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Assessment of Executive Functions (Inhibition and Cognitive Flexibility) in Children with Dyslexia

Dr. Belkadi Nehed

University of Blida 2- Lounici Ali, Algeria

n.belkadi@univ-blida2.dz

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Abstract:
The present study seeks to assess executive functions in a group of children with dyslexia enrolled in a primary school in Algiers. The participants were aged between 9 and 11 years and were attending the fourth and fifth grades of primary education. The study focused on the evaluation of specific executive functions, namely inhibition and cognitive flexibility, through the administration of several tests, including an intelligence test, a dyslexia diagnostic test, the Stroop Test to measure inhibition, and a verbal fluency test to assess cognitive flexibility. The descriptive method was adopted, as it was considered the most appropriate approach for this study. The initial sample consisted of seven children who obtained low scores in Arabic language during the second term of the academic year, while the final study sample was limited to six children who met the main criteria of the study.

Keywords: executive functions, inhibition, cognitive flexibility, dyslexia.

Introduction

Executive functions refer to a set of cognitive and behavioral skills responsible for goal-directed activity. They represent a high level of human functioning, encompassing intelligence, thinking, self-regulation, and social interaction. In recent years, executive functions have become a central focus of research interest, despite the relatively limited number of studies addressing them. They are commonly defined as a group of mental processes that enable individuals to regulate their behavior and guide their thoughts and emotions in order to achieve specific goals.In the present study, we focused on two executive functions: cognitive flexibility and inhibition. Cognitive flexibility refers to the ability to change patterns of thinking or behavior in response to unexpected situations, such as accidents or sudden events. It involves the capacity to shift from one task to another. Inhibition, on the other hand, is the ability to control automatic responses and suppress undesirable behaviors, including the regulation of emotions and impulses.

This study aimed to assess executive functions in children with dyslexia, who experience deficits in linguistic communication. Dyslexia is characterized by difficulties in understanding, interpreting, and comprehending spoken and written words in children over the age of eight.

Research Problem

Do children with dyslexia suffer from impairments in executive functions?

Research Questions

- Do children with dyslexia experience deficits in inhibitory control?

- Do children with dyslexia experience deficits in cognitive flexibility?

Hypotheses

- Children with dyslexia exhibit impairment in the function of inhibition.
- Children with dyslexia exhibit impairment in the function of cognitive flexibility.

Conceptual Definitions

Executive Functions:

Executive functions encompass a set of processes involved in regulating and monitoring behavior, particularly in non-routine situations that require planning, evaluation, implementation, and correction in order to achieve specific goals (Amer &Boughoul, 2018, p. 90).

Operational Definition:

They are a set of abilities that enable individuals to adapt to new situations, including inhibition, flexibility, planning, decision-making, problem-solving, working memory, and organization.

Inhibition:
Inhibition refers to the intentional suppression of undesirable responses and the ability to regulate behavior at appropriate times while resisting impulsivity. Children with deficits in inhibition tend to display impulsive behavior, high levels of physical activity, inappropriate responses toward others, frequent interruptions, and disruptive behavior in group activities (Zeddam&Lakhal, 2022, p. 158).

Operational Definition:

It is the score obtained by the child with dyslexia on the inhibition assessment test.

Cognitive Flexibility:

Cognitive flexibility is the ability to shift between different responses, learn from mistakes, generate alternative strategies, distribute attention, and process multiple sources of information simultaneously (Hassanin, 2021, p. 230).

Operational Definition:

It is the score obtained by the child with dyslexia on the cognitive flexibility test.

Objectives of the Study

- To determine whether children with dyslexia exhibit impairment in inhibitory control.
- To determine whether children with dyslexia exhibit impairment in cognitive flexibility.

Significance of the Study

The importance of this study lies in the population to which it was applied—children with dyslexia. Dyslexia has become a growing concern for many parents, as it prevents children from decoding linguistic symbols despite the absence of intellectual disability. Therefore, this research seeks to examine executive functions in this group in order to assess them and identify potential impairments.

Theoretical Framework

Cognitive Flexibility

Cognitive flexibility is the ability to transfer knowledge, behavioral responses, or perspectives as a form of adaptation to the demands of situations encountered by the individual. This executive function is considered one of the fundamental requirements for organizing thinking processes and producing appropriate behavioral and cognitive responses. Therefore, it is regarded as an essential cognitive resource for psychologically disturbed individuals in dealing with various life circumstances and problems, enabling them to correct mistakes and reconsider their actions.

