Abnormal Resting-State Brain Networks and their Relationship with Cognitive Reappraisal Preferences in College Students with Depressive Tendencies

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Abstract

This study investigates resting-state brain network characteristics in college students with depressive tendencies (DT) and their link to cognitive reappraisal strategies. A group of 38 DT students and 41 healthy controls (HCs) were assessed using questionnaires on cognitive reappraisal strategies, followed by alpha and beta frequency band EEG feature extraction. Through complex network analysis, significant reductions in cognitive reappraisal preferences were noted among DT participants compared to HCs, alongside abnormalities in brain network centrality, particularly in the frontal and limbic lobes across different frequency bands. A notable correlation was found between the preference for cognitive reappraisal in DT participants and significant changes in graph indices. The findings highlight substantial alterations in the resting-state brain networks of DT individuals, closely associated with cognitive reappraisal strategy preferences. These alterations may affect emotion regulation strategy choices, offering insights into the neural mechanisms of emotional regulation difficulties in DT.

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Keywords : depressive tendency; resting state; complex network; cognitive reappraisal

Introduction

College students are a high-risk group for emotional disorders, with depression being the most prominent and showing an increasing trend in detection rates year by year (Chen, Zhang & Yu, 2022). Depressive tendencies represent a mild state of depression, lying between the normal depressive emotions of healthy individuals and clinical depression that meets diagnostic criteria (Rodríguez et al., 2012). Studies have indicated that DTs have an increased risk of experiencing their first episode of depression compared to HCs (Lee et al., 2019). College students are more likely to exhibit depressive emotions when encountering negative or stressful life events. If these emotions are repeatedly induced without effective emotional regulation strategies, the likelihood of developing clinical depression increases. Therefore, DT college students who are at higher risk of a depressive episode warrant significant attention and consideration from researchers.

Difficulty in emotional regulation is one of the core features of the onset mechanism of depression (Joormann & Stanton, 2016). Studies have found that frequent use of effective emotional regulation strategies can promote an individual's physical and mental health development, while ineffective strategies may lead to an increase in negative emotions (Campbell-Sills, Barlow, Brown, & Hofmann, 2006). Therefore, exploring effective emotional regulation strategies is crucial. Cognitive reappraisal, which involves changing one's understanding of an emotional stimulus and thereby altering its meaning and emotional impact, is considered a highly effective emotional regulation strategy for maintaining mental health and is closely related to the occurrence and maintenance of depression (Gross & John, 2003; Buhle et al., 2014). Zhang et al. (2016) found that although individuals with depression could use cognitive reappraisal to reduce negative emotions, its effectiveness was lower than that of the control group. Additionally, the effectiveness of cognitive reappraisal under laboratory guidance in depressed individuals is also influenced by the symptoms of depression (Dillon & Pizzagalli, 2013). Liu and Thompson (2017) demonstrated that the frequency of cognitive reappraisal use is negatively correlated with depression symptoms. These studies indicate that the effectiveness of cognitive reappraisal in regulating negative emotions is related to the severity of DT, but the underlying neurophysiological basis of this relationship is currently unclear.

