READING EXPOSURE AND ITS EFFECT ON COGNITIVE ABILITY IN CHILDREN WITH DOWN SYNDROME

By

Brittany Leigh Wertenberger

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Approved by:

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Dr. Lynn Nadel
Department of Psychology

STATEMENT BY AUTHOR

SIGNED: ______________________________

Abstract

Previous research has established a positive and dynamic relationship between reading and cognitive abilities across development. Limited research, however, has been conducted on the effects of reading exposure on specific cognitive function in Down syndrome. Using a 12-item questionnaire, a reading exposure index was established for 19 Down syndrome and 18 control participants. This was compared to performance on a cognitive assessment battery using measures of hippocampal and prefrontal function, as well as general knowledge and IQ. The Down syndrome group was divided into high and low reading groups using a median split. Although there was no significant difference in specific cognitive abilities between the high and low reading Down syndrome groups, it was found that children with Down syndrome are being read to less often, given fewer opportunities to acquire literacy skills and ask to be read to less often than controls. It was also shown that mother's age negatively relates to reading exposure for children with Down syndrome. Since limitations of this study include a small sample size and a limited questionnaire, implications for further research includes a more age-adaptive questionnaire. Since reading enrichment is limited within the Down syndrome group, these findings show a need for an increase in literacy encouragement in the Down syndrome population.

Literacy and exposure to reading are important factors for typically developing children. It has been shown that across the ages of 1-12 years, there is a very positive and dynamic relationship between reading and cognitive ability (Ferrer et al., 2007). This has also proven to be true among those with disabilities, although to a lesser extent. Young people with Down syndrome often have diminished reading ability compared to typically developing children, and a lower IQ as well. However, it has been shown that a lower IQ does not necessarily correspond to a lower literacy rate. In fact, it has been shown that disabled children with low IQ scores can be quite good at reading (Siegel, 1989). Reading requires a different set of skills from those tapped on measures of IQ. Therefore, the strengths of individuals with Down syndrome, such as visual learning, may help them to learn to read at any level of IQ.

A variety of factors have been proven to affect literacy and reading ability in individuals with Down syndrome. For one, it has been shown that mainstream schooling, as opposed to specialized school, increases reading ability (Turner et al., 2008). This demonstrates that exposure to higher-level reading in general may lead to a higher literacy rate among those with Down syndrome.

There have been many studies exploring this different way of learning to read, specifically, reading when phonological awareness is impaired. Phonological awareness is defined as being able to distinguish and separate different sounds, or phonemes, of language (Cossu et al., 1993). This alternative way of reading, called sight-reading, is considered the most effective way of reading for those with developmental disabilities such as Down syndrome (Greene, 1987). These studies also suggest that because of this alternative way of reading, visual memory is especially important for literacy in those with Down syndrome.

Although there is much variation of skill in the reading abilities of those with Down syndrome, many individuals show considerable ability in certain aspects of reading, such as word identification, but greater deficits in areas such as reading comprehension (Fidler and Nadel, 2007). This division of skills often becomes more pronounced as the child matures (Kay-Raining Bird et al., 2000). Because of this, there is support for the asking of higher-level questions while reading with individuals with Down syndrome, as this will increase their reading comprehension ability.

Children with Down syndrome who have higher scores in reading show vast, above-average improvement in scores and abilities through adulthood (Shepperdson, 1994). This demonstrates the importance of reading exposure, as it paves the way for increased all-around abilities in the future. Specifically, an increased literacy in Down syndrome has been shown to improve a variety of functions. For example, an increase in reading was correlated with increased language development and communication skills (Buckley & Bird, 1993). It is unclear, however, whether literacy leads to improved language skill, language skill leads to literacy or if there is a third cognitive process that is responsible for both (Boudreau, 2002).

In a study done by Trenholm and Mirenda (2006), an exploratory survey was conducted to try to gain a better understanding of home and community literacy practices for children with Down syndrome. They found that although many homes contain ample reading material for children, few parents engage the children by asking higher-level thinking questions. This research suggests that although the opportunity to achieve literacy skills is available to many children, the breadth of materials actually used at home is quite small. Accordingly, exposure as well as use of reading materials is required to attain adequate reading levels.

