8, F4, F3, FP1, and FP2, of 32 channels. A single channel consisting of bipolar electrodes was attached to the ears as a reference. The ground electrode was located in the space between Fz and FPz. The signal was sampled at 250 Hz. The impedance of the electrodes was lower than 5 kΩ. Also, the band-pass filtration of the EEG signals was performed using Mitsar 202 at a frequency of 0.1-40 Hz. The recordings of the WinEEG setup were transmitted to the EEGLAB toolbox (NG 2.5.5; Applied Neuroscience, Inc., St. Petersburg, USA) to undergo standard preprocessing. The Artifact rejection toolbox was employed to perform offline artifact removal. Furthermore, the visual inspection of the EEG recordings was carried out to eliminat artifact effects (such as eye muscle movement effects). Then, a rapid Fourier transform was applied in MATLAB to analyze the spectra (MathWorks, Natick, Massachusetts, USA). The cleaned EEG data at 9 frequency bands including, gamma (30-40Hz), beta2 (19-30Hz), beta1 (13-21Hz), beta (13-30Hz), alpha2 (11-13Hz), alpha1 (8-10Hz), alpha (8-13Hz), theta (4-8Hz), and delta (1-4Hz), were utilized to extract the absolute (uV2) power. Based on (Bastos, Adamatti, & Billa, 2016), the activities in seven sites were hypothetically employed as frontal regions (i.e., F8, F4, FP2, Fz, F7, F3, and FP1). This study concentrated on gamma, beta, and alpha frontal region activities to examine the proposed hypotheses.

Statistical analysis

Before the formal analysis, we conducted an exploratory data analysis to identify and remove outliers to avoid the possibility of spurious results. We used Pearson's correlations and multiple regression analysis to explore the relationships between the resting-state EEG activities and the paranormal beliefs of the subjects. Statistical analyses were performed using IBM SPSS Statistics v. 24 (IBM Inc., New York, USA), and P values less than 0.05 were considered statistically significant.

3. Result

In the present study, 20 subjects participated and the Mean±SD age was 22.50±4.07; 10 subjects were girls (50%) and 10 subjects were boys (50%); the Mean±SD years of education was 15.50±1.72. The Mean±SD of paranormal beliefs for the participants were 84.80±17.03.

Table 1 presented a negative correlation between the paranormal beliefs and the coherence of alpha in the left hemisphere regions (r=-0.455, P<0.05) (Figure 1). In the right and left hemispheres, no relationship was observed between paranormal beliefs and EEG coherence in the Δ, Θ, α1, α2, β, β1, β2, and gamma-band of the regions.

Table 2 presented a negative correlation between paranormal beliefs and the coherence of alpha (r=-0.471, P<0.05), beta1 (r=-0.547, P<0.05), beta2 (r=-0.568, P<0.001), and gamma-band activities (r=-0.453, P<0.05) between the regions in the right hemisphere (Figure 2). However, in the right hemispheres, no relationship was observed between paranormal beliefs and EEG coherence in Δ, Θ, α1, α2, and β-band activities of the regions.

Table 3 presented a negative correlation between paranormal beliefs and α (r=-0.503, P<0.05), β1 (r=-0.449, P<0.05), β2 (r=-0.517, P<0.05), and gamma-band activities (r=-0.460, P<0.05) between the regions of the two hemispheres (Figure 3). In the two hemispheres, no relationship was observed between paranormal beliefs and

Table 1. Demographic and behavioral characteristics of the participants

Variables	Mean±SD / No.
Age (y)	22.50±4.07
Gender: male/female	5
Education (y)	15.50±1.72
PRBS	60.05±28.29

RPBS: revised paranormal belief scale.

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Table 1. Pearson correlation between paranormal beliefs and EEG activity of left intrahemispheric

Variables	1	2	3	4	5
α coherence	1.00				
β1 coherence	0.727**	1.00			
β2 coherence	0.675**	0.887**	1.00		
Gamma coherence	0.650**	0.792**	0.913**	1.00	
Paranormal beliefs	-0.455*	-0.237	-0.356	-0.276	1.00

* P<0.05; ** P<0.01.