The human brain is a highly integrated and collaborative complex system, exhibiting substantial spontaneous activity even in a resting state without specific tasks (Van Den Heuvel, Stam, Kahn, & Hulshoff Pol, 2010). Exploring the integration between brain regions in this resting state provides a foundation for understanding the infrastructure of functional brain networks and the ways in which information is transmitted between brain regions (Hulshoff Pol & Bullmore, 2013). This approach has been widely applied in recent years to explore changes in the topological neural mechanisms of the brain in depressive populations (Liu et al., 2010; Chen et al., 2017; Hasanzadeh et al., 2020; Li et al., 2021; Yao et al., 2019). Our study aims to analyze the overall characteristics of brain networks in DT college students during the resting state, with the goal of exploring the potential connection between these characteristics and anomalies in the use of cognitive reappraisal strategies. Through this macroscopic perspective, we can more comprehensively understand the challenges faced by DT individuals in emotional regulation, particularly in terms of the coordination and connectivity of brain network functions. Hasanzadeh et al. (2020) found that the brain network structure of participants with depression tends to be more randomized, manifesting as changes in global network feature path length and efficiency, as well as alterations in the clustering coefficient, primarily concentrated in areas such as the frontal lobe, temporal lobe, and parahippocampal gyrus. Another study revealed the direct impact of the degree of depression on the brain's topological neural mechanisms, noting that this impact is related to the preference for the use of cognitive reappraisal (Mohammadi & Moradi, 2021). Since DT individuals are considered an early stage of depression, the relationship between changes in brain network characteristics in the resting state and the preference for cognitive reappraisal use remains to be clarified. Therefore, our study aims to explore the changes in brain network characteristics in DT individuals during the resting state and the potential link between these changes and the preference for cognitive reappraisal use.

Although some studies have explored the neuroscience world of emotional regulation using magnetic resonance imaging (MRI), electroencephalography (EEG) is a more suitable technique in comparison. It evaluates the timing and frequency of rapid and delayed spontaneous brain activity, characterizing the intrinsic neural cognitive networks (Canuet et al., 2011). Since the electrical activity of neuronal populations is conducted through the brain to the scalp, scalp recordings and neuronal activity occur almost simultaneously, allowing the measurement of early and rapid changes in neural processes. The relationship between EEG time series reflects the information transfer between different brain regions' electrical signals, revealing cooperative work patterns of various functional networks during cognitive processing. Additionally, the brain employs synchronous activities at different frequencies to achieve its functions. Studies have shown that abnormalities in the alpha frequency band are closely related to emotional processing (Olbrich & Arns, 2013), and beta frequency mainly occurs in the frontal lobe, related to cortical excitability, reflecting emotional and cognitive processes (Li et al., 2017). Shim et al. (2018) studied the brain network characteristics of patients with depression in a resting state based on EEG data. This research found that at a global level, patients with depression had reduced strength and clustering coefficients in the alpha frequency band, along with increased path length and reduced global efficiency. Other research comparing the different topological features of weighted directed networks between patients with depression and healthy individuals found an increase in global efficiency in the beta band for the former, with no significant difference in E_{loc}, indicating a more randomized brain network structure in patients with depression (Hasanzadeh et al., 2020). Additionally, research has highlighted a significant negative correlation between the clustering coefficient and the severity of depression in the alpha frequency band (Mohammadi & Moradi, 2021), suggesting that the severity of depression directly affects changes in the brain's topological neural mechanisms. Considering these findings, our study focuses on the alpha and beta frequency bands, employing complex network analysis to delve into the brain network characteristics of DT participants in a resting state, and the relationship between these characteristics and the preference for cognitive reappraisal use.

In summary, this study will explore the brain network characteristics of DT participants and healthy controls (HCs) in a resting state, employing complex network analysis combined with frequency domain analysis. Additionally, we will conduct correlational analyses to investigate the relationship between the resting state brain network characteristics of DT participants and their preference for cognitive reappraisal use. This aims to explore the extent to which the topological changes in the brain associated with DT affect their preference for cognitive reappraisal use. Based on evidence from existing literature, this study proposes two hypotheses: (1) Compared to HCs, DT participants will exhibit abnormal activity in their brain networks during a resting state; (2) There will be a significant correlation between the brain networks of DT participants and their preference for cognitive reappraisal use.

Methods and materials

Ethics statement

This cross-sectional study was approved by the Ethics Committee of China. All participants were informed of study aims, and were given the option of participating anonymously, refusing to participate, or withdrawing at any time. All participants provided informed written consent.

