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Cognitive Functions in Georgian Children with Dyslexia and Comorbid Dyslexia and Attention-Deficit/Hyperactivity Disorder

Khatuna Parkosadze[a*], Marina Kunchulia[b], Archil Kezeli[c]

[a,b,c]*Ivane Beritashvili Center of Experimental Biomedicine, Tbilisi, Georgia*
[a,b]*Free University of Tbilisi, Institute of Cognitive Neurosciences, Tbilisi, Georgia*
[a]*Email: mantskavamaka@bk.ru*

Abstract

In spite of the fact that dyslexia and Attention-deficit/hyperactivity disorder (ADHD) are highly comorbid, less studies have investigated cognitive functions during co-occurring of those disorders. Here we studied such cognitive abilities as attention, memory, and executive functions in children with dyslexia and comorbid dyslexia/ADHD. Three groups of age- and IQ-match children participated in our study: children with dyslexia (group 1), children having ADHD and dyslexia together (group 2) and typically developing children (group 3). All participants performed the visual search tasks, visual working memory task (visual N-back task) and executive function task (WCST). We found that children with comorbid dyslexia/ADHD showed a strong impairment in performance of search tasks while children with dyslexia showed significant worse performance than typically developing children only when task condition was more complex. However, both dyslexia and dyslexia/ADHD groups showed deficits in visual working memory compare to typically developing children. As for executive function task, only children with comorbid dyslexia/ADHD showed a significant worse performance compare to typically developing children. Here, we concluded that visual attention and visual working memory are impaired in children with either dyslexia or comorbid dyslexia/ADHD and these impairments are stronger in dyslexia/ADHD group. Yet, deficits in executive functions are more specific for children with comorbid dyslexia/ADHD.

Keywords: dyslexia; ADHD; attention; executive functions.

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* Corresponding author.

1. Introduction

Neurodevelopmental disorders are group of conditions that are caused by impairment in learning, language, or behavior areas. These disorders begin during the developmental period, appear in childhood and some of them even are preserved in adults. Examples of neurodevelopmental disorders in children include attention-deficit/hyperactivity disorder (ADHD), learning disabilities (including dyslexia, dyscalculia, dysgraphia etc.,), autism spectrum disorder, intellectual disability, cerebral palsy, and many others. Approximately 20% of school age children worldwide are affected by neurodevelopmental disorders. Among these conditions, ADHD and learning disabilities had the greatest prevalence and one of the common types of learning disabilities - dyslexia is the dominant. Moreover, many children have more than one of these conditions together.

Dyslexia is reading disorder characterized by difficulties with accurate and/or fluent word recognition as well as poor spelling and decoding abilities. There are many theories proposed to explain mechanisms of reading difficulties and two of them are dominant: deficits in phonological processing and deficits in visual information processing that involved those brain areas where integration of sensory inputs happen, and that are responsible for word analysis and for attention [1]. ADHD is characterized by difficulties with attention, hyperactivity and impulsiveness. Core deficits in ADHD are related to cognitive disabilities that are explained by evidences about atypical neurophysiological patterns in fronto-striatal, fronto-parietal, and sensory circuits in children and adults with ADHD [2].

It is evidenced that ADHD often co-occurs in combination with dyslexia [3]. These two disorders apparently have same genetic basis and share some biological and cognitive dysfunctions [4]. Still, the etiology of comorbidity of the two disorders stays unclear.

Cognitive functions including such domains as attention, memory and executive functions were subject of intensive investigation in children with neurodevelopmental disorders. However, evidences from those studies are controversial and sometimes even conflicting. For exemple, Varvara and colleagues [5] have shown that children with dyslexia compare to their age-match controls show deficits in visual-spatial attention and visual short-term memory. While Moura and colleagies [6] have shown deficits in verbal but not in visual memory. Stins and colleagues [7] investigated sustained attention and executive functions in children with ADHD and showed overall performance deficit for children with ADHD but no difference in reaction times compare to control group children. On the other hand, the evidence shows that dyslexia and ADHD both have cognitive deficits in processing the speed [4].

