

# Research on the Rehabilitation Effect of Repetitive Transcranial Magnetic Stimulation Combined with Cognitive Training on Children with Mental Retardation

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**Abstract:** This study investigated the rehabilitation effect of repetitive transcranial magnetic stimulation (rTMS) combined with cognitive training on children with mental retardation (MR). Through a randomized controlled trial design, 40 children aged 2–6 years with mental retardation were selected as study subjects and randomly divided into two groups: conventional treatment group and rTMS combined with cognitive training treatment group. The results showed that compared with the conventional treatment group, the rTMS combined with cognitive training treatment group exhibited more significant effects in improving children’s cognitive function, social adaptability, and quality of life. This study not only enriched the theoretical basis of rehabilitation treatment for children with mental retardation but also provided strong evidence support for clinical practice.

**Keywords:** Repetitive transcranial magnetic stimulation (rTMS); Cognitive training; Mental retardation; Rehabilitation treatment; Children

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## 1. Introduction

Mental retardation is a common neurodevelopmental disorder in childhood, characterized by significantly lower intelligence levels than their peers, accompanied by inadequate social adaptability. This disorder not only severely affects children’s daily lives and learning but also imposes a significant burden on their families and society. Rehabilitation treatment for children with mental retardation has relied heavily on special education, behavioral therapy, and medication, yet the efficacy of these methods is often limited, with varying degrees of side effects and limitations. Therefore, exploring more effective and safe rehabilitation treatment methods is crucial. With the continuous development of neuroscience and rehabilitation medicine, repetitive transcranial magnetic stimulation (rTMS), as a non-invasive brain stimulation technique, has gradually demonstrated potential applications in the rehabilitation treatment of children with mental retardation. rTMS promotes the connection and remodeling of

neurons by altering the excitability of the cerebral cortex, potentially improving children's cognitive function and social adaptability. Meanwhile, cognitive training, as a training method targeting specific cognitive domains, is also widely used in the rehabilitation treatment of children with mental retardation. However, current research on the effects of rTMS combined with cognitive training in the rehabilitation treatment of children with mental retardation is scarce. Therefore, this study explored the effect of rTMS combined with cognitive training on the rehabilitation treatment of children with mental retardation through a randomized controlled trial, providing a scientific basis for clinical practice<sup>[1-3]</sup>.

## **2. Research subjects and methods**

### **2.1. Research subjects**

This study selected 40 children aged 2–6 years with mental retardation who visited the hospital and psychology department from January 2021 to December 2023 as research subjects. All children met the diagnostic criteria for mental retardation and excluded other diseases or factors that might affect the study results. The children were randomly divided into two groups using a random number table: conventional treatment group (20 cases) and rTMS combined with cognitive training treatment group (20 cases). The two groups were comparable in terms of age, gender, and severity of illness.

### **2.2. Research methods**

#### **2.2.1. rTMS treatment**

rTMS treatment was performed using a repetitive transcranial magnetic stimulator, with treatment parameters adjusted according to the specific conditions and treatment needs of the children. In this study, rTMS treatment was administered three times a week, with each session lasting 20 minutes, for a total of 12 weeks. The treatment sites were primarily selected from areas of the cerebral cortex related to cognitive function, such as the frontal and temporal lobes<sup>[4]</sup>.

#### **2.2.2. Cognitive training**

Cognitive training is tailored by professional rehabilitation therapists based on the children's cognitive level and developmental needs. The training content primarily encompasses attention training, memory training, thinking skills training, and social skills training. The training modalities incorporate game-based guidance, scenario simulation, emotional guidance, systematic training, and other diverse approaches, aiming to stimulate children's learning interests and motivation. The training frequency is set at five sessions per week, with each session lasting 25 minutes, spanning a total of 12 weeks<sup>[5]</sup>.

#### **2.2.3. Assessment tools**

This study employs a range of assessment tools to evaluate the therapeutic effects on children. Key among them are the Gesell Developmental Schedules and the Wechsler Preschool and Primary Scale of Intelligence (WPPSI). These assessment tools provide a comprehensive and objective reflection of changes in children's cognitive functions and social adaptation abilities.

## **3. Research results**

After 12 weeks of treatment and assessment, both groups of children demonstrated varying degrees of improvement in cognitive functions and social adaptation abilities. However, the improvement in the rTMS

combined with cognitive training group was the most notable. Specific findings are as follows.

### **3.1. Improvement in cognitive functions**

In the rehabilitation treatment of children with mental retardation, the enhancement of cognitive functions serves as a crucial indicator of therapeutic efficacy. As an innovative non-invasive treatment method, repetitive transcranial magnetic stimulation (rTMS) combined with cognitive training exerts a positive influence on children's cognitive functions, particularly in speech comprehension and perceptual reasoning abilities, providing valuable practical experience and scientific evidence.