2.2 Participants

In this study, a total of 84 participants were recruited. Prior to the experiment, participants were screened using the Beck Depression Inventory-II (BDI-II) (1996). Those scoring BDI-II [?] 14 were preliminarily classified as DT participants, while those with BDI-II [?] 13 were classified as HCs (De Zorzi et al., 2021). During this process, we used DSM-5 (version 7.0.2) to exclude major depressive disorder (Sheehan et al., 1997). 43 students met the criteria for the DT group, and 41 students were selected for the HC group. Approximately one week later, they were invited to the laboratory for a secondary screening using Self-Rating Depression Scale (SDS) (1965). College students scoring SDS [?] 50 were classified into the DT group, while those scoring SDS ¡ 50 were classified in HC group (Benning & Ait Oumeziane, 2017). Five DT participants were excluded because they didn't not meet the secondary screening standards. Consequently, a total of 79 participants were included in the final sample, comprising 38 DT and 41 HC participants. All participants had no history of affective disorders or use of psychiatric medications, were right-handed, and had normal or corrected-to-normal vision.

2.3 Measures

We used Emotion Regulation Questionnaire (ERQ) and Cognitive Reappraisal Emotion Regulation Questionnaire (CRER) to measure participants' preference for the use of cognitive reappraisal strategies. ERQ is an 10 items self-report questionnaire and divided into two dimensions: cognitive reappraisal and expressive suppression. It uses a 7-point scoring system, where higher scores for a particular strategy indicate more frequent use of that strategy. The Cronbach's alpha coefficients for the two dimensions of the Chinese version are 0.85 and 0.77, respectively. To further refine the study on cognitive reappraisal strategies, we used the CERQ to measure the subjects' preferences when using different subtypes of cognitive reappraisal strategies. It was divided into four dimensions: negative reappraisal, positive reappraisal, involved reappraisal, and detached reappraisal, each containing four items, totaling 16 items and ranging from 1 to 5 (Wei, 2014). The Cronbach's alpha coefficients for the four dimensions of this scale are 0.734, 0.779, 0.762, and 0.739, respectively. In addition, we used the Positive and Negative Affect scale (PANAS) to assess the emotional state of the subjects at this time. It was divided into two dimensions: positive affect and negative affect, and Cronbach's alpha coefficients for the two dimensions of this scale are 0.85 and 0.83, respectively.

2.4 Complex Network Analysis

EEG signals were collected using the ERPs recording and analysis system from Brain-Products, Germany, with a 64-channel cap according to the 10-20 international system for EEG recording. During signal recording, the AFz electrode served as the ground, and FCz as the reference electrode. An electrode placed below the right eye recorded vertical electrooculography (VEOG). The filter bandwidth was set from 0.01Hz to 100Hz, with an A/D sampling rate of 500Hz per channel, and the resistance at each electrode point was kept below 10kΩ. Participants were asked to sit comfortably in a chair, close their eyes and remain awake, while resting brainwaves were recorded for 6 minutes. EEG data were analyzed offline using Brain Vision Analyzer 2.0 software. Data re-referencing used the Reference Electrode Standard Technique (REST) with an infinity zero reference, and the sampling rate was reduced to 250Hz. The bandpass filter was set from 0.01-30Hz, and eye movement artifacts were eliminated using ICA. The artifact-free EEG data were then segmented into 2 second intervals, with electrode signals exceeding ±150μV excluded to minimize artifacts. After baseline correction, artifact-free data were selected and imported into the sLORETA software for source localization analysis (Pascual-Marqui, 2002).

For the study, clustering coefficient (C), characteristic path length (L), global efficiency (E_g), local efficiency (E_{loc}), and maximal betweenness centrality (maxBC) were selected as the measurement metrics. C measures the degree of cliquishness of the network at a local level. L is used to assess the network's parallel information transmission efficiency and the degree of functional integration (Rubinov & Sporns, 2010). E_g is the average indicator of parallel information transmission between all node pairs in a network, assessing how efficiently brain functional networks transmit and process information. E_{loc}, the inverse of the shortest path length for a given node, measures the efficiency of local information exchange (Achard & Bullmore, 2007; Latora & Marchiori, 2001). Both these metrics primarily quantify the network's functional segregation, i.e., the ability to process specialized functions within closely connected brain regions (Rubinov & Sporns, 2010). MaxBC identifies core hub nodes primarily responsible for the communication and restoration of brain information. In local network features, betweenness centrality (BC) is used as a measure of the importance of individual nodes, assessing the impact of brain regions on information transmission within the network (Li et al., 2017).

