



ORIGINAL ARTICLE

An Investigation of Executive Function in Children with Dyslexia

Gokcen Akyurek[✉], Gonca Bumin[✉]

Hacettepe University, Faculty of Health Sciences, Department of Occupational Therapy, Ankara, Turkey

ABSTRACT

Objective: Executive functions are high-level cognitive skills that control other functions and behaviors. Executive dysfunctions are described in a variety of developmental disorders. But there is no consensus on the problems of daily life behavior caused by executive function problems in children with dyslexia. In this study, we aimed to examine the problematic executive functions in children with dyslexia.

Methods: Using a simple random sampling, we recruited 158 children with dyslexia (mean age: 10.48 ± 2.37 years; 55 girls) who presented to the Hacettepe University's Occupational Therapy Department in between September, 2015 and March, 2017. Control group who was typical developed children ($n=167$; mean age: 10.08 ± 2.63 years; 59 girls) and similar age and gender with children with dyslexia who were included in the study. The data was collected by administering the Behavior Rating Inventory of Executive Function (BRIEF)'s teacher and parents forms, which assess children's executive function. In this present study, the Cronbach's alpha coefficient for the BRIEF teacher form and its subscales were between 0.85 and 0.92; for parents form and its subscales were between 0.82 and 0.92. Data analysis was performed using SPSS 23.00 software. Descriptive statistical techniques and the independent groups student t-test were used.

Results: There were statistically significant differences in BRIEF teacher and parents form scores between the children with dyslexia and the controls (typical developed children) ($p < 0.001$).

Discussion: These findings suggested that children with dyslexia demonstrated problems in the executive function. For this reason, it is important to be considered in activities related to executive functions of treatment of dyslexia in the planned therapy program by occupational therapists.

Keywords: Behavior, dyslexia, executive function, learning disabilities

INTRODUCTION

Although specific learning disabilities have intact senses, a true motivation, average intelligence, and adequate socio-cultural level, it is a general term with significant, unexpected, specific and persistent neurobehavioral difficulties in learning which defines a heterogeneous group who have difficulty in active reading, writing, and calculating (1). Dyslexia is the most common type of specific

learning disabilities (1,4). Substantial evidence has established that the children with dyslexia have deficits in phonologic awareness, which consistently distinguish them from those who are not reading-impaired (5) and the primary problems of the children with dyslexia are, language-based, reading and writing. However, dyslexia consist of multiple neurocognitive deficits and not solely related to a phonological system dysfunction, and parents and professionals (6) often report other symptoms such as lack of concentration, disorganization, and forgetfulness. Moreover, there are functional anomalies in medial and left lateral frontal lobe reported in children with dyslexia (6–9). Thus, the executive functions have been explored as a contributing factor to dyslexia recently (1,10–14).

Corresponding author: Gokcen Akyurek,
Hacettepe University, School of Health Sciences, Department of Occupational
Therapy, 06100 Samanpazari, Ankara, Turkey
E-mail: gkcnakyurek@gmail.com
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Executive functions are high-level cognitive skills that control other functions and behaviors (13,15). These include skills such as planning, problem-solving, working memory, organization, cognitive flexibility and inhibition. Executive functions which play an essential role in the child's behavior, emotional regulation, and social interactions develop during childhood and adolescence (1,6). There are some assessment techniques such as record review, direct observation, interview, questionnaires, and rating scales that are structured and flexible as they pertain to EF. Context is critical when assessing for EF and EdF (6). Behavior Rating Inventory of Executive Function or BRIEF is the test that aims to evaluate a child's executive functioning behaviors in a real-world setting (16). The BRIEF has provided an alternative to prevailing neuropsychological tests (17). The traditional neuropsychological tests are administered under controlled laboratory conditions while the BRIEF measures a child's executive functioning behaviors in everyday situations and settings and uniquely evaluate a set of metacognitive, behavioral, and emotional abilities that go beyond common psychopathology and behavioral disturbances measured (17). Vriezen and Pigott found that among children with traumatic brain injury (TBI), BRIEF may show the difficulties in everyday life than on any other performance-based neuropsychological tests that children can perform relatively well (18). The authors suggest that the BRIEF measures a unique aspect of executive functioning. Executive dysfunctions are described in a variety of developmental disorders such as ADHD, autism spectrum disorder (ASD), reading disabilities and TBI (19–23). Information processing, recalling the steps that will take place during a daily life mission are the problematic executive functions in dyslexia (10,24–26).