Development of Cognitive Flexibility

Cognitive flexibility skills begin to develop in early childhood, with a sharp increase in abilities between the ages of 7 and 9. Cognitive flexibility becomes largely mature by the age of 10; however, these skills continue to improve throughout adolescence and into adulthood, reaching their peak between the ages of 21 and 30 (Djani et al., 2015, p. 6).

Inhibition

Inhibition refers to the ability to suppress irrelevant information. There are two types of inhibition: intentional inhibition and automatic (mechanical) inhibition. The inhibitory process is strongly influenced by situational context, psychological factors, and mental disorders. These factors affect several cognitive functions such as attention control, attentional shifting, and inhibitory regulation, all of which contribute to the emergence of anxiety disorders. When inhibition is impaired, it becomes difficult for the individual to perform organized and coordinated actions, leading to random shifting between stimuli (Qalfat, 2023).

Practical Framework

After presenting the theoretical background of the study, the following section outlines the methodological steps undertaken to obtain the results.

Pilot Study

The pilot study represents a preliminary stage preceding the actual application of the research instruments. It is the first step through which the researcher gathers as much information as possible about the target research group (Belkadi, 2016, p. 214).

Through this step, the study sample was determined. Initially, it consisted of seven children who had obtained below-average scores in Arabic language. After administering an intelligence test to all participants, it was found that none of them suffered from intellectual disability. The following table presents the results obtained by the children:

Intelligence Test: Draw-a-Person Test

The Goodenough Draw-a-Person intelligence test was administered individually to the selected sample, who had previously obtained low academic results in the first and second terms.

Case	Test Score	Interpretation
M. Wael	108.33	Average intelligence
M. Dania	104.20	Average intelligence
A. Abdelraouf	92.30	Average intelligence
M. Rami	115.83	Average intelligence
L. Rahim	120	Above-average intelligence
A. Ibrahim	96.26	Average intelligence
B. Mohamed	106.30	Average intelligence

Interpretation of the Draw-a-Person Test Results

After administering the test to the seven children, it was found that all participants demonstrated normal intelligence levels, with no signs of intellectual impairment. This allowed the researchers to proceed with the second diagnostic test related to dyslexia.

Dyslexia Diagnostic Scale: "The Holiday" Text by Saliha Ghallab

In this study, we selected the text entitled *"The Holiday,"* which was adapted by the researcher Saliha Ghallab in her magister's thesis entitled *Reading Learning Disorders in Primary School*.

Test Administration Procedure

The pupil is asked to sit upright and read the provided text silently first, indicating when they have finished. Afterwards, the pupil is required to read the text aloud. During this process, the examiner records the reading duration, identifies errors, and classifies them.

The text consists of 267 words divided into four paragraphs, composed of short, simple, and complex sentences. It was written in different fonts across paragraphs to ensure the absence of visual difficulties and to observe whether reading speed changes according to word size.

Application Method

First, the child is asked to examine the text and read it silently. Then, a timer is started while the child rereads the text aloud. At this stage, errors are recorded and classified. The examiner evaluates:

- Total number of words read
- Number of correct words
- Number and type of errors

These indicators allow the determination of reading performance, whether it is normal, impaired, or disordered.

Scoring and Correction

In evaluating reading performance, the examiner considers:

- Reading time

- Total number of words read
- Number of correct words
- Number of errors

The average reading time for typical pupils does not exceed three minutes, whereas pupils with learning difficulties usually exceed this duration. This represents the quantitative evaluation.

The qualitative evaluation involves classifying errors such as deletion, repetition, self-correction, hesitation, segmentation, and substitution. It also includes determining the child's reading rhythm (fast, slow, fragmented, automatic, or normal).

Table: Results of the Reading Test for Children with Dyslexia

Case	Reading Type	Words Read	Number of Errors	Type of Errors	Reading Level
M. Wael	Slow	46	43	Deletion, reversal, substitution	0.06
M. Dania	Slow	65	46	Deletion, reversal, substitution	0.29
A. Abdelraouf	Slow	42	41	Deletion, reversal, substitution	0.02
M. Rami	Slow	60	15	Deletion, reversal, substitution	0.75
L. Rahim	Fast	267	1	Reversal	1.00
A. Ibrahim	Slow	42	41	Addition, deletion	0.02
B. Mohamed	Fragmented	46	25	Addition, deletion, reversal	0.43

Qualitative Analysis of the Dyslexia Diagnostic Test

Following the administration of the dyslexia diagnostic test, it was found that six out of the seven children who had obtained low academic results during the first and second terms of the school year exhibited dyslexia. This was due to their inability to read the words in the text within the allotted time.