2.5 Statistical Analysis

Statistical analyses were conducted using SPSS Statistics 22.0. Initially, a one-way ANOVA was performed to assess differences in global network characteristics between the DT group and the healthy control group. Subsequently, an independent samples t-test was used to compare differences in local network characteristics across different frequency bands, with the False Discovery Rate (FDR) method applied to correct for multiple comparisons. Finally, Pearson's correlation coefficient was used to analyze the degree of correlation between global and local network characteristics and cognitive reappraisal preference in DT participants .

Result

3.1 Descriptive statistics relating to the questionnaires

In the DT group, the lowest score on BDI-II was 14, recorded by 6 participants, and the highest was 30, recorded by 1 participant. For SDS, the lowest score was 50, also recorded by 6 participants, and the highest was 63.75, recorded by 1 participant. In the HC group, the lowest BDI-II score was 0, recorded by 9 participants, and the highest was 12, recorded by 1 participant. The lowest SDS score was 27.5, recorded by 3 participants, and the highest was 48.75, also recorded by 3 participants. The scores of DT group on both the BDI-II and SDS were significantly higher than those of HC group. There were no significant differences in age and gender between the two groups, as shown in Table 1.

Table1. Subject demographics and scale scores for depressive tendencies (DT) and healthy controls (HCs)

Items	DT(N=*38)*	HCs (N=41)	*p* value
Sex (Male/Female)	13/25	18/23	0.378[a]
Age (years)	20.895±2.153	21.634±2.416	0.156[b]
BDI-II	20.342±5.318	4.512±4.038	**0.001[b]**
SDS	60.132±6.632	40.689±7.458	**0.001[b]**
ERQ			
Cognitive reappraisal	26.895±5.727	30.146±5.931	**0.016[b]**
Expressive suppression	17.000±4.943	14.098±5.014	**0.012[b]**
CRER			
Detached reappraisal	13.263±2.708	13.951±2.247	0.222[b]
Involved reappraisal	10.342±2.623	7.122±2.293	**0.001[b]**
Positive reappraisal	13.579±2.891	15.781±2.139	**0.001[b]**
Negative reappraisal	8.447±2.490	7.366±2.672	0.067[b]
PANAS			
Positive emotions	27.553±4.864	34.342±6.880	**0.001[b]**
Negative emotions	25.632±7.607	17.902±6.971	**0.001[b]**

[a] indicates that a Chi-square test was conducted;[b] indicates that independent samples t-test was conducted.

3.2 Global Network Characteristics in the Resting State

At the global level, we quantified functional integration using E_g, L, and maxBC, and quantified functional segregation using the C and E_{loc}, with results presented in Table 2. In the alpha frequency band, the mean value of maxBC were significantly lower in the DT participants with respect to HCs (p =0.011), while other metrics showed no significant main effect (p >0.05). In the beta frequency band, the mean value of C were significantly lower in the DT participants with respect to HCs (p =0.017), as did the mean value of E_{loc}(p =0.021), but other metrics showed no significant effect (p >0.05).