The question that was specifically addressed in this research was what areas of the brain and cognitive tasks, if any, does exposure to reading improve. Since it has been shown that overall IQ does not appear to be improved with increased literacy (Cossu et al., 1993), looking at abilities more narrowly may show an effect. This study aimed to look at how reading exposure may be linked to differences in types of learning closely related to brain functions (i.e. neuropsychological tasks tapping hippocampal and prefrontal function).

Since reading develops attention (Ferrer et al., 2007), it may be that an increased exposure and ability to read will improve performance on prefrontal tasks. Learning to read also has several other cognitive impacts on typically developing children. Reading corresponds to auditory and visual memory skills, and has a significant impact on language abilities and development (Laws et al., 1995). However, reading may influence cognition in a more general way, resulting in increases in performance across multiple domains. Therefore, this study has competing predictions. First, if reading is particularly important for planning or problem solving, we would expect that reading exposure scores would only relate to prefrontal measures, and not IQ or other neuropsychological measures. The opposing prediction is that abilities as a whole increase directly with reading exposure, so an increase in exposure would correspond to an increase of general IQ.

Therefore, against this general background, the aims of our study were:

1). To compare the level of reading exposure in a sample with Down syndrome (n =19) and a sample of typically developing control children (n = 18).

2). Within the group with Down syndrome, we will relate the level of reading exposure to cognitive outcomes to determine if reading influences cognition generally or if effects are specific to prefrontal function.

3). To control for any background factors that may differ in the low and high Down syndrome reading groups.

Measures

Participants

The participants were 19 children with Down syndrome and 18 typically developing controls. A Down syndrome participant is one who is clinically diagnosed with trisomy 21, and a typically aging child is one that had no signs of developmental disabilities. Each participant received a $20 gift card to Target upon completion of the laboratory portion of the study. Participants were recruited from both Tucson and Phoenix, Arizona and surrounding cities.

Procedures

When the child came into the lab, the parent or guardian was asked to fill out surveys on background information, medical history, child gender, ethnicity and trisomy status. In addition to the battery of tests done in the lab, environmental factors that may contribute to development were assessed via an in-home assessment using the HOME inventory. The reading questionnaire was administered as a part of the home interview assessment. While the parent or guardian was filling out this paperwork, the participants were tested on the neuropsychology battery.

Stimuli and Materials

The materials used in this study are an established battery that assesses neuropsychological developmental differences and a survey assessment. This battery measures general ability and IQ as well as hippocampal and prefrontal measures via the following neuropsychological and developmental tasks.

General Ability

The Kaufman Brief Intelligence Test – Second Edition (KBIT-II) measures both verbal and nonverbal intelligence, including tests of language such as verbal knowledge and riddles. It is also a test of nonverbal reasoning, including matching pictures based on themes and completing patterns. It is appropriate for use for individuals aged 4-90 years old (Kaufmann & Kaufmann, 2004). It has been proven valid as it correlates to similar IQ tests, such as the WISC-III.

The Scales of Independent Behavior-Revised (SIB-R) is a checklist-style rating scale that is completed by the caregiver of an adolescent. It assesses adaptive functioning and everyday skills. This allows identification of cognitive or everyday deficits, and it also assesses issues of development not measured in IQ, such as motor, social, personal living and communication skills. It creates a summary score composed of the sum of raw scores of adaptive function (Bruininks et al., 1997).

Prefrontal Function

The CANTAB Intra-Extra Dimensional Set Shift (ID/ED) requires shifting and flexibility of attention. The participant is shown two simple, colored shapes and sorts them according to either color or shape. The rule is then shifted partway through the task. The participant is assessed on the number of errors made as well as normative data. This test is very sensitive to changes in fronto-striatal areas of the brain, and has been found to be impaired in Down syndrome as well as other ID populations in previous studies. In addition, previous studies have shown reliability of the ID/ED to be r=.70 for the total errors prior to the ED shift and r=.75 for stages completed (Lowe & Rabbit, 1998).

The Frogs and Cats Test of Working Memory and Inhibition is a test of inhibitory control and working memory. It has been correlated with prefrontal function in children in fMRI studies (Davidson et al., 2006). This task is appropriate for participants aged 4 years old to adult. In this task, there are three different phases. In the first phase, the participant learns the congruent location rule, or the rule associated with the cat stimuli. They are instructed to press the button that is located on the same side, or right underneath, the cat. In the second phase, the participant learns the incongruent rule, or the rules associated with the frog stimuli. They are instructed to press the button that is located on the opposite side of the frog. Finally, on the third phase, the two rules are alternated and combined. Memory of the response rules is required on all trials, and behavioral inhibition is required on incongruent trials. Data of interest are the accuracy and reaction time for each stage, particularly in the third and final phase of the test.