As seen in the literature, although there are many studies about the problems of the executive functions of children with dyslexia, there is no consensus on the problems of daily life behavior caused by executive function problems in children with dyslexia. Therefore, in this present study we aimed to assess various aspects of executive functioning of children with dyslexia. In

addition, we aimed to determine the differences between the dyslexic children and a control group in their executive functions. The light of this information will provide a more detailed understanding of the executive functioning of children with dyslexia as well as an increased chance of a targeted educational program.

METHODS

Study Design and Participants

This study was a cross-sectional study which was carried out by using a questionnaire that was given to 158 parents of children with dyslexia (55 females and 103 males; mean age, 10.48 ± 2.37 years; age range, 8-17 years) who applied to Hacettepe University, School of Health Sciences, Department of Occupational Therapy for their children. Children who were diagnosed with dyslexia according to the DSM-IV criteria among the children who presented to Hacettepe University Department of Child and Adolescent Psychiatry Clinic between the years of 2015 and 2017 were selected by simple randomization method. At the beginning of the study, children and their parents were informed about the study and a child consent form and a parental consent form which were found to be convenient by Hacettepe University Ethics Committee were signed, and it was found appropriate from the viewpoint of medical ethics.

Inclusion criteria; children who were diagnosed with dyslexia, were between the ages of 8-17, going to school in general education institutions (criteria for the dyslexia group), those continuing in the special education institution (criteria for the dyslexia group) and were dominant in the right hand. A score below 90 in the total intelligence score determined by the Wechsler Intelligence Scale for Children-Revised (WISC-R) test (the criterion for the children with dyslexia) and accompany of other physical, neurological and psychological problems were the exclusion criteria for children.

For the children with dyslexia, there were 162 children between the ages of 8-17, attending the special education program and who have been shown not to have any

physical, neurological and psychological problem and their families have been interviewed. Of the interviewed children, 160 have met the inclusion criteria. One hundred fifty-eight signed the consent forms by agreeing to participate in the study, and they were evaluated in the pediatric unit of Occupational Therapy Department of Hacettepe University.

As the control group, 167 children with typical development were included with similar age and gender from the schools selected by the Directorate with the permission of the Ministry of National Education. "The Demographic Information form" and "Behavior Rating Inventory of Executive Function (BRIEF) teacher and parents form" assess children's executive functions were used and was filled by children's teachers and parents (27,28).

Instruments

Demographic Information: A demographic information form prepared by the researchers by taking a comprehensive story from the children and the age, gender, grade of the child, the age of the mother and father, and the educational status of the mother and father were recorded.

Evaluating Executive Functions: The BRIEF was used to evaluate executive functions. This scale is an inventory that measures the daily behaviors of executive functioning of the children and adolescents aged between 5 to 18 years with the teacher, parents, and self (12-18 years) evaluation form and measured across eight domains/subscales (Inhibit, Shift, Emotional Control, Initiate, Working Memory, Plan/Organize, Organization of Materials, and Monitor) (6,28). It had 86 items, and a three-point scale was used with indications of 'Never,' 'Sometimes,' 'Often,' and respondents who at least were the fifth-grade education level found it easy to complete with the straight forward instructions. Approximately 10 to 15 minutes was enough to complete each questionnaire and a hidden carbon copy that simplifies later addition of item scores within each scale for computation of T scores was also included. The Turkish version of the test was made by Batan et al. (27). High internal consistency

(alphas=0.80-0.98); test-retest reliability ($r=0.82$ for parents and 0,88 for teachers); and moderate correlations between teacher and parent ratings ($r=0.32-0.34$) were computed for original forms.

Statistical Analysis

IBM SPSS statistics for Windows 23.0 program (IBM SPSS Statistics for Windows, Version 23.0. Armonk, New York, United States of America) was used for statistical analysis of the data. Power analysis was applied to determine the appropriate number of samples. The sample size of this study was calculated by taking the effect size of the study as 0.50, with 95% power and at least 150 children per group with 0.05 α error. Cronbach's alpha coefficients were computed to assess the reliability of

Table 1: The demographic characteristic of groups

	CwD (n=158) %	Control (n=168) %	p
Gender			
Boys	65.2	64.7	0.92
Girls	34.8	35.3	
Class			
2.	20	11.4	0.44
3.	13.5	15.6	
4.	20.6	23.4	
5.	14.8	12	
6.	8.4	9.6	
7.	12.3	9.6	
8.	4.5	8.4	
9.	3.9	5.4	
10.	1.9	3	
11.	0	0.6	
12.	0	12	
Education of mother			
Primary school	32	61.7	0.001*
High school	36	16.7	
University	29.3	15.8	
Literate	2.7	5.8	
Education of father			
Primary school	39.9	47.5	0.15
High school	30.4	33.1	
University	28.4	16.9	
Literate	1.4	2.5	
Employment of mother			
Working	41.1	12.5	0.001*
Not working	53.6	87.5	
Retired	5.3	0	
Employment of father			
Working	91.3	88.9	0.58
Not working	4	6.8	
Retired	4.7	4.3	

* $p<0.05$; ** $p<0.001$; CwD: Children with Dyslexia; Control group: Typical Developed Children

the BRIEF parents and teacher form (29). Percentage values for qualitative variables were calculated (Table 1), and the variables determined by measurement were expressed as the mean standard deviation ($X \pm SD$) (Table 2) (30).