Table 2. Global Network Characteristics for depressive tendencies (DT) and healthy controls (HCs)

Band	Global Network Characteristics	DT	HCs	*F*	*p* value
alpha	L	0.953±0.033	0.957±0.016	0.605	0.439
	E_g	0.528±0.024	0.525±0.012	0.511	0.477
	C	0.438±0.055	0.449±0.049	0.979	0.326
	E_{loc}	0.560±0.030	0.566±0.027	1.101	0.297
	maxBC	83.586±24.469	101.602±35.609	6.764	**0.011***
beta	L	0.957±0.014	0.954±0.044	0.208	0.650
	E_g	0.524±0.010	0.528±0.030	0.551	0.460
	C	0.433±0.035	0.460±0.059	5.899	**0.017***
	E_{loc}	0.557±0.021	0.571±0.031	5.528	**0.021***
	maxBC	95.639±30.815	100.189±32.052	0.400	0.529

*represents p <0.05

3.3 Local Network Characteristics in the Resting State

There were significant differences in specific local brain regions between DT participants and HCs during the resting state, as shown in Table 3 and Figure 1.The results indicated that in the alpha frequency band, compared to HCs, DT participants showed increased BC in the right posterior cingulate cortex (PCC), right parahippocampal gyrus (PHG), and left middle temporal gyrus (MTG), while the BC in the bilateral anterior cingulate cortex (ACC) decreased. In the beta frequency band, increased BC was observed in the bilateral posterior central gyrus (PoCG), left middle frontal gyrus (MFG), and left precentral gyrus (PreCG) in students with depressive tendencies, whereas a decrease was noted in the left PHG.

Table 3. Regions showing altered BC in DT participants as compared with HC participants in alpha and beta frequency band

Band	Comparison of BC between two groups	Brain region	Brodmann area	p value
alpha	DT > HCs	Right PHG	30	**0.011**[a]
		Right PCC	23	**0.029***
		Left MTG	21	**0.037***
		Right PCC	29	**0.038***
	DT < HCs	Right ACC	33	**0.002**[a]
		Left ACC	33	**0.040***
beta	DT > HCs	Right PoCG	2	**0.012***
		Left PoCG	2	**0.014***
		Left MFG	11	**0.025***
		Left PreCG	44	**0.049***
	DT < HCs	Left PHG	35	**0.041***

*represents$p$ <0.05,[a] represents significance after FDR correction.

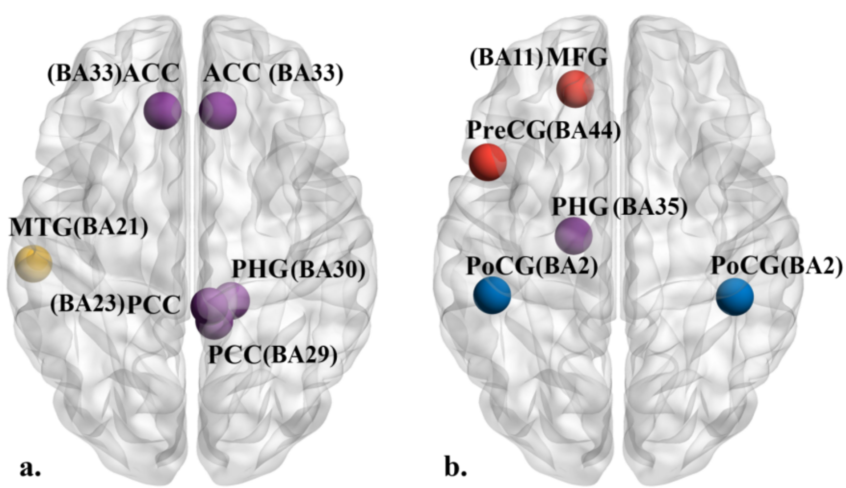

Figure 1. The source brain regions showing significantly different BC between the DT and HC groups in the alpha and beta bands. (a) alpha band,(b)beta band. Different colors of the nodes indicated different brain regions: red indicated the frontal lobe, yellow indicated the temporal lobe, blue indicated the parietal lobe, and purple indicated the limbic lobe. The brain regions were overlaid on inflated surface maps with the BrainNet Viewer toolbox (Xia, Wang, & He, 2013).