The Dimensional Change Card Sorting task (DCCS) (Zelazo, Frye, & Rapus, 1996) is a commonly used measure of executive abilities in young children. It is based on the Wisconsin card sort test (WCST), which is sensitive to prefrontal damage and activates it in normal subject fMRIs. In this task, the participant is shown two target cards that are either red or blue and either a flower or a car. They are then asked to sort a series of test cards according to one dimension, such as color, and then told to switch and sort by the other dimension, shape. The switch in rules demonstrates executive ability that emerges in most children at around 4 years of age. The task involves three trials, first with sorting from color to shape, then from shape to color and finally between background texture and ambiguous shape.

Hippocampal Function

The Computer-generated Morris Water Maze (cg-arena) assesses hippocampal function and has been found to be impaired in those with damage to the hippocampus (Thomas et al., 2001). The participant must learn to find a target hidden on the floor of a computer-generated maze over several trials. The maze is shown in a first-person perspective and navigated using a joystick. There are landmarks, or distal cues, on the walls of the maze that allow for learning of the fixed target position. The variables assessed are the slopes of the learning curve of trials as well as the percentage of time spent searching in the specific quadrant that contains the target. In addition, this task has been successfully used in individuals with DS and other developmental disabilities (Pennington et al., 2003; Edgin & Pennington, 2005).

The CANTAB Paired Associates Learning (PAL) task requires the participant to learn visual patterns and locations on a computer monitor. It increases from having to remember 1 to 8 patterns. It is measured by the total number of errors on all of the levels of difficulty. It has very high retest reliability, and has a 98% accuracy of diagnosing dementia (Miller et al., 1993).

Reading Exposure

To obtain an accurate measure of reading exposure and ability, a questionnaire of reading exposure was also developed (See Appendix A). This questionnaire asks questions to get a general idea of how much the child reads or is read to (“About how many hours per week do you read to your child?" "About how many different books or stories do you read together per session" and "About how many hours per week does your child read on his or her own?"). Other questions assess how encouraged reading is in the family ("About how old was your child when you started to read to him or her?" and "About how many books does your child own?"). In addition, there are six questions assessed on a 5 point likert scale asking how engaged the child is during reading, whether they are regularly taken to the library, whether they ask to be read to, whether the family owns a dictionary and encourages their child to use it, and whether the child is provided structured literacy activities, such as a reading program. These are ranked as never, not very often, some of the time, most of the time or all of the time. It also asks whether a parent in the household buys and reads the newspaper, which was later shown irrelevant and removed. Most likely, this is because regardless of the family's opinion on the importance of reading, many families choose to read the news via alternative sources, such as the Internet, instead of receiving a daily newspaper. The scores from all 12 questions were transformed onto a continuous scale ranging from 0 to 1 and summed to create a composite reading index. This scale obtained a .79 Cronbach's alpha of internal consistency after removing the question "A parent in the household buys and reads the newspaper daily."

Statistical Analyses

1.) To determine differences between Down syndrome and controls, t-tests were performed to examine differences in participant characteristics between the two groups.

2.) To examine the relationship between reading exposure index and cognitive outcomes, we grouped the Down syndrome participants into high and low reading groups based on a median split. A t-test was performed to determine differences in performance on various parts of the battery.

3.) To control for background factors, we examined group differences in an ANCOVA with reading group as one factor and age or mother's age as a covariant.

Results

Down Syndrome Versus Control

First, the Down syndrome group and the control group were compared on background factors. They differed significantly on age, IQ and reading exposure index obtained, $p<.001$ (See Table 1).

On the reading questionnaire, significant differences existed between the Down syndrome and control group on hours read to, age started reading, mean stories read per session and mean books owned ($p<.05$) (See Table 2).

Language Measures

We compared means of the raw score obtained on the KBIT vocabulary and riddles tests. An independent samples t-test was performed to compare language ability in high and low reading conditions. For the verbal knowledge raw score, there was not a significant difference between low reading ($M=15.90$ and $SD=6.57$) and high reading ($M=12.50$ and $SD=6.11$) conditions; $t(16)=1.12$, $p>.05$. For the riddles raw score, there was also not a significant difference between low reading ($M=11.70$ and $SD=4.90$) and high reading ($M=9.38$ and $SD=3.78$) conditions; $t(16)=1.10$, $p>.05$. These results suggest no difference between the means of the two groups on language performance (See Table 3).

