Impaired theory of mind in Chinese children and adolescents with idiopathic generalized epilepsy: Association with behavioral manifestations of executive dysfunction

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Abstract

Background: Epilepsy is a common neurological disorder with a core feature of cognitive impairments. Previous studies showed that patients with focal epilepsy have deficits in both theory of mind (ToM) and executive function (EF). However, there are few studies of ToM in patients with idiopathic generalized epilepsy (IGE), especially in populations with pediatric epilepsy. The aim of this study was to examine the characteristics of ToM and EF, including some of their subcomponents, and explore the relationship between them in Chinese children with IGE.

Materials and methods: We recruited 54 children and adolescents with IGE as the experimental subjects and 37 typically developing children and adolescents as control subjects. Both groups completed ToM tests, namely, second-order false belief tasks (FBTs) and faux pas tasks (FPTs). Their caregivers completed the Behavior Rating Inventory of Executive Function (BRIEF) at the same time.

Results: Children and adolescents with IGE displayed worse performance on some of the FBTs and FPTs than healthy controls (p < 0.01). They also exhibited widespread EF deficits, comprising eight subcomponents (p < 0.05). Pearson’s correlation analysis revealed that several subcomponents of EF (inhibition, emotional control, initiation, working memory, and monitoring) were unequally correlated with FBT and FPT. Regression analysis showed that ToM had associations with inhibition, working memory, and duration of seizures. Analysis of variance (ANOVA) indicated that children with newly diagnosed epilepsy displayed significant deficits in FBT, FPT, and distinct subscales of EF.

Conclusions: Our results revealed significant impairments in ToM and EF in children and adolescents with IGE compared with healthy controls. We found significant correlations between ToM and two subcomponents of EF (inhibition and working memory) in children with IGE. Additionally, the duration of seizures affected ToM in patients but was a less powerful predictor than the two subcomponents of EF. Even for children with new-onset seizures and without medication, the deficits in ToM and some distinct subscales of EF were apparent. This result has clinical implications for both nonpharmaceutical therapies and cognitive rehabilitation.

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1. Introduction

Epilepsy is a common chronic neurological condition characterized by recurrent seizures that affect the daily lives of patients. According to the International League Against Epilepsy (ILAE), epileptic seizures can be classified as generalized or partial [1]. From an etiological point of view, epilepsy can be divided into idiopathic, symptomatic, and cryptogenic types. Worldwide, it is estimated that the overall incidence rate for epilepsy is 50:100,000–112:100,000. Approximately 50 million people globally bear the pain of epileptic seizures [2], with idiopathic generalized epilepsy (IGE) accounting for 15% to 20% [3]. More than half of the cases begin in childhood and adolescence, so comprehensive treatment of children with epilepsy has become the focus of a wide range of concerns. Evidence from recent studies suggests that patients with epilepsy have deficits in theory of mind (ToM) that contribute to lower social competence [4]. Children with epilepsy may have difficulty accomplishing academic tasks and establishing true friendships with
peers, so they often feel lonely. These children are also at risk for autism spectrum disorders [5,6]. Sadly, social cognition vulnerabilities may last into adulthood, contributing to unemployment, marriage failure, and a tendency toward crime and social instability [7,8].

Theory of mind refers to the ability to infer the thoughts, intentions, emotions, and feelings of other people, and predict their future behavior accordingly. This ability is the most representative mechanism of high-order social cognition [9]. The insight that people act based on their own distinct interpretations of the world is critical for social functioning, because it allows each individual to approach social situations in an appropriate way. Children who suffer from impaired ToM will demonstrate worse performance in social competence and academic tasks, and they will experience [10]. Previous research has developed and utilized various assessment methods to evaluate ToM in children and adolescents. An important step in the development of ToM takes place at around 4 to 6 years of age, when a child develops an understanding of false beliefs, i.e., when they understand that others may have mistaken ideas or thoughts different from their own. Researchers have found that understanding of false beliefs is the benchmark for assessing the acquisition of ToM in typically developing children. Numerous studies suggested that children can pass first-order false belief tasks (FBTs) by the age of 4 years, while children at age 6 years can pass second-order FBTs. First-order false belief tests are a primary method for evaluating a subject’s ability to predict the actions of another person who is experiencing an unexpected incident, reflecting the capacity to focus on reality [11]. Second-order FBTs utilize a similar but more complex paradigm concerning the subject’s own possibly false belief about another’s beliefs [12]. Recent literature has presented a range of advanced tasks for assessing ToM at the 9- to 11-year-old level [13]. One representative task is the faux pas task (FPT), which requires the subject to demonstrate the following two levels of understanding: 1) the main character in a story said something that she/he should not have said, but she/he is unaware of having made an error and 2) the person in the story who heard the main character’s statement would feel embarrassed or hurt.