3.4 Correlation Between the DT's Resting State Brain Network Characteristics and Cognitive Reappraisal Preference

In different frequency bands, we analyzed the global network characteristics with significant main effe1cts of group, which mainly included three global network metrics: BC, L, and E_{loc}. These were correlated with the cognitive reappraisal use preference of DT participants using Pearson's correlation analysis, with results shown in Figure 2. The results indicated that in the alpha frequency band, maxBC was significantly positively correlated with the detached reappraisal scores of DT (p =0.036). In the beta frequency band, E_{loc} was significantly negatively correlated with the positive reappraisal scores of DT participants (p =0.043).

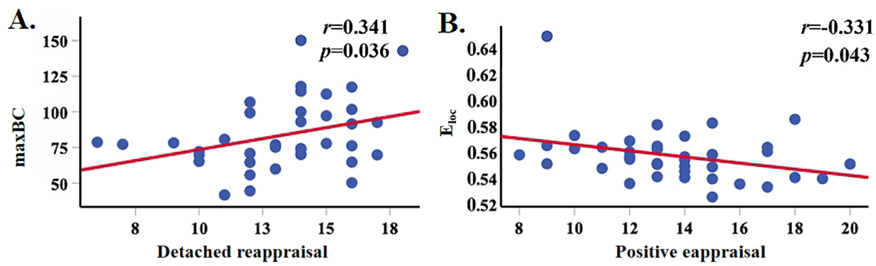

Figure 2. (A)alpha frequency band,(B)beta frequency band. Scatter plots showing the partial correlations between the DT's global network characteristics and the preference for using cognitive reappraisal.

In the study, BC was used for correlational analysis between local network characteristics and the cognitive reappraisal use preference of DT participants , with results shown in Figures 3 and 4. The results indicate that in the alpha frequency band, there was a significant positive correlation between the right ACC of DT participants and cognitive reappraisal (p =0.032), a significant negative correlation between the bilateral ACC and negative reappraisal scores (p =0.027), and a significant positive correlation between the right PHG and positive reappraisal scores (p =0.040). In the beta frequency band, there was a significant negative correlation between the left anterior central gyrus and negative reappraisal scores (p =0.031), a significant positive correlation between the left PHG and positive reappraisal scores (p =0.049), and a significant positive correlation between the left PoCG and involved reappraisal scores (p =0.016).

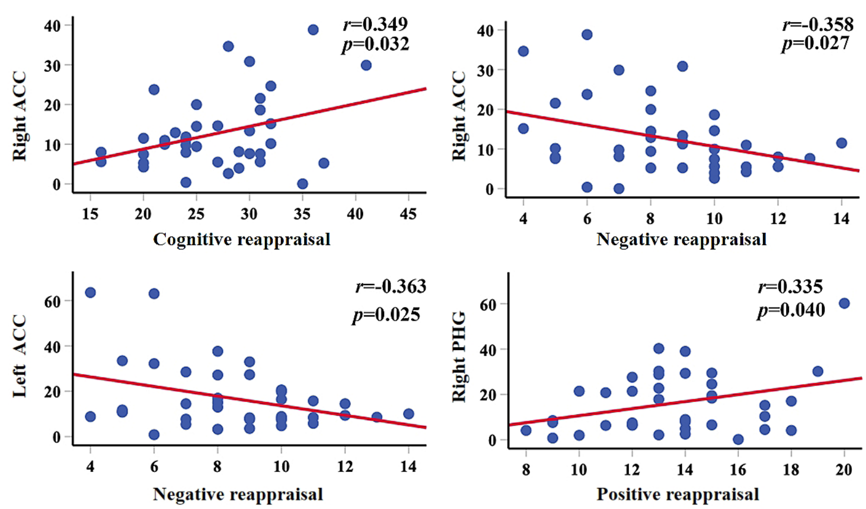

Figure 3. Scatter plots showing the partial correlations between the DT's local network characteristics and

the preference for using cognitive reappraisal in alpha frequency band.