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EEG coherence in delta, theta, alpha1, alpha2, and beta-band activities of the regions.

In the present study, we conducted a regression analysis to identify the effects of volumetric conduction on EEG coherence using average band activities in hemispheres. Table 4 presented that any of the band activities of the frontal lobe were not predictors of paranormal beliefs (R^2=0.26, F=1.75, P=0.19).

Table 5 revealed that the coherence of right hemisphere regions predicted 51% of the total variance of paranormal beliefs (R^2=0.51, F=3.19, P<0.04). In addition, α (b=-1.19, P<0.03), α1 (b=-1.59, P<0.01), β (b=-0.73, P<0.02), and β2 (b=-1.85, P<0.04) coherence at the left frontal regions negatively predicted paranormal beliefs.

The results of Table 6 revealed that the coherence of two hemisphere regions (interhemispheric) predicted 58% of the total variance of paranormal beliefs (adjusted R^2=0.58, F=4.02, P<0.02). In addition, delta (b=-0.455, P<0.02), α1 (b=-0.74, P<0.01), and β (b=-0.72, P<0.01), coherence at the interhemispheric (two hemispheres) negatively predicted paranormal beliefs.

4. Discussion

The present study aimed to examine the correlation between the EEG coherence over frontal regions and

Table 2. Pearson correlation between paranormal beliefs and EEG activity of right intrahemispheric

Variables	1	2	3	4	5
α coherence	1.00				
β1 coherence	0.875**	1.00			
β2 coherence	0.728**	0.877**	1.00		
Gamma coherence	0.742**	0.745**	0.871**	1.00	
Paranormal beliefs	-0.471*	-0.547*	-0.568**	-0.453*	1.00

* P<0.05; ** P<0.01

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Table 3. Pearson correlation between paranormal beliefs and EEG activity of the right and left interhemispheric

Variables	1	2	3	4	5
α coherence	1.00				
β1 coherence	0.890**	1.00			
β2 coherence	0.823**	0.921**	1.00		
Gamma coherence	0.785**	0.805**	.931**	1.00	
Paranormal beliefs	-0.503*	-0.449*	-0.517*	-0.460*	1.00

* P<0.05; ** P<0.01

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Table 4. Regression analyses for paranormal beliefs based on eeg activity of left intrahemispheric

Predictor	B	SE	b	P
Δ (left hemispheric)	-3.981	2.637	-.332	.162
Θ (left hemispheric)	2.842	4.126	.190	.507
α (left hemispheric)	-12.794	5.478	-.798	.042
α1 (left hemispheric)	-7.715	5.175	-.477	.167
α2 (left hemispheric)	2.295	7.363	.102	.762
β (left hemispheric)	-5.235	4.014	-.372	.221
β1(left hemispheric)	-23.670	12.541	-1.433	.088
β2 (left hemispheric)	10.882	8.491	.718	.229
Gamma (left hemispheric)	14.547	10.810	.736	.208
R^2	0.26			

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Table 5. Regression analyses for paranormal beliefs based on EEG activity of right intrahemispheric

Predictor	B	SE	b	P
Δ (right hemispheric)	-4.193	2.425	-.311	.115
Θ (right hemispheric)	1.232	2.872	.093	.677
α (right hemispheric)	-14.965	6.163	-1.195	.036
α1 (right hemispheric)	-22.519	7.837	-1.599	.017
α2 (right hemispheric)	21.312	12.058	1.173	.108
β (right hemispheric)	-10.036	3.632	-.736	.020
β1 (right hemispheric)	16.283	9.685	1.196	.124
β2 (right hemispheric)	-27.383	12.165	-1.854	.048
Gamma (right hemispheric)	15.261	8.240	.980	.094
R^2	0.51			

