

Research Paper



Relationship Between Cognitive Flexibility, Attention Shifting, and Planning With Accuracy, Speed, and Reading Comprehension in Normal Children and Children With Dyslexia

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ABSTRACT

**Background and Aims** Dyslexia is a type of learning disorder that causes problems in reading. Children with dyslexia are affected by various problems, including executive functions. The aim of this study was to investigate the relationship between executive functions and components of reading (comprehension, speed, and accuracy).

**Methods** In this study, 22 normal students and 22 dyslexic students between the age of eight and nine years participated in order to evaluate their executive function and reading skills. Diagnosis of dyslexia was determined by reading and dyslexia test (NEMA). To evaluate the components of reading (speed, accuracy, and comprehension), the comprehension text of the test was used. The Wisconsin Card Sorting Test (WCST) for cognitive flexibility assessment, the Tower of London (TOL) test for the evaluation of planning, and the Color Trail Test (CTT) was used to evaluate attention transmission.

**Results** The average score of dyslexic children in attention shifting, cognitive flexibility, planning, comprehension, speed, and reading accuracy was significantly lower than normal children ( $P < 0.001$ ). A significant correlation was observed between reading accuracy and speed and attention shifting ( $P < 0.05$ ). There was no significant correlation between reading components and other executive function factors ( $P < 0.05$ ).

**Conclusion** Attention shifting, planning, cognitive flexibility, comprehension, speed, and accuracy of reading in dyslexic students are weaker than in normal students, and recovering these factors will lead to an overall improvement in reading. It seems that enhancing the ability of attention shifting in a particular way for students with a major weakness in reading speed or accuracy will be effective.

**Keywords** Cognitive flexibility, Attentional shifting, Planning, Reading Disorder, Dyslexia

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## Extended Abstract

## Introduction

**D**yslexia is characterized by an unexpected difficulty in reading in spite of normal intelligence and sufficient motivation to read. Several theories have been suggested to explain the causes and consequences of dyslexia, including phonological theory, rapid auditory processing theory, cerebellar theory, and cognitive theories. In cognitive theories, core components of executive functions in reading skills have received a great deal of attention in the literature. Executive performance is defined as a process that monitors and regulates cognitive processes during complex cognitive tasks. These abilities include inhibition, shifting, updating, cognitive flexibility, organization, and planning. Research has also shown that people with learning disabilities have a deficit in planning, cognitive flexibility, and attention. For example, Moura et al. (2015) reported that children with developmental dyslexia performed poorly compared to the control group in shifting, verbal fluency, and speed processing. There is a link between executive function skills and reading components. Therefore, the aim of this study was to investigate the relationship between the components of attentional shifting, planning, cognitive flexibility, and the components of comprehension, speed, and accuracy of reading in children with dyslexia.

**Materials and Methods:** In this study, 22 normal students and 22 dyslexic students between the age of eight and nine years participated in order to evaluate their executive function and reading skills. Diagnosis of dyslexia was determined by reading and dyslexia test (NEMA). To evaluate the components of reading (speed, accuracy, and comprehension), the comprehension text of the test was used. The Wisconsin Card Sorting Test (WCST) was used

for cognitive flexibility assessment, the Tower of London (TOL) test for the evaluation of planning, and the Color Trail Test (CTT) to evaluate attention transmission. Statistical analysis was performed by SPSS v. 22.0. Comparisons between groups were performed by parametric and non-parametric tests. Correlation coefficients are used to assess the strength and direction of the relationships between variables. When both variables are normally distributed, we use Pearson's correlation. Otherwise, we use Spearman's correlation coefficient. A P-value of  $< 0.05$  was considered statistically significant.

**Results:** The average score of dyslexic children in attention shifting, cognitive flexibility, planning, comprehension, speed, and reading accuracy was significantly lower than normal children ( $P < 0.001$ ). A significant correlation was observed between reading accuracy and speed and attention shifting ( $P < 0.05$ ). There was no significant correlation between reading components and other executive function factors ( $P < 0.05$ ) (Table 1).

**Conclusion:** The present study showed that attention shifting, planning, cognitive flexibility, comprehension, speed, and accuracy in reading in dyslexic students are weaker than in normal students, and recovering these factors will lead to an overall improvement in reading. It seems that enhancing the ability of attention shifting in a particular way for students with a major weakness in reading speed or accuracy will be effective.

## Ethical Considerations

## Compliance with ethical guidelines

In the implementation of the research, ethical considerations were considered according to the instructions of the ethics committee of [Tehran University of Medical Sciences](#) and the code of ethics was received under the number IR.TUMS.FNM.REC.1397.063.

**Table 1.** Relationship between planning, attentional shifting, and cognitive flexibility and comprehension, speed, and reading accuracy in both normal and dyslexic groups

Variables	Normal Children			Children with Dyslexia		
	Attentional Shifting	Planning	Cognitive Flexibility	Attentional Shifting	Planning	Cognitive Flexibility
Reading Accuracy	-0.105	0.052	0.175	-0.492	-0.80	0.004
	0.643	0.819	0.436	0.020	.0724	0.986
Reading Speed	0.052	-0.273	-0.099	0.914	-0.169	0.351
	0.819	.0289	0.662	0.000	0.453	0.109
Reading comprehension	-0.083	0.121	-0.056	-0.140	0.262	-0.171
	0.713	0.804	0.804	0.533	0.240	0.447

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### **Authors' contributions**

Research study design: Hoshang Dadger, Zahra Soleimani and Mehdi Tehranidoost; Preparing the draft of the article and collecting the data of the article: Aida Karimzadegan; Guidance, analysis and interpretation of article data: Hoshang Dadger, Zahra Soleimani; Scrutinized revision and correction: Hoshang Dadger.

### **Conflict of interest**

The authors declared no conflict of interest.

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