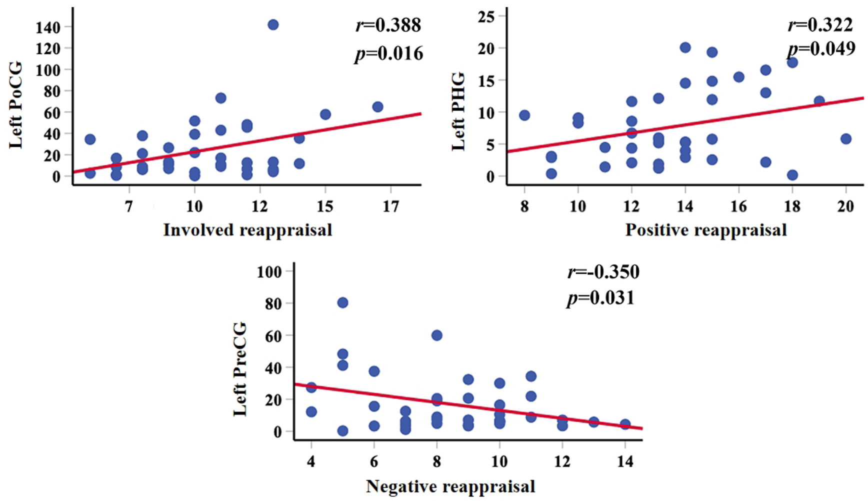

Figure 4. Scatter plots showing the partial correlations between the DT's local network characteristics and the preference for using cognitive reappraisal in beta frequency band.

Discussion

This study extracted EEG signal characteristics in the alpha and beta frequency bands through frequency domain analysis and explored changes in brain network characteristics of DT participants in a resting state using complex network analysis. The results revealed significant differences in the brain networks between DT and HC groups in both alpha and beta frequency bands. Specifically, in terms of global network characteristics, significant differences were observed in metrics such as C, E_{loc}, and maxBC. Regarding local network characteristics, significant differences were primarily located in the anterior and PCC, PHG, anterior and PoCG, MFG, superior temporal gyrus, and MTG. These results suggest that compared to the control group, the global and local brain networks of DT participants are affected in the resting state, and the abnormal activities in both global and local brain networks are also related to the cognitive reappraisal use preference in individuals with depressive tendencies.

The study found that DT participants showed significantly lower maxBC in the alpha frequency band compared to the control group, indicating a decrease in their ability to integrate functions. In the beta frequency band, DT participants had lower Cs and local efficiency, meaning the efficiency of information transmission in local brain networks and the overall brain network's information transmission capability were reduced. This is consistent with previous research (Mohammadi & Moradi, 2021; Zhao et al., 2022), which found that, compared to healthy individuals, DT participants exhibit abnormalities in neural mechanisms for cognitive processing and emotional handling. However, the study did not find differences in L and E_g between groups, which is inconsistent with previous studies (Chen et al., 2017; Shim et al., 2018; Li et al., 2021; Yao et al., 2019). This discrepancy may be due to the fact that previous studies involved patients with severe depression, whereas the present study focused on DT participants who did not meet the clinical diagnostic criteria for depression, resulting in no significant differences in L and Eg compared to the control group.