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Table 6. Regression analyses for paranormal beliefs based on EEG activity of left and right interhemispheric

Predictors	B	SE	b	p
Δ (interhemispheric)	-5.995	2.232	-0.455	0.023
Θ (interhemispheric)	2.871	2.817	0.205	0.332
α (interhemispheric)	-9.828	6.705	-0.664	0.173
α1 (interhemispheric)	-11.759	3.683	-0.741	0.01
α2 (interhemispheric)	7.211	3.830	0.407	0.089
β (interhemispheric)	-10.088	3.517	-0.722	0.017
β1 (interhemispheric)	10.160	9.916	0.685	0.33
β2 (interhemispheric)	-26.490	14.399	-1.673	0.096
Gamma (interhemispheric)	13.092	10.655	0.711	0.247
R^2	0.58			

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paranormal beliefs. In the left hemisphere, the results of this study showed that paranormal beliefs were negatively related to the EEG coherence of alpha band activity. In addition, paranormal beliefs were associated with EEG coherence of α and β1, β2, and gamma-band activities in the right frontal lobe. We found a negative correlation between paranormal beliefs and the EEG coherence of α and β1, β2, and gamma band activities between the frontal lobe of the two hemispheres.

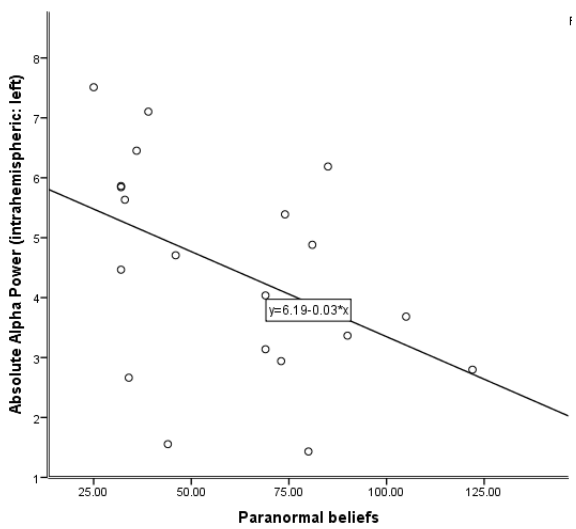

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Figure 1. Correlation between paranormal beliefs score and alpha band in the left hemisphere

The X-axis represents the scores of paranormal beliefs and the Y-axis represents the alpha band in the left hemisphere.

Additionally, EEG coherence of α, α1, β, and β2 band activities between the right frontal lobe and EEG coherence of Δ, α1, and band activities in the frontal lobe of the two hemispheres predicted paranormal beliefs.

The findings expectedly revealed that low frontal region activity is negatively related to paranormal believers. Previous works observed paranormal beliefs and phenomena to be associated with functionality reduction in frontal regions, particularly the prefrontal cortex (Cristofori et al., 2016; Wain & Spinella, 2007). These findings are consistent with the executive inhibition hypothesis. Previous works demonstrated a relationship between the dysfunction of the frontal region and increased paranormal experience. These findings can support this hypothesis via the mechanism proposed for the association of frontal lobe activity dysfunction with supernatural beliefs, resulting in increasing supernatural beliefs.

Decreased gamma, beta, and alpha-band activity in the frontal regions and the paranormal belief enhancement can be related to executive frontal dysfunction in paranormal beliefs. According to the findings, alpha power implies a neural inhibitory mechanism in external sensory information influx in resting-state EEG (Mathewson et al., 2011). Based on alpha power, such a neural mechanism can be associated with the gamma-aminobutyric acid (GABA)ergic inhibitory activity via a brain inter-neuronal network (Jensen & Mazaheri, 2010) as well as unbalanced glutamatergic-GABAergic neurotransmission. Furthermore, when no external stimuli exist, dysfunction of resting-state beta-band activity could