Despite the facts that both ADHD and dyslexia are quite popular disabilities and attract attention of researchers from different scientific backgrounds, there are still controversies whether cognitive functions are affected in children with these disorders or not and even less is know when the two disorders co-occur.

In the present study we aimed to investigate the cognitive such functions as attention, visual working memory and executive function in Georgian children with dyslexia and with comorbidity of dyslexia and Attention-deficit/hyperactivity disorder. To the end, we used the visual search task, visual n-back task and Wisconsin

Card Sorting Test (WCST), and compared performance between three groups: children with dyslexia (group 1), children having ADHD and dyslexia together (group 2) and typically developing children (group 3).

2. Materials and Methods

2.1.Participants

Sixty age and IQ match children (aged between 8 and 10 years) participated in the study. Participants were divided into three groups: group 1 - children with dyslexia (n=24, 18 boys) group 2 - children with ADHD+dyslexia (n=12, all boys) and group 3 - typically developing children (n=24, 18 boys) (see details in table 1). The diagnosis of dyslexia and ADHD were made by a specialist of the Multi-Disciplinary Group of the Ministry of Education, Science, Culture, And Sport of Georgia. The tests used for diagnosis were cross -cultural adapted and normalized on Georgian population, including Wide Range Achievement Test (WRAT-4), test for nonverbal intelligence (TONI-4),the Woodcock-Johnson Tests (WJ III). However, we had not direct access to individual screening data and therefor did not report the dyslexia and ADHD screening details here. General intelligence of all participants were evaluated by officially standardized tests TONI-4 (fourth edition) and all included participants had normal IQ to their age (table 1).

The study was performed in accordance with the Declaration of Helsinki and was approved by the local Bioethics Committee of Ivane Beritashvili Center of Experimental Biomedicine (10 / 30.01.2017). Parents of all participants gave their informed consent prior to starting the experiment. All participants received compensation for participation.

2.2.Stimuli and Procedure

Children were tested individually in a quiet experimental room. Data were collected on a Windows PC with LCD display (screen resolution 1280x800 pixels). We used The Psychology Experiment Building Language (PEBL) program for running experiments [14].

The following tests were used:

2.3.Visual Search Task

The test provides a good measure of visual selective attention. The target stimulus is green horizontal line presented on task of a participant was to find and respond on presence of target stimulus - a within distractors (red and green lines). The display elements were presented on a uniform grey background. The search dislpay consisted of 4, 9 or 16 elements and the numbers of elements were changed trial-by-trial. Participants were instructed to search and respond as soon as possible by giving answer ‘yes' if a target was presented and press the green button in right hand and 'no' if target was not presented and press the red button with left hand. At the beginning of a trial, a central fixation dot appeared for 700 milliseconds (msec), then the fixation dot was replaced by the stimulus field which was presented for 200 msec. Participants performed a single block of 120 trials in which there were equal numbers of target present and target absent trials. The reaction times (RT) and response accuracies were recorded and analysed.

2.4.Visual n-back task

The N-back task is a continuous performance task that is commonly used to assess working memory. In this task ‘n’ refers on how many previous stimuli must be remembered. 1-back and 2-back conditions were used. Participants are presented the sequence of visual stimuli (pictures of different objects like tree, umbrella, ball etc.,) and during 1-back condition they responded whether current stimulus matched with the previus one or not by pressing right and left arrow on the computer keyboard respactevely; during 2-back condition participants indicated whether current stumulus matched with the stimulus before the previous one. The Stimuli were presented in pseudorandom sequences in a fixed central location on a computer screen for 500 msec duration with 2500 ms interstimulus interval. Both correct responses and false alarms were recorded and analysed.