Hippocampal Measures

To measure differences in hippocampal abilities, we compared performance on the Virtual Morris Water Maze total targets obtained and the CANTAB paired associates learning mean errors obtained. An independent samples t-test was performed to compare hippocampal performance between high and low reading conditions. For the Water Maze total targets obtained, there was not a significant difference between low reading (M=5.44 and SD=.73) and high reading (M=4.75 and SD=1.16); t (15) = 1.49, p =.16. For the CANTAB PAL mean errors obtained, there was also not a significant difference between low (M=5.49 and SD=2.86) and high (M=7.51 and SD=4.55) reading conditions; t (17) = -1.17, p>.05. These results suggest no difference between the means of high and low reading groups on hippocampal measures (See Table 3).

Prefrontal Tasks

Prefrontal abilities were assessed by comparing performances on the CANTAB ID/ED set-shifting task, the proportion correct on the Frogs and Cats as well as the percent of times accurately shifting to new rules on the dimensional change card sorting task. An independent samples t-test was performed to compare prefrontal performance between the high and low reading conditions. For errors on the CANTAB ID/ED task, there was not a significant difference between low reading (M=12.60 and SD=8.18) and high reading (M=16.33 and SD=6.93) conditions; t (16) = -.98, p>.34. For the proportion correct on the Frogs and Cats, there was also not a significant difference between low reading (M=.52 and SD=.14) and high reading (M=.58 and SD=.25) conditions; t (16)

=-.633, $p>.05$. Finally, performance on percentage of times accurately shifted to new rules on the dimensional change card sorting task was also not significant between low reading (M=62.5%) and high reading (M=40%) conditions, $p>.05$. These results suggest no difference between high and low Down syndrome reading groups on prefrontal tasks (See Table 3).

Background Measures

Within children with Down syndrome, there was not a significant difference in age between low (M=19.5 and SD=6.55) and high (M=14.3 and SD=8.54) reading groups, percent male between low (M=40) and high (M=55.6) reading groups, or IQ between low (M=45.44 and SD=9.28) and high (M=42.2 and SD=3.49) reading groups; $p>.05$. In terms of family background factors, there was not a significant difference in percent income less than $25,000 between low (M=0) and high (M=33.3) reading groups or education between low (M=15.57 and SD=3.10) and high (M=15.02 and SD=2.74) reading groups. There was, however, a significant difference in Mother's age between low (M=58.29 and SD=6.18) and high (44.0 and SD=11.45) reading groups, $p<.05$. This significance remained even after controlling for age of child and mothers (See Table 4).

Since the questionnaire assesses both reading enrichment and reading exposure, composites of enrichment items and reading exposure items were separately examined in relation to cognitive function. There was still no effect found.

Discussion

The goal of this study was to determine differences in reading exposure between children with Down syndrome and typically developing control children. Secondly, we were interested to see how reading exposure influences cognition in this population. It was found that on average, children with Down syndrome are given less exposure to reading and literacy than control groups. After the Down syndrome group was split into high and low reading groups, background as well as performance on the cognitive battery was compared. There was a significant difference in mother's mean age. An ANCOVA was performed controlling for background factors, and this significance still remained.

No significant difference was found, however, on performance on the neuropsychological battery between the high and low Down syndrome reading groups. This was also the case after splitting the questionnaire into separate enrichment and encouragement scales.

These findings suggest a number of things. It is known through the literature that reading in Down syndrome is important for development. Children with Down syndrome need to be given more opportunities to gain literacy and reading ability. In addition, these findings suggest that children with Down syndrome with older mothers are getting fewer reading enrichment and encouragement opportunities. This finding may be confounded with birth order. Many mothers may rely on older siblings for reading enrichment of third or fourth born children. Since birth order was never measured in this study, this could be investigated in future research.

There are a number of limitations for this study. For one, a small sample size may not be adequate enough to show an effect of reading whether or not it is there. A larger number of participants would improve this study. In addition, one of the dependent measures was a self-report study filled out by parents. Parents may have overestimated the amount of reading their child is exposed to without realizing it or meaning to. Also, since it was a mail-in survey, the group of parents who mailed back the survey may have differed inherently from the group that did not. Finally, the questionnaire used may have been more suitable for young children. Since the mean age of the Down syndrome group was around 18 years old, it may not have been age-adapted and caused artificially low reading exposure indexes.

