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The attentional networks in benign epilepsy with centrotemporal spikes

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ABSTRACT

Benign epilepsy affecting children with normal mental development often occurs at a particular age, responds well to medication, and could be resolved completely by puberty. Although several studies have shown neuropsychological disabilities of children with benign epilepsy with centrotemporal spikes (BECTS), there is no clear evidence about the impairment of attentional systems and the comorbidity of attentional problems. Our research was based on the attention network model and assessed the characteristics of three anatomically defined subnetworks (alerting, orienting, and executive control) of 90 children with BECTS and 90 healthy children. All the subjects enrolled in the study participated in the attention network test (ANT) with assessment of both the reaction time (RT) and accuracy of the test. The results indicated that the performance of healthy controls was significantly better in orienting of attentional system ($P < 0.001$) and the accuracy of attention network test ($P < 0.001$), compared with that of children affected by BECTS. The grand mean effect (higher score worse) was significantly higher ($P < 0.001$) in the patient group than that in the control group. The multiple linear regression analysis revealed a positive correlation between the age of onset and the accuracy of attention network test results, and a negative correlation between the age of onset and the results of grand mean effect. A negative correlation was observed between spike index (SI) of the non-REM sleep stage and the accuracy of attention network test results. We found no relationship between the grand mean effect and clinical factors such as gender, duration of clinical course, duration of seizures, total number of seizures, severity of seizures (seizure frequency), hemispheric lateralization of electroencephalograph (EEG), and the awake SI. Furthermore, no relationship was observed between the clinical factors and the accuracy of the test results. The findings showed that BECTS is associated with impaired attentional networks, and impairments are greater at younger ages of onset.

1. Introduction

Benign epilepsy with centrotemporal spikes (BECTS) in children is an idiopathic partial epilepsy. It is the most common childhood epilepsy syndrome and accounts for 15–24% of all the epilepsy reported in children [1]. Initially, BECTS was considered as a benign epilepsy with no comorbidity associated with it. However, the "benign" nature of BECTS has been recently called into question because of cognitive and behavioral impairments, for example speech and sound disorders, language disabilities, and memory deficit, which are frequently observed in children with BECTS [2–5]. The most important behavioral impairment is an attentional problem that could seriously impact the learning process and the living condition of patients, even when the seizures have remitted [6].

Many factors, such as the age of onset, gender, frequency of seizures, duration of seizures, duration of clinical course, hemispheric lateralization, and spike frequency of electroencephalograph (EEG), may influence cognitive abilities and interact with each other. It is difficult to determine which factor has caused a particular impairment [4]. Attentional function is considered to be a foundation for complex cognitive activity [3]. Since cognition and attention are also closely related, decreased attention in children with BECTS may lead to the lack of a specific neuropsychological profile [7]. The attentional system can be divided into three subsystems: alerting, orienting, and executive control, based on their neuroanatomical and physiological mechanisms, amid these three systems are coordinated to complete the entire information procession of attentional networks. Their functions are independent of each other, but sometimes they interact together to complete a certain task [8].

Ponser and Petersen [9] proposed that sources of attention are formed by three networks, including the alerting network, the orienting network, and the executive control network. These networks carry out functions of alerting, orienting, and executive control. The alerting network involves the ability to tonically maintain the alert state and to physically respond to a warning signal processed by specific frontal and parietal areas, and involves the cortical projection of the norepinephrine system [10,11].

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The orienting network involves the selection of information from the cholinergic input, and numerous sensory inputs related to the superior parietal lobe and temporal parietal junction [11,12]. Executive control of attention involves conflict processing, which could respond to relevant aspects and ignore irrelevant aspects of a stimulus. It may relate to the anterior cingulate cortex and lateral prefrontal cortex, which is modulated by dopamine [13–15].

The attentional network test (ANT) is a combination of the cued reaction time task and the flanker task, examining the effects of cues and targets within a single-reaction time limit, in order to explore the efficiency of alerting, orienting, and executive control networks [8]. The ANT has been previously applied in the assessment of attentional function in healthy children as well as in patients with Alzheimer's disease or schizophrenia [16,17].

It has been reported that frontoparietal developmental disorders, metabolic abnormalities, and damage to the corpus callosum and cingulate gyrus are factors closely related to the impairment of attention networks in children with BECTS [18–22]. We designed this study to explore whether there is attentional deficit in children with BECTS using ANT, and to evaluate the prognosis of the disease more effectively.

2. Methods

2.1. Subjects

Written informed consent was obtained from parents and/or guardians of all the subjects before enrolling. The following inclusion criteria were used to enroll children with BECTS: (1) each subject was diagnosed in a pediatric neurology unit with BECTS based on clinical history and recent EEG recordings, according to the criteria of the International League Against Epilepsy (ILAE) classification; (2) only subjects that had not taken any antiepileptic drug; (3) subjects had no history of birth trauma/asphyxia, prior diseases, and mental retardation; (4) the testing age should be between 6 and 14 years; and (5) their color vision reaction and audiovisual power were normal, and they were able to understand and perform throughout the experiment. In total, 90 children with BECTS including 57 boys and 33 girls were recruited from the Department of Neurology, Children's Hospital of Anhui Province, Hefei, China. The average age was 8.47 years, and 90 healthy children matched by age and gender [57 boys and 33 girls, average age (8.48 ± 1.70) years] were also enrolled in the study. They all completed the attention network test (ANT). Children in both the BECTS and control groups had agreed to participate in test, then we had received the parents' or guardians' oral consent. Ethical approval was given by the medical ethics committee of Anhui Provincial Children's Hospital.