2.5.Wisconsin Card Sorting Test (WCST)

This test is used to evaluate the executive functions. WCST contains 128 cards that differ from each other in three dimensions (color, amount and shape) and a participant need to sort cards according to one of the dimensions. In every 10 trials sorting dimension is changed and a participant is required to change and adjust to new sorting strategies. Performance is evaluated according to several outcomes, e.g. perseverative errors (cognitive flexibility), non-perseverative errors (distractibility), number of trials to complete the first category (conceptual ability), and failure to maintain set (working memory) and so on.

2.6.Data analysis

For all three groups we calculated reaction times and overall accuracy. Reaction times (RT) faster than 150 msec were categorized as ‘fast guesses’ and slower than 3500 msec as ‘too slow’ for that age of children and were excluded from the analysis. Both of these categories occurred in <1% of trials. RTs and accuracies were analyzed with analysis of variance (ANOVA) in SPSS statistical program (IBM corp., Version 20.0). Performance of tasks (accuracy) and RTs were compared between the groups.

3. Results

3.1.Visual Search Task

We calculated mean reaction times (RTs) and mean percentage of correct responces for each group. Figure 1 shows the mean RTs for each group. RTs are increased with number of distractors for all groups of participants, indicating that participants use serial search. RTs between groups were different and children of group 2 had longer RTs and children of group 3 had shorter RTs. An analysis of variance (one-way ANOVA) showed significant group effect for RTs on search displays with 4 and 9 elements, $F(2,30)=5.379$, $p=0.01$ and $F(2,30)=6.697$, $p = 0.004$ respectively . No significant group effect effect was found for 16 element displays, $F(2,30)=2.388$, $p=0.109$. However, both dyslaxia and dyslaxia/AHDH groups showed significant worse perforamce than TD group for 16 element displayes condition.

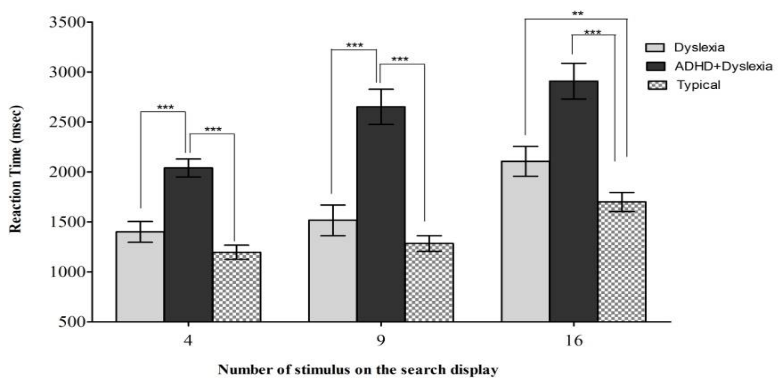

Figure 1: Reaction time of visual search task. Y axis shows the RT in milliseconds.

Figure 2 shows performance of search task. Mean performances varied across the different displays and groups, F(2, 30)=5.379, p=0.01. Pair-wise comparison between the groups showed that for 4 and 9 elements search displays there were no significant differences between the performance of group 1 and group 2 (p > 0.05) and group 1 and group 3 (p > 0.05), but there was significant difference between the performance of group 2 and group 3 (p < 0.05); for 16 elements search displays there were no significant differences between the performances of all groups (p > 0.05).