Global network characteristics reflect the overall topological structure of the brain network, while local network characteristics provide more specific information about particular brain regions. The results showed significant differences between the two groups of participants in brain regions primarily located in the anterior and PCC, PHG, anterior and PoCG, MFG, superior and MTG. Compared to the control group, DT participants in the resting state had reduced BC in the bilateral ACC, left PHG, and left superior temporal gyrus, while increased BC was observed in the right PCC, right PHG, left MTG, left MFG, bilateral PoCG, left anterior central gyrus, and right occipital middle gyrus. Changes in the importance of local nodes may reflect reasons for altered local brain topology in the depressive group compared to the control group (Peng et al., 2019). Among these regions, the ACC and PHG are associated with emotional processing (Chen et al., 2021). Additionally, research has found reduced activity in the superior temporal gyrus in the depressive group during resting state (Peng et al., 2019), a key component of the brain's default network. This reduction may impair the default network in the depressive tendency group, which is mainly associated with emotional processing (Price & Drevets, 2012), leading to abnormalities in emotional processing. The PoCG is mainly related to distinguishing, perceiving, and processing emotions (Kassam et al., 2013), and impairment in this area in individuals with depressive tendencies could result in abnormal emotional responses (Peng et al., 2019). The anterior central gyrus is associated with negative cognitive styles (Picó-Pérez et al., 2017), and structural abnormalities in the MFG and occipital middle gyrus may play a role in bottom-up attention orientation to negative stimuli (Cabeza et al., 2008), making individuals more prone to activating negative schemas when faced with negative stimuli. Beck's cognitive model of depression suggests that early adverse events promote the formation of negative cognitive schemas in individuals, which are activated in response to negative emotional events, leading to negative biases in memory and emotions (Picó-Pérez et al., 2017). Therefore, impairment in these areas may constitute the neural basis for the preference for negative cognition in individuals with depressive tendencies. In summary, our study results are consistent with existing research and further demonstrate the important role of these regions in brain network abnormalities in individuals with depressive tendencies. This not only helps to deepen the understanding of the neural mechanisms of depressive tendencies but also provides important clues for psychological intervention and treatment.

The finding that the preference for cognitive reappraisal use in individuals with depressive tendencies is positively correlated with maxBC and negatively correlated with E_{loc} has clinical significance. maxBC represents core hub nodes in the brain network. The more frequently an individual uses cognitive reappraisal, the more it facilitates interaction between the brain's core hubs and other regions, thus enhancing the brain's functional integration. E_{loc}primarily measures the brain's capacity for local information transmission, meaning that the more frequently an individual uses cognitive reappraisal strategies, the lower the brain's local regions' ability to process information specifically. This may be because individuals with depression have limited cognitive resources for information processing, leading to slower information transmission efficiency in local brain networks when using cognitive reappraisal to regulate negative emotions, thereby affecting the effectiveness of cognitive reappraisal use (Picó-Pérez et al., 2017). Additionally, the frequency of cognitive reappraisal use preference in individuals with depressive tendencies is related to an increase in brain network functional integration and a decrease in functional segregation. This might indicate that the use of cognitive reappraisal strategies in daily life by individuals with depressive tendencies could influence the topological mechanisms of brain networks.

Furthermore, compared to the control group, changes in local nodes in DT participants were primarily concentrated in the bilateral ACC and PHG, as well as the left anterior and PoCG. Previous research has indicated that the ACC is associated with cognitive control, and individuals need to exert more cognitive effort to downregulate negative emotions during cognitive reappraisal. The PHG is related to the negative emotional bias in individuals with depression (Roxo et al., 2011), and abnormal activity in the PHG may affect these patients' emotional regulation and memory functions, thereby influencing their cognitive reappraisal of emotional experiences. Cognitive reappraisal in patients with depression affects activity in the anterior central gyrus, while the PoCG is primarily involved in perceiving and processing negative emotions (Kassam et al., 2013). Thus, it can be inferred that abnormal activities in these brain areas are closely related to emotional regulation disorders, causing individuals with depressive tendencies to prefer negative emotional stimuli and thereby be unable to use cognitive reappraisal strategies to downregulate negative emotions.

This study extracted EEG signal characteristics in the alpha and beta frequency bands through frequency domain analysis and explored the characteristics of changes in the brain networks of DT participants in a resting state using complex network analysis. This provides new empirical evidence for revealing the neural mechanism differences between the depressive tendency group, healthy population, and patients with depression. Additionally, this study also attempts to analyze the relationship between the resting state brain network characteristics and cognitive reappraisal use preference in DT participants, to understand the extent to which the brain network characteristics of depressive tendencies reflect their cognitive reappraisal use preference and the severity of depressive tendencies. Nonetheless, this paper only investigates the brain networks in the resting state of individuals with depressive tendencies using EEG data. Future research could employ novel multimodal EEG integration methods for further study.

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