The Shapiro Wilks test was used to determine whether the distribution of the numerical variables was normal. Since this test provided a normal distribution assumption, the independent-sample t-test was used to compare the mean of the groups (30).

RESULTS

Age, gender, parental education and work status of the parents of the children were compared, and all the

characteristics of the groups were found to be similar except maternal education and maternal employment status ($p > 0.05$) (Table 1).

When we compared the groups in terms of the total and sub-scores of the BRIEF-teacher and parents form that we used for the evaluation of executive functions, the average of the executive functions of the children with dyslexia regarding inhibition, shift, emotional regulation, initiation, memory, plan, organization and monitor parameters were found very low and the difference between the groups was statistically significant ($p = 0.001$). Moreover, emotional regulation (Table 2 and 3). Children with dyslexia were found to be negatively affected by these parameters compared to children with typical development.

Table 2: Independent Simple t-test for 2 groups comparison for BRIEF-parents form

	Children with dyslexia Mean (SD)	Control group Mean (SD)	t	p
BRIEF parents form				
Inhibition	58.64 (11.28)	49.30 (9.91)	7.681	0.001**
Shift	64.94 (11.39)	56.51 (8.94)	7.063	0.001**
Emotional control	58.82 (11.31)	56.21 (10.48)	2.082	0.038*
Initiation	63.09 (10.97)	50.77 (9.21)	10.663	0.001**
Working memory	65.35 (9.45)	52.10 (9.46)	12.164	0.001**
Plan	64.47 (10.59)	50.39 (10.05)	11.878	0.001**
Organization	52.77 (10.12)	46.55 (8.80)	5.743	0.001**
Monitor	60.87 (9.49)	49.88 (9.22)	10.220	0.001**
BRI	61.65 (11.16)	54.04 (8.84)	6.639	0.001**
MI	63.78 (10.43)	50.04 (9.35)	12.115	0.001**
GEC-p	63.79 (10.55)	51.64 (9.15)	10.761	0.001**

** $p < 0.001$; BRIEF: Behavior Rating Inventory of Executive Function; BRI: Behavioral Regulation Index; MI: Metacognition Index; GEC: Global Executive Composite; SD: Standard Deviation; Control Group: Typical Developed Children

Table 3: Independent Simple t-test for 2 groups comparison for BRIEF- teacher form

	Children with dyslexia Mean (SD)	Control group Mean (SD)	t	p
BRIEF teachers form				
Inhibition	61.52 (13.98)	51.45 (11.84)	6.710	0.001**
Shift	72.46 (16.37)	61.51 (14.60)	6.178	0.001**
Emotional control	63.45 (12.99)	55.95 (12.41)	5.114	0.001**
Initiation	67.35 (13.45)	52.84 (11.62)	10.067	0.001**
Working memory	69.70 (15.51)	53.09 (12.07)	10.230	0.001**
Plan	67.27 (13.78)	51.89 (10.24)	10.811	0.001**
Organization	62.65 (15.76)	51.12 (11.26)	7.114	0.001**
Monitor	65.17 (13.75)	50.75 (11.06)	9.711	0.001**
BRI	67.60 (14.82)	57.01 (11.92)	6.948	0.001**
MI	66.36 (16.09)	52.37 (11.09)	8.661	0.001**
GEC-t	68.89 (14.45)	54.54 (11.89)	9.560	0.001**

** $p < 0.001$; BRIEF: Behavior Rating Inventory of Executive Function; BRI: Behavioral Regulation Index; MI: Metacognition Index; GEC: Global Executive Composite; SD: Standard Deviation; Control Group: Typical Developed Children

DISCUSSION

In this study, we examined the executive functional problems of children with dyslexia, and it was found that children with dyslexia were behind the normal development group in terms of executive functions such as planning, organization, inhibition, monitor, initiation, working memory, and emotional regulation.