Most of the children required an extended period to complete the reading task. According to the study conducted by Huey (1908), the average reading speed is approximately 6.3 words per second for oral reading and 6.5 words per second for silent reading. The children in this study demonstrated significantly slower reading rates.

In addition, numerous errors were observed, including reversals, deletions, and additions. The children frequently resorted to spelling out words due to difficulties in decoding, along with incorrect word segmentation and the insertion of words not present in the text.

However, the fifth case demonstrated normal reading performance, making only one error. Based on a clinical interview conducted with the teachers, it was revealed that this child had experienced a traumatic event at the beginning of the first-term examinations, involving the death of his mother and sister. This psychological trauma explained his academic decline rather than dyslexia. Consequently, this case was excluded, and the final sample consisted of six children.

Main Study

Temporal and Spatial Scope of the Study

The study was conducted between January and April 2024 at JelloulBoudina Primary School in Bordj El Kiffan, Algiers.

Research Method

The descriptive method was adopted, as it was the most appropriate approach for this study, which aimed to assess executive functions in children with dyslexia.

Sample

The study sample consisted of six children diagnosed with dyslexia, who were selected after administering both an intelligence test and a dyslexia diagnostic test. This ensured the absence of intellectual disability and confirmed the presence of dyslexia.

Research Instruments

1. Semi-Structured Clinical Interview

A semi-structured clinical interview was conducted with teachers in order to gather comprehensive information about the children with dyslexia. The interview covered the following areas:

- Personal background information
- Health status
- Psychological condition
- Academic performance

2. Inhibition Test: Stroop Test

The Stroop Test was administered to measure inhibitory control in children with dyslexia. It consists of three cards displaying words printed in different ink colors and is conducted across four trials. The child is required to read the words while inhibiting the automatic tendency to read the written word and instead naming the ink color.

3. Cognitive Flexibility Test: Verbal Fluency Task

This task was adapted from the BEC-96 Cognitive Assessment Battery and was used to assess cognitive flexibility. The child is asked to generate as many words as possible belonging to a given category within one minute, such as naming animals.

Instruction:

"Mention as many animal names as you can (for example, animals that start with the letter A)."

Scoring:

- Each correct word = 1 point (maximum counted = 12 words)

Number of Words	Score
10–12 words	3 points
6–9 words	2 points
3–5 words	1 point
0–2 words	0 points

Presentation and Discussion of Results

Results of the Inhibition Test (Stroop Test)

The Stroop Test assesses inhibitory control. The maximum score for each subtest is 50 points, with a total possible score of 200 points.

Case 1 (M. W.)

Subtest	Card	Score	Errors	Repetitions	Error Score
Reading 1	Card A	46	3	1	7
Reading 2	Card B	40	2	0	4
Naming	Card C	40	0	2	2
Interference	Card B	40	1	3	5

Interference Score: 13

Case 2 (M. D.)

Subtest	Card	Score	Errors	Repetitions	Error Score
Reading 1	Card A	23	5	4	14
Reading 2	Card B	20	2	2	6
Naming	Card C	20	1	4	6
Interference	Card B	30	1	5	7

Interference Score: 10

Case 3 (A. A.)

Subtest	Card	Score	Errors	Repetitions	Error Score
Reading 1	Card A	44	8	6	22
Reading 2	Card B	20	5	4	14
Naming	Card C	40	2	6	10
Interference	Card B	40	3	3	9

Interference Score: 7

Case 4 (M. R.)

Subtest	Card	Score	Errors	Repetitions	Error Score
Reading 1	Card A	45	10	1	21
Reading 2	Card B	46	3	4	10
Naming	Card C	45	4	5	13
Interference	Card B	45	5	6	16

Interference Score: 3

Case 5 (A. I.)

Subtest	Card	Score	Errors	Repetitions	Error Score
Reading 1	Card A	30	2	1	5
Reading 2	Card B	34	0	0	0
Naming	Card C	49	1	0	2
Interference	Card B	10	4	3	11

Interference Score: 11

Case 6 (B. M.)