Previous studies showed that ToM deficits have been associated with psychiatric disorders, including autism [14,15], bipolar disorder [16], and schizophrenia [17]. Recently, several studies attempted to explore ToM in patients with epilepsy, but this work yielded inconsistent results. For example, some studies [18,19] revealed impaired ToM in adults with focal seizures emanating from the critical brain regions underpinning ToM (temporal and frontal lobes), but not in adults with focal seizures originating outside these regions. In contrast, other studies [20,21] found that children with generalized seizures always have impaired ToM. Overall, there is limited literature on ToM in children with epilepsy, especially in Chinese children with IGE. The increasing interest in the occurrence of ToM impairments among patients with epilepsy has revealed that apparent deficits in social skills resulting from isolation, psychological distress, and impaired capacity for social communication begin in childhood. Previous studies showed that deficits in ToM might account for the poverty of social skills not only in adults [18] but also in children [6].

In addition to social complications, children with epilepsy (CWE) may bear the risk of neurocognitive dysfunctions, including language disability, attention deficits, and executive function (EF) impairment [19–22]. Executive function is a product of the coordinated operation of various processes to accomplish a particular goal in a flexible manner [23]. Executive function includes thinking ahead, suppressing impulse, holding short-term memory, and attention flexibility. The study presented in this paper focused on the data provided by parents using the Behavior Rating Inventory of Executive Function (BRIEF) [24]. BRIEF is a well-recognized method for assessing behavioral manifestation of EF, an important component of neurocognitive function, with high internal consistency and test–retest stability [25]. BRIEF provides better reliability and ecological validity than previous EF tasks [26] such as the Wisconsin Card Sorting Task [27], and disk-transfer tasks such as the Tower of Hanoi [28]. Such assessments regularly provide children with degrees of structure and redirection that are not applicable in the “real world” [29].

Behavioral manifestation of EF may be manifested by controlling emotion and by adapting behavior to unstable circumstances. Impaired EF is often discovered in some atypical populations, such as individuals with attention deficit hyperactivity disorder (ADHD) [30], autism spectrum disorder [31], schizophrenia [32], and traumatic brain injury [33]. A growing body of research indicates that widespread deficits of behavioral manifestation of EF are found in patients with epilepsy, not only in focal epilepsy, but also in generalized epilepsy [34,35]. Accordingly, CWE have difficulty succeeding in a career, and they face challenges attaining healthy social, cognitive, and psychological development. A new study proposed the comorbidity of executive dysfunction [36].

Language is a necessary means of social communication and is regarded as an underlying factor of social competence [37]. However, previous research found a risk for disorders of language in children with epilepsy who had intact global cognition [38]. Even so, a moderate association was found between EF and ToM, even when the effect of verbal ability was controlled [39]. The relationship between ToM and EF has been investigated primarily in Western cultures [40]. Performance of the FBTs was believed to have association with conflict inhibition or working memory [39]. Other research showed that FBT performance was best predicted by tasks that recruited both conflict inhibition and working memory [41]. However, for Eastern cultures, demonstrations of the link between ToM and EF are thin. Previous studies that focused on cross-cultural comparisons found that the sequence of steps in ToM varied with culture [42]. In Western children, the following order was observed: diverse desires, then diverse beliefs, then knowledge access, then false beliefs, and finally, hidden emotions. Eastern children, however, showed the following order: diverse desires, then knowledge access, then diverse beliefs, then false beliefs, and finally, hidden emotions. The differences may be attributed to the values emphasized in traditional Eastern culture, including filial duty, avoiding disputes, and acquiring knowledge. A study that examined the development of EF and ToM by comparing Chinese and U.S. preschoolers indicated that Chinese preschoolers outperformed U.S. counterparts on all measures of EF but not in ToM reasoning [43]. Nevertheless, individual differences in EF predicted ToM for children in both cultures. The few studies of East Asian children yielded conclusions ranging from a significant positive relationship to no relationship. It is important to note that the previous literature concentrated on focal epileptic populations. To our knowledge, the studies rarely involved a wide range of ToM tasks, and they seldom examined the roles of specific EF subdomains in ToM development in Eastern cultures [44]. Notably, there was only one study involving the relationship between ToM and EF in children with IGE [4]. Significantly, that study did not use ecological assessment to evaluate EF, and the relationship between the two cognitive functions remained unclear. To date, there has been no systematic research focused on the link between ToM and EF in Chinese children with IGE.

The study presented in this paper fills these gaps by evaluating the performance of Chinese children with IGE in terms of ToM, EF, and the links between them. The importance of this study is not only for advancing the understanding of the underlying ToM–EF relationship, but also for clinical care. If we recognize the ToM deficits of children with epilepsy and health practitioners conduct cognitive function exercises sooner, patients will obtain more ability to adapt to society and achieve academic success.

The purpose of our study was to answer the following four questions:

1. Do Chinese children and adolescents with IGE demonstrate more deficits in ToM compared with control group? Our hypothesis was that children and adolescents with IGE would display poor ToM. To resolve this question, we used second-order false belief and faux pas tests.
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