In future studies, using a more age-adaptive questionnaire may yield significant results. In addition, measuring reading ability and comprehension instead of just exposure and encouragement may show neuropsychological differences on performance on the battery.

According to the literature, reading greatly affects skills and abilities in children with Down syndrome all the way up through adulthood. Even though this study did not find differences in cognitive outcome based on reading exposure, reading should still be encouraged for all ages. Since reading enrichment is shown to be limited within the Down syndrome group, these findings show a need for an increase in literacy encouragement and enrichment in the Down syndrome population.

Tables and Figures

Table 1
Participant Characteristics DS v Control

	Down syndrome N=19	Control N=18	*p*
~~Child Background Factors~~			
M(SD) Age	18.98(8.63)	5.03(.60)	<.001*
% Male	47.4	72.2	.12
M(SD) IQ	44.28(7.70)	113.8(11.07)	<.001*
M(SD) Reading Exposure Index	4.57(2.71)	8.69(2.21)	<.001*

*$p<.05$

Table 2
Reading Exposure Differences DS v Control

	Down syndrome N=19	Control N=18
Reading Questionnaire		
M(SD) Hours Read To	1.3(1.17)	3.97(2.52)
M(SD) Hours Read on Own	2.5(2.36)	2.92(2.29)
M(SD) Age Started Reading	1.0(1.66)	.35(.35)
M(SD) Stories Read per Session	1.7(.92)	3.14(1.96)
M(SD) Books Own	77.9(65.14)	105(46.05)
Engage child when read	2.93	3.06
Child encouraged to read	3.00	3.11
Own/encourage use of dictionary	2.00	2.11
Library Once a Month	1.80	3.00
Provided Structured Literacy Activities	2.79	3.50
Child asks to be read to	2.36	3.33

Table 3
Cognitive Test Results High vs. Low Reading in DS

	DS Low Reading N=10	DS High Reading N = 9	*p*
Language tasks			
***M(SD)* KBIT Verbal Raw Score**	15.9	12.5	.28
***M(SD)* KBIT Riddles Raw Score**	11.7	9.4	.29
Hippocampal tasks			
***M(SD)* Virtual Morris Water Maze Total Targets**	5.44 (.73)	4.75(1.16)	.16
***M(SD)* CANTAB Paired Associates Learning Mean Errors**	5.49(2.86)	7.51(4.55)	.20
Prefrontal tasks			
***M(SD)* CANTAB Intra-dimensional/Extra-dimensional set-shifting**	12.60(8.18)	16.33(6.93)	.30
***M(SD)* Proportion correct Frogs/Cats**	52(.14)	.58(.25)	.54
Dimensional Change Card Sorting task % shifted to new rules	62.5	40	.43

Table 4
Participant Characteristics High vs. Low Reading in DS

	DS Low Reading N=10	DS High Reading N = 9	*p*
Child Background Factors			
***M(SD)* Age**	19.5(6.55)	14.3(8.54)	.16
% Male	40.0	55.6	.50
***M(SD)* IQ**	45.44(9.28)	42.2(3.49)	.47
Family Background Factors			
% Income <25,000	0.0	33.3	.12
***M(SD)* Education**	15.57(3.10)	15.0(2.74)	.75
***M(SD)* Mother's age**	58.29(6.18)	44.0(11.45)	.02*

*p<.05

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Appendix A

Reading Exposure Questionnaire

About how many hours per week do you read to your child? _______

About how many hours per week does your child read on his or her own?_______

About how old was your child when you started to read to him or her? _______

About how many different books or stories do you read together per session? _____

About how many books does your child own? _________

Please check the most appropriate box for each question.	**Neve r**	**Not Very Often**	**Some of The Time**	**Most of The Time**	**All of The Time**
6. When I read to my child, I engage them by asking questions.					
7. My child is encouraged to read on his or her own.					
9. My family owns a dictionary and encourages my child to use it.					
10.. My child has access to a library card, and is taken there once a month.					
11. My child is provided structured activity to acquire literacy skills at least 4 times a week. (Such as a reading program or class)					
12. My child asks to be read to.					
13. What reading programs, if any, have you enrolled your child in? (Please list.)					