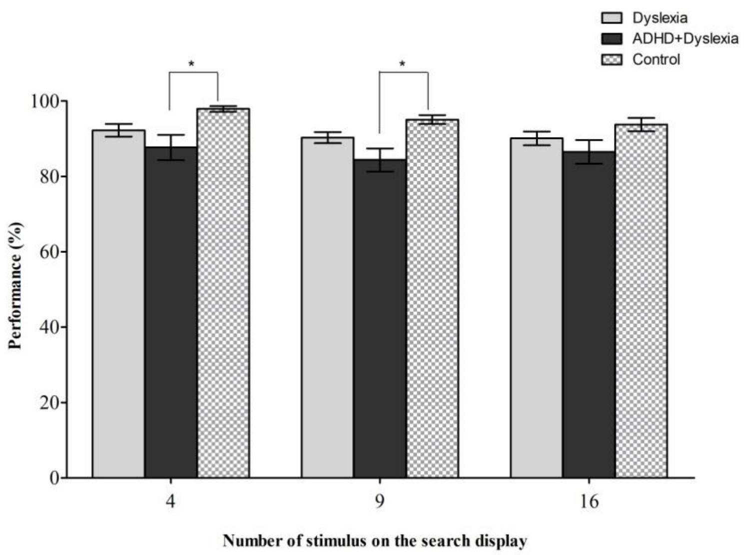

Figure 2: Performance of visual search task. Y axis shows the percepntage of correct responces.

3.2.Visual n-back task

The means of performances of 1-back and 2-back conditions for three groups are shown in Figure 3. Mean performances varied across the groups, F(2, 30)=4.246, p=0.024. Pair-wise comparison between the groups showed that there was no significant difference between the performances of group 1 and group 2 (p=0.299) but performance of typically developing children was statistically different from both groups 1 and 2, p=0.03 and p=0.018 respectevely. As for performance of 2-back condition, even there is difference in performance between the groups, there are no significant differences.

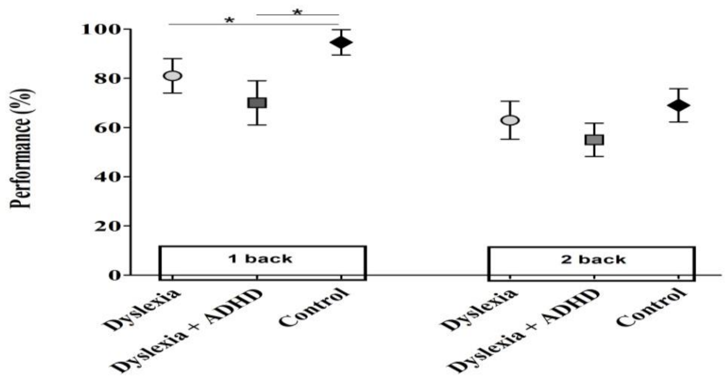

Figure 3: Performance of visual n-back task.

3.3.Wisconsin Card Sorting Test (WCST)

Results of WCST for all groups are shown in table 2. Paired-sample t-test showed no significant differences between group 1 and group 3 in all parameters measured by WCST ($p > 0.05$), and significant differences between group 1 and group 2 and between group 2 and group 3 ($p < 0.05$). These results show that children having dyslexia and ADHD together have deficits in executive functions that might be related to more ADHD rather than dyslexia

Table 2: Performance of WCST. Means and standard deviations are presented for each group.

Participants	Number of correct responses	Number of total errors	Number of perseverative Errors	Number of nonerseverative Errors	Conceptual Level Responses
Dyslexia	**83(±13)**	**45(±12)**	**24(±10)**	**21(±13)**	**69(±14)**
Dyslexia+ADHD	**70(±14)**	**58(±14)**	**26(±15)**	**32(±18)**	**45(±18)**
Controls	**94(±9)**	**34(±11)**	**21(±7)**	**13(±6)**	**80(±10)**

4. Discussion

In the present study we investigated cognitive functions in Georgian children with dyslexia and comorbid ADHD/dyslexia and compared the performance of these groups to age- and IQ- match typically developing children. This is the first attempt in Georgia to evaluate cognitive functions in Georgian children with neurodevelopmental disorders.

The visual search task was used to evaluate the state of attention. We analyzed reaction time and accuracy rates that are the most frequently assessed dependent variables for visual search. Visual search task is well investigated for dyslexia but not that much for ADHD. Our results showed that reaction times increased with number of search elements on display for all three groups that indicates serial search strategy by all participants. Reaction time for participants of group1 and group 2 were higher compare to group 3 children that is in accordance to the literature data that dyslexia and ADHD have delayed sensory processing and hence increased reaction time [4]. RTs for easier conditions (4 or 9 element search displays) showed group difference, however, when the task is more complex (16 elements on search display) there was no significant difference between RTs of different groups. Task accuracy (performance) results also showed the same tendency that when task is complex the performance is not significantly different for three groups.