As it is seen in many studies the most commonly studied parameter of executive functions in children with dyslexia is working memory (31–38). The general conclusions of these studies were that children with dyslexia had deterioration in complex visual-spatial (36) or auditory tasks (counting number) (37,38), which requires storage and processing skills. Also, these studies confirmed that children with dyslexia had more problems in the memory task than the controls (31). These findings suggested that children with dyslexia may have been able to keep visual and auditory information in their memory for a shorter period than children with typical development. According to these results, task memory and recall mechanism were found to be affected in children with dyslexia. This finding was also supported in the present study we performed. Children without dyslexia scored higher in the memory parameters than children with dyslexia. Notably, the questions "some things are difficult to remember even for a few minutes, and they cannot talk on the same topic for a long time" were the questions that the group of children with dyslexia scored the lowest for the task memory parameter.

There are inconsistent results in the literature related to the evaluation of impulse control ability (inhibition) (10,39,40). Tasks related to impulse control and flexibility can be straightforward for children with dyslexia, but there are still more studies pointing out the impulse control disorder in children with dyslexia compared to children without dyslexia, and this was also consistent with our results (39,40). In this study behaviors related to impulse control with a high incidence were "do not think about the results before doing something" and "talking in inappropriate times."

Problem solving and planning and organizational skills are the main elements of executive functions.

Although previous studies that question the integrity of these skills in children with dyslexia are inconsistent, most studies have reported significant differences in problem-solving between children with and without dyslexia (41,42). The literature, especially, reveals the significant differences between the duration of solving a problem and the number of problems; also, the study reveals that control group showed significantly better behavioral patterns related to problem-solving (10). In this study, typically developed children demonstrated significantly better behaviors of planning and organizing skills. Also, the most problematic planning and organizational behaviors on the scale were; "cannot be creative in organizing," "cannot properly adjust the time that is required to fulfill the tasks assigned to him" and "does not come prepared to class."

A component of executive functions, attention shift, is a problematic area in children and adults with dyslexia and our result is consistent with these findings (43–45). It is reported in the literature that this problem arises from the source of auditory perception problem (46). However, it has been described many times that the main problem is visual with dyslexia (47–49). In this present study, the most problematic behavior related to attention shifting that is seen in children with dyslexia was "difficulty in performing an activity with multiple stages" The problem about attention shifting is visual or auditory, or whether the same problem causes both is a matter to investigate.

Emotional regulation, a significant problem seen in children with dyslexia, is also a component of executive functions (50,51). However, in the current literature, researchers are predicting that problems in emotional regulation should not be seen as a reason for dyslexia, and not be kept ahead of the problematic cognitive processes. Besides, it is also thought that people with dyslexia should be under control during studies on the grounds of contradictory data on their emotional states (50). There is also a significant difference in emotional regulation among children with and without dyslexia in this study. At this precise point in this study, problematic behaviors related to emotional regulation in children with dyslexia were "be frustrated for a long time after

experiencing a problem" and "very easily be upset." In this context, it was thought that emotional regulation is vital in the lives of these children and it should take place in therapies.

Some studies examined the effect of self-monitoring over the reading performance on children with dyslexia, and in the literature, it has been reported that self-monitoring, decreases errors (52) and improves reading behavior and academic performance (53). Consistent with the literature, in this study, there was a significant difference in monitor behaviors of children with dyslexia compared to those who without dyslexia. Teachers of children with dyslexia have expressed this difficulty by indicating the behaviors such as "do not realize their behavior in a group" and parents expressed for this "do not realize that their behavior causes negative reactions."

As a result, when comparing the parameters of executive functions between children with and without dyslexia, there was a meaningful difference against children with dyslexia regarding working memory, impulse control, shift, problem-solving, organization, emotional regulation, and monitoring. The present results are valuable because a control group monitors the groups with similar in age and sex. However, the Intelligence Quotient (IQ) level of the control group was not examined and can be seen as a limitation due to the fact that the groups were not homogenized according to the IQ score. Future studies should also examine the impact of IQ situations on executive functioning. Also examining executive functions with an inventory instead of psychometric tests may be a limitation in this study. For this reason, it is important that future studies should be conducted under more favorable conditions with psychometric tests. Nevertheless, the high number of participants and the fact that this is a randomized controlled study design, this study may help shed light on the everyday and academic problems of children with dyslexia.

CONCLUSIONS

In conclusion, executive functions may affect not only attention and memory in children with dyslexia but also

behavior and interactions of the child negatively. Hence children with dyslexia may have great difficulty in developing these skills spontaneously. Executive functions have an essential contribution to both daily and school life, and it is essential to evaluate executive functions for the development of therapy programs for children with dyslexia and as well as implementing effective targeted treatment strategies.

Ethics Committee Approval: This study was evaluated by the Ethics Committee of Hacettepe University at 16-375 application number at the meeting held on 31.05.2016 and it was found appropriate from the viewpoint of medical ethics.

Conflict of Interest: There is no conflict of interest with any financial organization regarding the materials discussed in the manuscript.

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