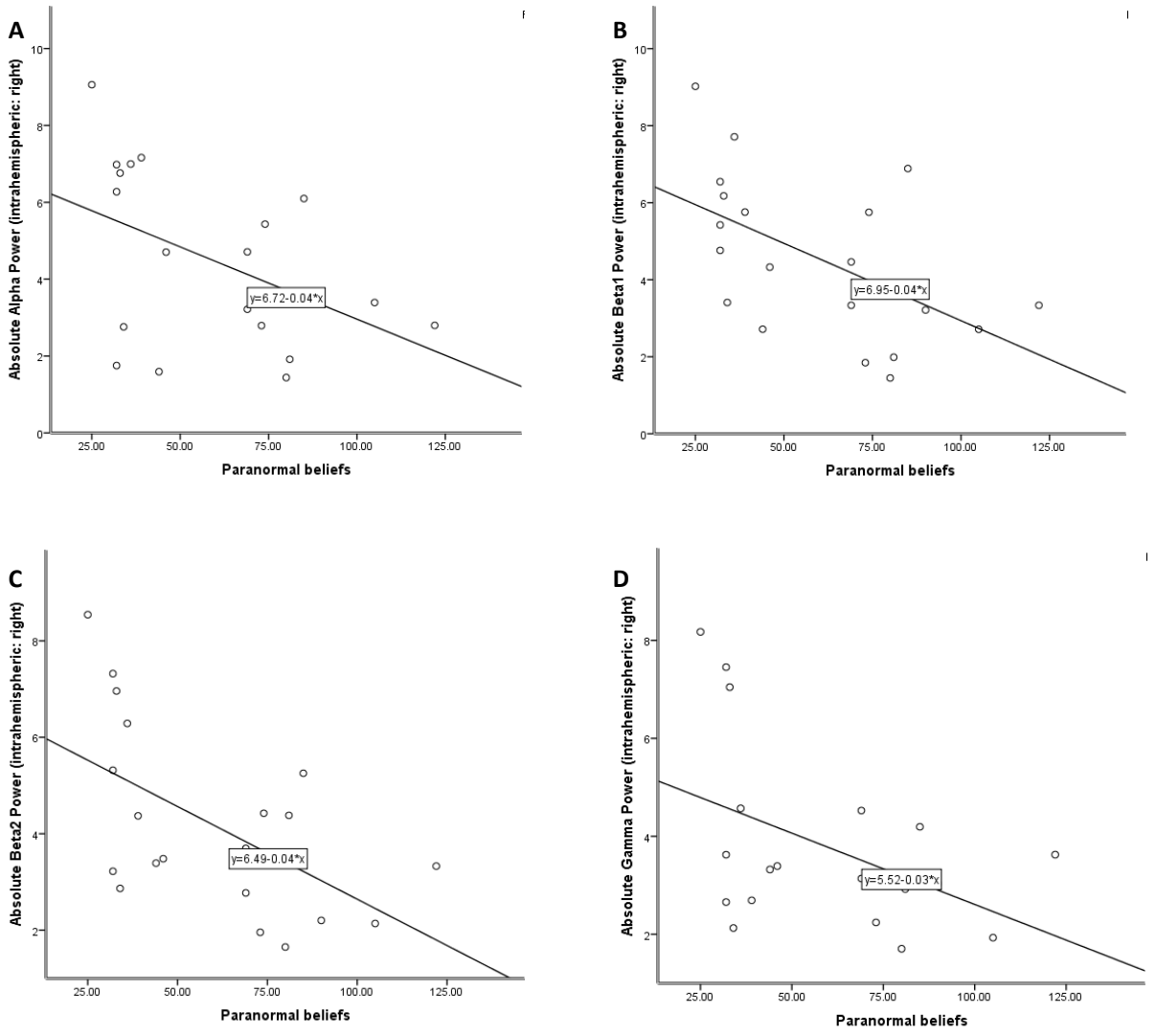

Figure 2. Correlation between paranormal beliefs score and absolute (A) α, (B) β1, (C) β2, and (D) Gamma bands in the right hemisphere

