

Resting-EEG Activity in Autism Disorders

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Introduction

In recent years, the incidence rate of Autism spectrum disorder (ASD) has increased rapidly, and has become a special group that cannot be ignored in society. ASD is a complex heterogeneous developmental disorder, involving a variety of nervous system dysfunction such as nervous system dysfunction, stereotyped behavior, language disorder, social communication disorder, narrow interest and so on. ASD usually begins before the age of 3 [1]. However, studies on high-risk infants have shown that specific behavioral characteristics of ASD can appear at the age of one or two [1-3]. Since the diagnosis of ASD is mainly based on behavioral characteristics, children usually have to wait a few years or later before they are diagnosed.

Current studies have shown that the specific social and non-social behaviors can be used as the basis for the initial diagnosis of ASD, such as abnormal eye contact, lack of response to names, and attention transfer disorder at the end of the first year of life [3]. However, these early behavioral manifestations of ASD are often very subtle, not easy to be detected, but gradually show up in the development period. Therefore, appropriate measures and techniques such as biomarkers are needed to explore the early symptoms of autism for early diagnosis.

At present, the key obstacle to the early accurate diagnosis of ASD is the lack of effective neural indicators. Actually, the quantitative EEG (qEEG), especially resting EEG, has been an important tool for early screening, accurate diagnosis and efficacy evaluation of ASD. EEG signals mainly include delta (1~4 Hz), theta (4~7 Hz), alpha (8~13 Hz), beta (13~30 Hz) and gamma (> 30 Hz) activities, which represent different aspects of cognitive, sensory, and motor processes [4]. The spectrum of each EEG band I the resting EEG is often used as a measure of indices of variation in brain function, such as the baseline level of developmental propensity to respond or the level of arousal to respond, and has been shown to be a stable indicator of neurological development [5]. For example, Devitt and colleague found increased δ activity and reduced α activity [6].

To date, the resting EEG of ASD patients mainly has three aspects different from normal controls: U-shaped power distribution, lower coherence and brain asymmetry with higher power of the left hemisphere than that of the right hemisphere.

Power distribution

ASD individuals have excessive power in the low (delta, theta) and high (beta, gamma) frequency bands, but the power in the middle band decreases (alpha), showing U-shaped power. Excess delta power was found in several brain regions, including the dorsal mid-line parietal right temporal lobe and the frontal cortex, suggesting that the abnormality was widespread [7]. However,

the study of U-shaped power mode in ASD is still controversial. There was evidence that there was no significant difference in EEG power in ASD children compared with normal controls [8,9]. Moreover, Dawson and colleagues found that the power of theta was reduced in the frontal, temporal, and parietal lobes, but there was no significant beta-wave difference between groups [10]. These different findings may be related to the IQ and age of the subjects in the different studies. It has been found that the power excess of the delta wave is more pronounced in low-functioning children (IQ =37), intelligence age more than 20% and intelligence age less than 28% [11,12].

Brain asymmetry

The main findings of brain asymmetry of ASD are the left hemisphere dominance, i.e., enhanced EEG power in the left than the right hemisphere in all frequency bands [12-14]. For example, Stroganova and colleague found left hemisphere dominance for delta wave in the frontal, temporal and parietal lobes, theta wave in the frontal parietal temporal and occipital regions and alpha wave in the middle frontal temporal, parietal and occipital regions [12].

Coherence

It has been found that the coherence between the frontal and occipital regions of delta and theta frequencies is weaker in ASD patients [8], while Duffy and Als (2012) [15] found that the beta band has weaker left frontal and temporal connectivity. These findings are similar to those findings in brain-imaging studies. For example, Horwitz and colleagues used positron emission tomography (PET) scans to show that individuals with ASD at rest have reduced correlations in prefrontal and other cortical areas of glucose metabolism [16]. ASD also found a general decrease in frontal parietal and frontal occipital connectivity on resting-state fMRI [17]. In general, long-range connectivity between the frontal lobes and other cortical areas of autism patients have reduced. However, there have also been studies that have found a significant increase in the local correlation of slow waves (3-6 Hz), especially in the left hemisphere frontal and temporal lobes, which may reflect an increase in short-distance associative fibers [18]. These associative fibers bias cortical connections toward local information processing rather than global information processing. But the study was limited to adults with IQ above 80, the results could not be generalized to younger or more severely impaired populations [19,20].

Abnormal power and correlation in individuals with ASD may be related to attention to detail and social problems. It has been shown that that lower levels of alpha activity were associated with lower occipital area priority attention to detail in the ASD patients, not with social impairment [19]. Asymmetry abnormalities in the frontal area may be related to social and emotional dysfunction

in ASD individuals. Children with ASD showed greater social impairment and poorer social-emotional functioning reflected by complex brain processes related to individual differences in approach or avoidance motivation [19]. In addition, the abnormal cognitive behavior of ASD children is related to the weak connection of resting gamma band in the frontal lobe and the low efficiency of information integration [5]. In children with language impairment, individual differences in resting frontal Gamma power distribution were found to be highly correlated with language and cognitive skills, suggesting that high-frequency neural synchronization is essential for cognitive and language development and that children who have risk for language impairment may be delayed in this process [21].

In sum, resting EEG is an important tool for early screening, accurate diagnosis and treatment evaluation of ASD children. Although there is not enough evidence for the cognitive significance of different EEG bands, it is necessary to combine the behavioral performance of ASD patients with resting EEG to analyze the changes of brain structure and function, improve the sensitivity and specificity of single individual diagnosis, and provide more reliable reference indicators for early screening and diagnosis.

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