2.2. The attention network test (ANT)

2.2.1. Stimuli and test procedure [8]

All the subjects were asked to complete the childhood version of the attention network test (ANT) on a Lenovo compatible laptop computer with Java Runtime Environment program. Subjects were sitting in front of the computer, viewing the screen from a distance of about 60 cm. Before the onset of the test, operators explained the test processes.

All stimuli were displayed on the computer screen. Each trial began with a fixation cross with random duration of 400 and 1600 ms between them. Subsequently, a warning cue was presented for 150 ms. After a 450-ms brief fixation appeared, either the simultaneous appearance of

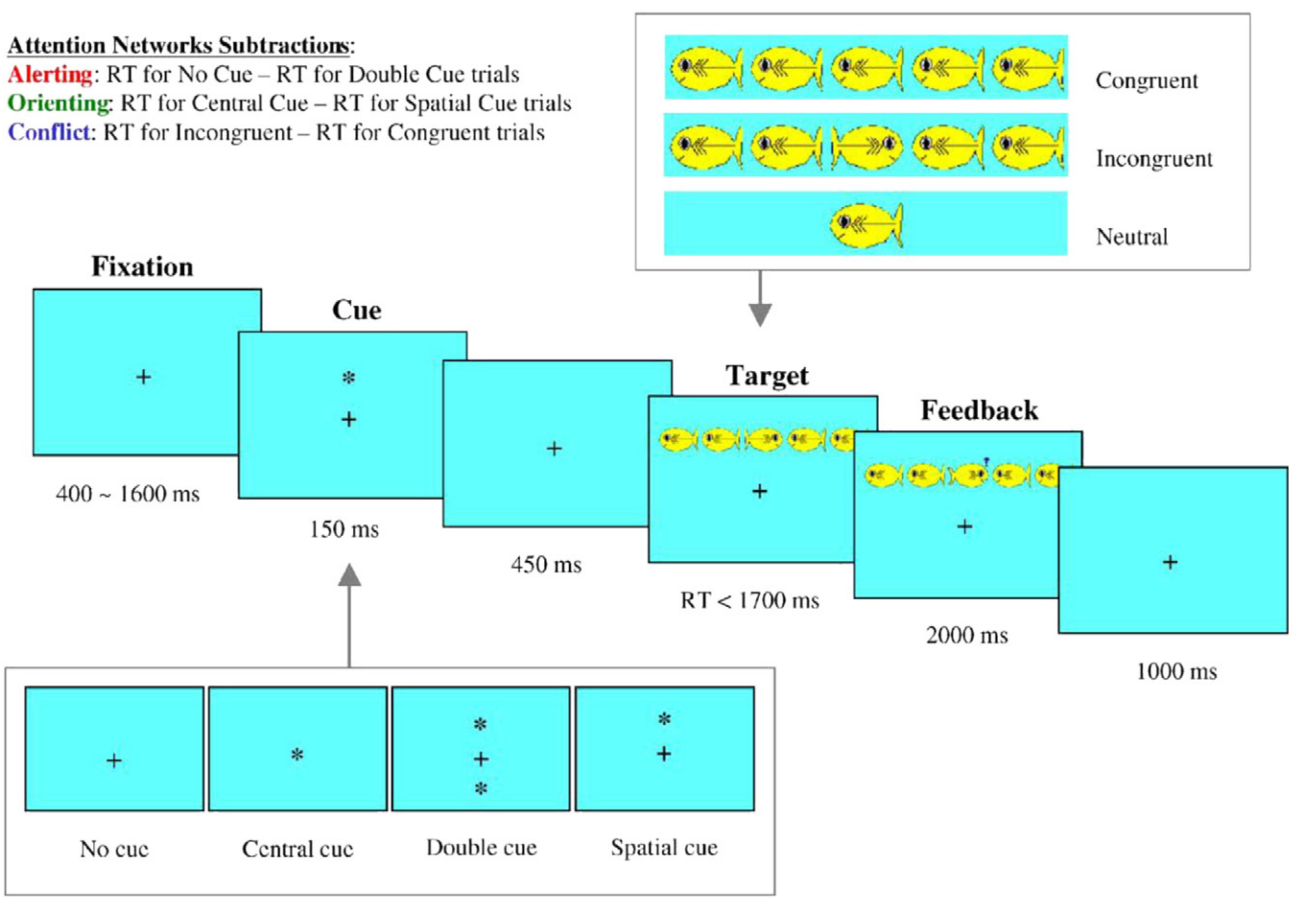

Fig. 1. The process of the attention network test.