#### **3.1.1. Enhanced speech comprehension**

Speech comprehension is a cornerstone of children's cognitive development, and its significance cannot be overstated. It not only affects children's ability to engage in fluent language communication but also profoundly influences their cognition and understanding of the external world. This study used the Gesell Scale to observe progress in speech comprehension among children in the rTMS combined with cognitive training group. This progress manifests in multiple layers. Firstly, children's comprehension speed for words and sentences accelerates, enabling them to quickly grasp language information and interpret it well. Secondly, there is some improvement in their ability to comprehend complex contexts and infer implications beyond the literal meaning, indicating that they can not only directly understand the literal sense but also comprehend the speaker's intentions and emotions through non-verbal cues such as context, tone, and facial expressions. The enhancement in speech comprehension further triggers a chain reaction, fostering development in other cognitive domains. With a better grasp of language information, children's abilities in memory, thinking, imagination, and other aspects also improve correspondingly, forming a virtuous cycle <sup>[6]</sup>.

#### **3.1.2. Enhanced perceptual reasoning ability**

Perceptual reasoning ability is a vital component of children's cognitive development, requiring individuals to process, analyze, and reason with perceived information using existing knowledge and experience. For children with mental retardation, the enhancement of this ability is particularly crucial as it directly relates to their ability to effectively tackle various challenges and problems in daily life.

In this study, children in the rTMS combined with cognitive training group also demonstrated improved scores in perceptual reasoning ability. They exhibited greater accuracy in processing visual, auditory, and other sensory information, enabling them to swiftly capture and process key information. Additionally, they showed progress in logical reasoning and problem-solving, with the most significantly improved children being able to apply learned knowledge and experience to effectively analyze and judge complex situations. This enhancement in perceptual reasoning ability has profound implications for the growth and development of these children. It not only helps them better adapt to school life and social environments but also lays a solid foundation for their future learning and work <sup>[7]</sup>.

### **3.2. Improved social adaptation ability**

Social adaptation ability, as a core element in children's growth process, plays a vital role in their overall development and future social integration. Following treatment, children's social adaptation ability also showed improvement, encompassing not only how they establish positive and healthy interpersonal relationships but also how they effectively adapt to complex and ever-changing social environments, as well as how they manage and regulate their emotions.

### **3.2.1. Enhanced social interaction skills**

Social interaction is an integral part of children's social adaptation ability and serves as the cornerstone for their integration into society and the establishment of positive interpersonal relationships. For children with mental retardation, cognitive and emotional development delays often pose significant challenges in social interactions. In this study, children in the rTMS combined with cognitive training group demonstrated enhanced social interaction skills. These children showed higher levels of initiative and cooperation in their interactions with others. Before treatment, they passively awaited attention and guidance from others, but after treatment, they initiated conversations and engaged in activities more actively. This transformation boosted their confidence and comfort in social situations <sup>[8]</sup>.

### **3.2.2. Improved self-care abilities**

Self-care ability is a prerequisite for children's independent living and is one of the essential indicators of their social adaptation ability. In this study, children in the rTMS combined with cognitive training group made significant progress in self-care. Through systematic cognitive training, these children gradually acquired basic skills for daily activities such as dressing, eating, and personal hygiene. They gradually began to complete these tasks independently, reducing their reliance on others. This transformation not only improved their quality of life but also strengthened their self-confidence and self-esteem.

### **3.2.3. Improved emotional management skills**

Emotional management is a crucial component of children's social adaptation ability and an essential safeguard for their mental health. Children with mental retardation often struggle to effectively manage their emotions due to cognitive limitations and immature emotional regulation mechanisms. In this study, children in the rTMS combined with cognitive training group showed improvement in emotional management. Through cognitive training, these children gradually learned to recognize and understand their emotions. They became aware of their emotional states and began to comprehend the impact these emotions have on themselves and others. They also acquired skills to express emotions appropriately and seek help when needed. Faced with difficulties and setbacks, they no longer resorted solely to crying or avoidance but instead sought solutions and actively reached out to others for support and assistance. This improvement in emotional management skills not only helps maintain a stable emotional state for the children but also enhances their psychological resilience and stress tolerance <sup>[9-10]</sup>.

### **3.3. Improved quality of life**

The improvement in quality of life serves as a crucial benchmark for evaluating treatment outcomes. In this study, comprehensive evaluations by parents and rehabilitation specialists revealed a notable enhancement in the quality of life among children in the rTMS combined with cognitive training group.

### **3.4. Enhanced self-confidence**

The increase in self-confidence is a significant manifestation of improved quality of life for these children. Throughout the treatment process, as their cognitive functions and social adaptation abilities continued to improve, the children gradually recognized their progress and changes. This positive self-awareness not only bolstered their self-confidence and self-esteem but also ignited their motivation for further learning and exploration <sup>[11]</sup>.