Subtest	Card	Score	Errors	Repetitions	Error Score
Reading 1	Card A	40	2	1	5
Reading 2	Card B	44	0	0	0
Naming	Card C	49	1	0	2
Interference	Card B	20	4	3	11

Interference Score: 11

Overall Stroop Test Results

Case	Score (out of 200)	Percentage
M. Wael	166	83%
M. Dania	93	46.5%
A. Abdelraouf	144	72%
M. Rami	181	90.5%
A. Ibrahim	112	56%
B. Mohamed	153	76.5%
Mean Score	—	**65.5%**

Results of the Verbal Fluency Test

Case	Number of Words	Percentage
M. Wael	8	66.66%
M. Dania	12	100%
A. Abdelraouf	6	50%
M. Rami	10	58.33%
A. Ibrahim	6	50%
B. Mohamed	8	66.66%

Discussion of the First Hypothesis

The first hypothesis stated that children with dyslexia exhibit deficits in the executive function of inhibition.

Based on the results obtained from the inhibition assessment using the Stroop Test, the findings indicated clear difficulties in inhibitory control among children with dyslexia. Their performance was characterized by slowness and hesitation, particularly in the first and second tasks, which involved reading. All cases showed prolonged response times, frequent repetitions, and a high number of errors.

The impairment became more evident in complex situations requiring greater attentional processing, especially in the interference condition. This task required reading words printed in different colors while suppressing either the semantic aspect (the word itself) or the color dimension, which posed significant difficulty for most participants. This weakness reflects a cognitive disturbance in stimulus selection and processing, resulting from an inability to inhibit automatic responses.

Overall, the participants' scores ranged from low to moderate, and most children struggled to suppress dominant responses and produce the required answers. This confirms weak inhibitory control, which involves preventing automatically activated processes when they are inappropriate for achieving a specific goal.

Discussion of the Second Hypothesis

The second hypothesis proposed that children with dyslexia suffer from deficits in cognitive flexibility.

Following the administration of the verbal fluency task adapted from the BEC-96 cognitive battery to assess cognitive flexibility, the results showed that most children with dyslexia performed between moderate and good levels. The participants demonstrated high attention and concentration during the task, perceiving it as an enjoyable game rather than a demanding test. This contrasted with reading-based tasks, in which they experienced considerable difficulty.

Cognitive flexibility requires the ability to shift thinking patterns and adapt to unexpected changes. Attention plays a crucial role in enabling flexible thinking. According to cognitive models of executive functions—particularly the attentional control model proposed by Tim Shallice and Paul Burgess (1996)—attention regulation directly influences cognitive flexibility by organizing and directing mental resources according to task demands. This model emphasizes adaptive control mechanisms that enhance an individual's capacity to adjust to changing tasks.

This theoretical framework helps explain the relatively good performance of children with dyslexia on the cognitive flexibility task compared to other executive function tests. However, these results remain limited to the selected study sample.

Conclusion

This study examined executive functions in children with dyslexia aged between 9 and 11 years through the application of several assessment tools. An intelligence test was first administered to ensure the absence of intellectual disability, followed by a dyslexia diagnostic test applied to seven children with low academic performance. The results indicated that six children met the criteria for dyslexia, while the seventh child's academic decline was attributed to psychological trauma resulting from a tragic life event.

Subsequent assessment of executive functions showed that children with dyslexia exhibited significant impairments in inhibitory control, particularly in tasks involving reading processes. This deficit was especially evident in tasks requiring the suppression of automatic responses and complex attentional processing.

These findings confirm the presence of inhibitory dysfunction in children with dyslexia within the limits of the studied sample, highlighting the importance of integrating executive function assessment into the diagnostic and intervention processes for learning disorders.

The six cases obtained moderate to good results on the cognitive flexibility test. Based on our observations, this outcome appears related to the nature of the task, which did not require reading skills. Instead, the children responded in a playful and motivated manner, perceiving the task as an

enjoyable game rather than a demanding assessment. This interpretation remains limited to the scope of the selected sample.

Suggestions and Recommendations

- Adapting educational programs that incorporate learning through play for children with dyslexia.
- Engaging children in tasks that require sustained mental effort in order to strengthen cognitive and neural functioning.
- Conducting relaxation and deep-breathing sessions for children with dyslexia to reduce stress and improve concentration.
- Involving children in brain games, puzzles, and activities that promote the development of new neural pathways.
- Carrying out broader studies on children with dyslexia to enhance understanding of their cognitive profiles.
- Establishing specialized centers dedicated to learning difficulties.
- Organizing workshops and training programs to raise awareness and improve professional knowledge regarding this population, which requires tailored educational interventions.

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