Dyslexia: Related Behaviors and Neuronal Abnormalities

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BACKGROUND

- Dyslexia is characterized as a deficit in reading and writing skills, despite having normal intelligence, but there is more to dyslexia then difficulty in writing and reading ability. Children with reading disabilities (RD) have been found to display behavioral disorders as well.
- Finnish children with dyslexia showed more problems with adaptability, social skills and attention compared to controls.[1] A strong association was also found between dyslexia and inattention.[1]
- On average, children with reading disabilities meet criteria for ADHD, oppositional disorder, conduct disorder, overanxious disorder, and depression more often than controls.[2]
  - Suggests that reading disabled children struggle with numerous problems, in addition to their reading deficit.[2]
- Children with ADHD display smaller volumes in the prefrontal area.[5] Attention problems are specifically linked to the lateral prefrontal cortex (LPC), dorsal anterior cingulate cortex (dACC), and the striatum, all of which share strong connections with one other.[5]
- The ventral anterior cingulate cortex (vACC) is thought to be involved in the regulation of emotional responses.[4] This area shares connections with the amygdala, nucleus accumbens, hypothalamus, and hippocampus, which are known to be involved in emotional and social behaviors.[4]
- The medial prefrontal cortex (MPC) is theorized to be involved in emotion processing.[3] Associations have been observed between the MPC and "theory of mind" tasks, the ability to understand the mental states of oneself and others.[3]

OBJECTIVES

- Dyslexia is still poorly understood neurologically. The purpose of this research is to better understand the nature of the issues that manifest in dyslexia.

HYPOTHESES

- Dyslexic children will display more issues with attention than non-dyslexic controls.
- Dyslexic children will show differences in neurological structures involved in attention compared to non-dyslexic controls.
- Dyslexic children will demonstrate more problems with adaptability and social skills than non-dyslexic controls.
- Dyslexic children will show differences in neurological structures involved in social behavior compared to non-dyslexic controls.

DATA

PARTICIPANTS

- $N = 60$
- 39 Controls, 21 Dyslexic
- 31 Males, 29 Females
- Ages ranged from 7-12 ($M = 10.32$)

METHODS

MATERIALS AND PROCEDURE

Behavioral Surveys:
Behavior Rating Inventory of Executive Function (BRIEF), the Child Behavior Checklist for ages 6-18 (CBCL), and the Vineland Adaptive Behavior Scales, Second Edition (Vineland-II).

Behavior Variables:
Inhibition, Shifting, Initiation, Working Memory, Attention Problems, Attention Deficit, Emotional Control, Social Problems and Socialization.

- Participants with ADHD were not included in this study

Structural Comparisons:
Control & Dyslexic: Lateral Prefrontal Cortex (LPC), Dorsal Anterior Cingulate Cortex (dACC), and the Parietal Lobe.

Measurements:
Structure Surface Area, Gray Matter Volume, and Average Cortical Thickness.

- Controlled for Intra-Cranial Volume
- Compared Left & Right Hemispheres
- Gathered data using 3T Siemens Prisma Magnetic Resonance Imaging (MRI) machine.

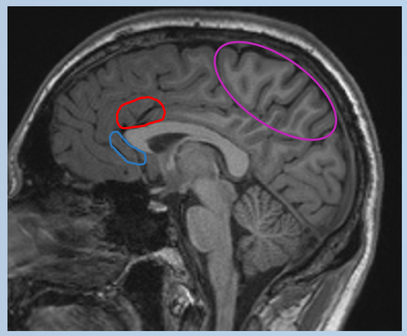

Figure 1. Red: dACC // Blue: vACC // Purple: Parietal Lobe

Figure 2. Green: Prefrontal Cortex

RESULTS

AGED MATCHED

- Dyslexic children scored significantly higher on shifting ($M = 54.25$), compared to controls ($M = 47.58$), $U(11) = 36$, $p < 0.05$.
- Dyslexic children performed significantly lower on scores of working memory ($M = 63$), compared to controls ($M = 48.25$), $U(11) = 18.5$, $p < 0.05$.
- Dyslexic children scored higher on measurements of attention problems ($M = 60.5$), compared to controls ($M = 54.08$), $U(11) = 34.5$, $p < 0.05$.

READING MATCHED

- Dyslexic children had significantly higher scores on problems with initiation ($M = 56$), compared to controls ($M = 45.6$), $U(9) = 16$, $p < 0.05$.
- Dyslexic children displayed significantly more issues with working memory ($M = 64.7$), compared to controls ($M = 47.5$), $U(9) = 9$, $p < 0.05$.
- Dyslexic children scored higher on measurements of attention problems ($M = 62.1$), compared to controls ($M = 57$), $U(8) = 19.5$, $p < 0.05$.

CONCLUSIONS

- These findings support our first hypothesis that dyslexic children will display more issues with attention than non-dyslexic controls; However, these differences were selective.
- Dyslexic children showed more problems with working memory and attention, regardless of controlling for age and reading level.
  - It is likely that these variables are related to dyslexia, and that children with dyslexia have a high co-morbidity for problems in attention and working memory.
- Differences in shifting scores were present when controlling for age, but not when controlling for reading level.
  - Shifting ability may be more related to reading ability rather than dyslexia, such that children with a lower reading ability may also display problems in shifting.
- Differences in initiation scores were found when controlling reading level, but not when controlling for age.
  - Age may be related to initiation ability, such that as children age, their ability to initiate improves.
- Because no differences were found during the neuronal analysis, it is possible that problems from dyslexia are not related to the LPC, dACC, or parietal lobe. Another explanation is that structural surface, gray matter volume, and average cortical thickness are unrelated to the problems that manifest in dyslexia.
  - It is more likely that the problems in dyslexia come from the pathways that form during development.
  - Future studies may consider exploring abnormalities in the connections between the LPC, dACC, and parietal lobe, rather than structural anomalies.

LIMITATIONS

- While running analyses on the behavioral data there was a considerable loss of participants. When controlling for age and reading level the sample size dropped from N = 60 to $n_1 = 12$ & $n_2 = 10$ respectively. Additionally, a few participants did not respond on important survey items, and hence had to be removed from the analysis.

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