The X-axis represents the scores of paranormal beliefs and the Y-axis represents the absolute power in the right hemisphere.

imply dopamine depletion in the dlPFC region (George et al., 2013), which associates with the executive inhibitory function. Also, reduced gamma-band activity can be associated with front lobe neural dysfunction (Rosanova et al., 2009) "mendeley":{"formattedCitation"; (Rosanova et al., 2009), and impairment reflection in pyramidal neuron synchronous inhibition (Gonzalez-Burgos & Lewis, 2008), and GABAergic neurotransmission (Lewis, Hashimoto, & Volk, 2005).

Nonetheless, the aforementioned executive function theories support previous works identifying inhibitory deregulation as a driver of paranormal experience. Future studies can investigate the possibility of reporting paranormal experiences by individuals. The findings of the present study are not only consistent with mysticism executive neuropsychological theories but also consistent with a wider range of executive brain function studies. dlPFC is essential for the control of emotional and attentional cognitive mechanisms (Davidson, Putnam, & Larson, 2000). In this respect, a large number of works demonstrated that the dlPFC contributes to the down-regulation of emotional processing. Neuroimaging research has shown that dlPFC activity rises under neural stimulus awareness and suppression of fearful stimulus (Amting, Greening, & Mitchell, 2010). In addition, previous studies employed functional and or electrophysiological methods and showed that the dlPFC activity consistently enhanced in re-evaluation (Ochsner et al., 2004). Considering the dlPFC contribution to rationality and emotional control, it is argued that