## **4. Discussion**

### **4.1. Synergistic effects of rTMS and cognitive training**

The results of this study indicate that rTMS combined with cognitive training exhibits significant synergistic effects in the rehabilitation of children with mental retardation. As a non-invasive brain stimulation technique, rTMS directly targets the cerebral cortex, promoting neuronal connections and remodeling, thereby improving the children's cognitive functions. Meanwhile, cognitive training, through targeted training activities, further consolidates and expands the therapeutic effects of rTMS, enabling comprehensive enhancement across multiple cognitive domains. This synergy not only enhances treatment efficiency but also strengthens the durability of the treatment outcomes <sup>[12]</sup>.

### **4.2. Analysis of influencing factors**

Age, as a significant marker of physiological development stages, exerts a notable impact on the response to disease treatment. Pediatric patients' brains and nervous systems are undergoing rapid development and are highly plastic. Therefore, younger children tend to exhibit stronger neuro-regenerative and adaptive abilities during treatment. For instance, in the treatment of neurological disorders such as cerebral palsy, autism spectrum disorder, or language development delay, early intervention can more effectively promote the remodeling of neural connections and accelerate functional recovery. Furthermore, young children's relatively weaker psychological defense mechanisms make them more receptive to new environments and treatment methods, which also contributes to improved treatment outcomes.

The severity of the condition is another crucial factor that cannot be overlooked when assessing treatment effects. Generally, children with milder conditions experience fewer functional impairments and have greater potential for recovery. These children often observe quicker symptomatic improvements, such as enhanced motor function, improved language abilities, or advanced social skills, during treatment. These positive feedbacks further strengthen their treatment confidence and motivation, creating a virtuous cycle. Conversely, children with more severe conditions may face more complex pathological mechanisms and broader functional impairments, resulting in longer treatment durations and potentially slower recovery rates. However, this does not imply that they cannot achieve significant improvements; they simply require more patient, sustained, and comprehensive treatment strategies.

Treatment adherence, or the degree to which patients and their families follow medical advice and actively participate in treatment activities, is one of the key factors determining treatment outcomes. Good treatment adherence ensures the complete implementation of the treatment plan, allowing children to receive adequate treatment doses and training time, thereby maximizing therapeutic effects. In contrast, poor adherence, such as frequent absences from treatment, irregular medication intake, or inadequate training intensity, can weaken treatment outcomes or even lead to treatment failure. Enhancing patients' and parents' awareness of treatment, strengthening doctor-patient communication, developing reasonable and feasible treatment plans, and conducting timely adherence assessments and adjustments are essential safeguards for ensuring treatment effectiveness.

### **4.3. Clinical application prospects**

The potential of repetitive transcranial magnetic stimulation (rTMS) combined with cognitive training revealed in this study for the rehabilitation of children with mental retardation undoubtedly brings new hope to this special group. As a non-invasive treatment method, rTMS promotes neuroplasticity by modulating the excitability of the cerebral cortex, providing a scientific basis for improving children's cognitive function, attention, memory, and language abilities. Its non-invasive and painless characteristics make the treatment process safer and easier for children and their families to accept, effectively avoiding the potential side effects and long-term dependence

issues associated with traditional pharmacological treatments <sup>[13–14]</sup>.

The integration of cognitive training further enhances the durability and comprehensiveness of treatment effects. Through systematic exercises, cognitive training specifically targets the enhancement of critical cognitive skills such as cognitive processing speed, working memory, and problem-solving abilities, complementing the physical stimulation of rTMS to collectively reshape and strengthen the brain's functional networks. This multimodal treatment model not only accelerates the rehabilitation process but also promotes the overall improvement of children's social adaptation abilities, laying a solid foundation for them to better integrate into society <sup>[15]</sup>.

Looking ahead, the promotion and application of rTMS combined with cognitive training should become an essential direction in the field of rehabilitation medicine. Firstly, efforts should be intensified to promote public awareness of this treatment method and reduce misunderstandings and biases. Secondly, multi-center, large-sample randomized controlled trials should be conducted to verify its efficacy through more rigorous scientific methods and explore optimal combinations of treatment parameters. Concurrently, deepening research into the neurobiological mechanisms underlying the interplay between rTMS and cognitive training, revealing their pathways and targets, will provide a theoretical basis for personalized treatment planning. Lastly, as technology advances and costs gradually decrease, this treatment approach is expected to benefit more economically disadvantaged families, achieving equitable distribution of rehabilitation resources.

## 5. Conclusion

This study systematically explored the effects of repetitive transcranial magnetic stimulation (rTMS) combined with cognitive training on the rehabilitation of children with mental retardation through a randomized controlled trial design. The results demonstrated that rTMS combined with cognitive training can significantly improve children's cognitive function, social adaptation abilities, and quality of life. This method exhibits remarkable therapeutic effects and vast application prospects, warranting clinical promotion and application. Future research should further investigate its therapeutic mechanisms and optimize treatment protocols to better serve the rehabilitation of children with mental retardation.

## Disclosure statement

The authors declare no conflict of interest.

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