Visual N-back task was used to evaluate visual working memory. Results of these tasks showed deficits in visual working memory for both groups of children with neurodevelopmental disorders. However, as soon as the task is more complex, such deficits are seen for typically developing children too, that could be explained by assumption that for the age of 8-10 years mechanisms of visual working memory is not fully developed.

Executive functions were tested using WCST that is a complex test requiring involvement of different cognitive capacities for successful performance and is very good tool for evaluation of executive functions in neurodevelopmental disorders. The results showed that children with neurodevelopmental disorders (groups 1 and 2) had worst performance compare to children of group 3. However, surprisingly the performance of children with dyslexia was not significantly different from the performance of children of group 3. These results indicate that children with dyslexia show fewer deficits in executive functions. Deteriorated executive functions in comorbid group of ADHD+dyslexia could be related to more ADHD mechanisms rather than dyslexia.

The limitation of the study is that we could not recruit and include in our study one more group of children having only ADHD. Because of thatthat, we can only speculate regarding our results .and future studies including ADHD group would need to confirm our finding.

5. Conclusions

In conclusion, we found that in children with dyslexia and comorbid dyslexia/ADHD both visual attention and visual working memory are deteriorated. However, these deteriorations are stronger in children with comorbid dyslexia/ADHD. Yet there is clear deficiency of executive functions only in children with comorbid dyslexia/ADHD

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References

[1]. Elliott J.G., Grigorenko E.L. The dyslexia debate. New York: Cambridge University Press. 2014

[2]. Cubillo A., Halari R., Smith A., Taylor E., Rubia K. Fronto-cortical and fronto-subcortical brain abnormalities in children and adults with ADHD: a review and evidence for fronto-striatal dysfunctions in adults with ADHD followed up from childhood during motivation and attention. Cortex. 2012; 48:194-215

[3]. Germanò E., Gagliano A., Curatolo P. Comorbidity of ADHD and dyslexia. Dev. Neuropsychol. 2010, 35, 475–493. doi: 10.1080/87565641.2010.494748

[4]. Willcutt E.G., Betjemann R.S., Mcgrath L.M., Chhabildas N.A., Olson R.K., Defries J.C., et al. Etiology and neuropsychology of comorbidity between RD and ADHD: the case for multiple-deficit models. Cortex. 2010; 46:1345-1361. doi: 10.1016/j.cortex.2010.06.009

[5]. Varvara P., Varuzza C., Sorrentino A. C., Vicari S., Menghini D. Executive functions in developmental dyslexia. Frontiers in human neuroscience. 2014; 8:120. https://doi.org/10.3389/fnhum.2014.00120

[6]. Moura O., Pereira M., Alfaiate C., Fernandes E., Fernandes B., Nogueira S., Moreno J., Simões M.R. Neurocognitive functioning in children with developmental dyslexia and attention-deficit/hyperactivity disorder: Multiple deficits and diagnostic accuracy, Journal of Clinical and Experimental Neuropsychology. 2016; DOI: 10.1080/13803395.2016.1225007

[7]. Stins J.F., Tollenaar M.S., Slaats-Willemse D.I.E., Buitelaar J.K., Swaab-Barneveld H., Verhulst F.C., Polderman T.C., Boomsma D.I. Sustained Attention and Executive Functioning Performance in Attention-Deficit/Hyperactivity Disorder, Child Neuropsychology: A Journal on Normal and Abnormal Development in Childhood and Adolescence, 2005; 11(3):285-294

[8]. Mueller S.T. The Psychology Experiment Building Language, Version 0.13. 2012; Retrieved from http://pebl.sourceforge.net