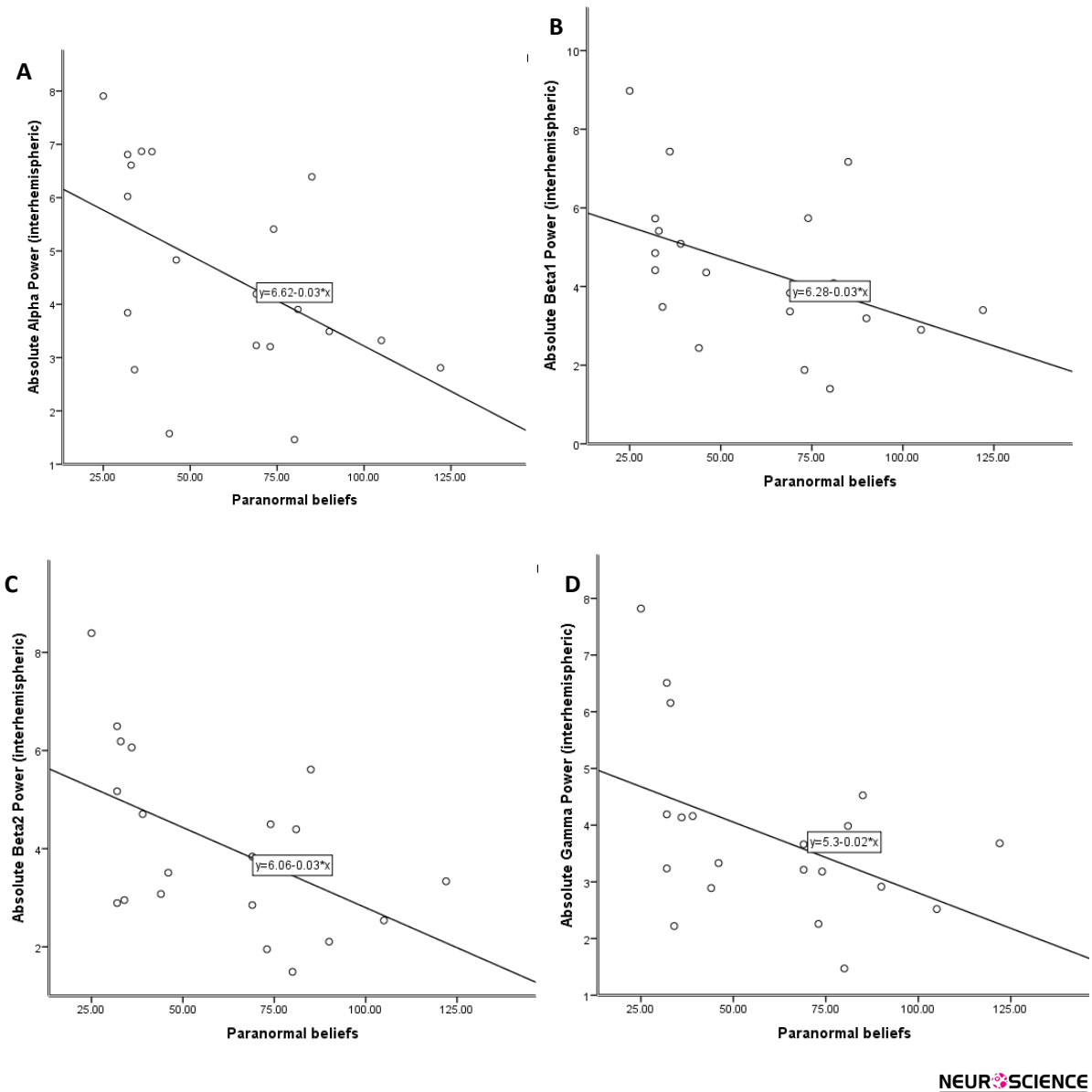

Figure 3. Correlation between paranormal beliefs score and absolute (A) α, (B) β1, (C) β2, and (D) Gamma bands in two hemispheres (interhemispheric)

The X-axis represents the scores of paranormal beliefs and the Y-axis represents the absolute power in two hemispheres (interhemispheric).

dlPFC plays a key role in regulating mystical experience via the binding of rational experience, deliberation, and context to posterior perceptual phenomenon-influenced cortices. Consequently, mystical experiences can enjoy more contextual search and thus weaken the prefrontal cortical representational process. A damaged superior PFC leads subjects to imagine that their perceptual experience is not in the real world and to adopt imaginary supernatural/mystical explanations (Bulbulia, 2009).

We had several limitations in this study. Firstly, convenient sampling and selection of the sample from university students constituted one of the limitations of the present study. Secondly, the sample size in the present study was small. Further investigations with a larger population focusing on other variables associated with frontal activity in paranormal beliefs such as executive function are necessary. Thirdly, paranormal beliefs were assessed with a self-report scale. Future studies using objective methods to assess paranormal beliefs level, including cognitive and behavioral function tasks, are needed. In addition, concerning the participation of women in this study, some studies have reported that the function of the prefrontal cortex may be affected by the levels of estrogen and progesterone hormones (Amin, Epperson, Constable, & Canli, 2006;

Solis-Ortiz, Guevara, & Corsi-Cabrera, 2004). Therefore, future studies are recommended to control the menstrual period of female participants.

5. Conclusion

Overall, the findings suggest that high paranormal beliefs are associated with reduced EEG alpha-band activity coherence and reduced EEG gamma, beta, and alpha-band activity coherence in the right and left hemispheres, respectively. Such findings imply that paranormal beliefs are related to the activity of the lower frontal region, particularly in the right hemisphere and two hemispheres. The present work supports the association of paranormal beliefs with executive brain functions and claims that frontal brain functions are likely to influence paranormal beliefs.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Conceptualization, methodology, software, writing-original draft, writing-review, and editing: Abdolvahed Narmashiri; Conceptualization, methodology, writing-review and editing, supervision: Javad Hatami; Methodology, software, writing-review and editing, supervision: Reza Khosrowabadi; Resources, supervision: Ahmad Sohrabi.

Conflict of interest

The authors declared no conflict of interest.

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