Read-Aid - An Assistive Reading Tool for Children with Dyslexia

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Abstract. We developed a software application, *Read-Aid* to help improve reading pattern in children with Dyslexia with visual processing problems. We hypothesized that after a dyslexic child's interaction with our application, there will be an improvement in their reading speed and comprehension. We compared our results with existing masked-reading intervention approach. A between-group study was conducted with 15 children. Results were significant ($p = 0.026$) suggesting that our Read-Aid tool has potential as an assistive technology application.

Keywords: Non-linear reading, Assistive technology, Learning disabilities.

1 Introduction

Developmental dyslexia is a specific and significant impairment in reading abilities of children and adults who otherwise possess adequate intelligence and motivation. The prevalence rate is estimated to be around 5% to 10% in school-age children. Dyslexia can be comorbid with language difficulties, writing and mathematics disorders.

There have been multiple theories [1, 2] attributing dyslexia to difficulties in visual perception, auditory perception and phonological processing. Many studies on visual processing in dyslexic readers [3–6] have established that the eye-movement pattern of dyslexic readers is different from that of typical readers. The general finding is that while the eye-movement pattern of typical readers follows a linear pattern, the pattern is arbitrary in case of dyslexic readers.

In particular, Geiger *et al.* [7] proposed that dyslexic readers tend to have a wider spatial attention. In their experiment that required dyslexic and typical readers to recognize centrally and peripherally presented stimuli, they found that dyslexics recognized letters visually farther in the periphery better than typical readers. They posit that this wider spatial attention results in difficulties in picking one word from others. For intervention, they used a specially designed mask to be laid on the text being read, and found that training with the mask improved reading performance.

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2 Read-Aid Tool

Inspired by the masked-text technique, we developed the Read-Aid Tool, which was built with a QT GUI front-end and a C++ backend. The GUI consists of two simple tabs: A start tab for setting the view, and a read tab to read the target text. (Fig. 1) shows the start tab of the tool. The read tab shown in (Fig. 2) is essentially blank except for a centered word or two of the text. The number of words, their font style and size are all set in the start tab. Read-Aid Tool replicates the masked-text technique by having only one word in the center, and then gradually increasing it to have more than one word during the course of intervention.

The input file of the text to be displayed is entered in the file name widget of the start tab, which is also used to set non-default font settings, and non-default number of words to display. If the default settings are acceptable, then the user needs to just enter the input or the source file to be browsed. The interaction between the Read-Aid Tool and the user is thus simplified, and the focus is shifted from tool interaction to the target text comprehension.

The effectiveness of the masked-text technique stems from having only one word in the center, and then gradually increasing it to have more than one word, and the Read-Aid Tool replicates it in the digital form.

Fig. 1. Read Aid - Teacher Interface

To evaluate the effectiveness of the ReadAid Tool, three null-hypotheses were identified.

1. (H1) A manual masked-text intervention for dyslexics with reading difficulty does not improve their reading skills
2. (H2) A software implementation of a similar masked-text technique also does not provide an improvement for reading skills for dyslexics
3. (H3) The quantum of improvement in reading skill for software technique is worse than the manual approach

Fig. 2. Read Aid - Student Interface

3 Evaluation

To test the *Read-Aid* tool, a between-groups experiment was setup. The participants were divided into three groups as below:

- Group 1 - No intervention control group
- Group 2 - Manual masked-technique group and
- Group 3 - Read-Aid Tool group

We identified three parameters to operationally measure the reading skill as follows:

Reading Speed is measured as the number of error-free words divided by reading time, where error-free words are the number of read words minus errors made in reading them; reading duration is measured as overall time taken for reading, which is the time lapse between the first-word utterance attempt and the completion of the last-word utterance.

Reading Errors Number of erroneous word-utterances during reading (not mispronunciations but incorrect word choices)

Reading Comprehension aggregate score in word recollection and word remembrance tests.

Pre- and post-tests were conducted to capture the quantum of reading skill improvement (dependent variable) observed due to the type of intervention (independent variable) applied.

4 Participants

Fifteen children (eight boys and seven girls) participated in the experiment, with their ages ranging from 8.5 to 11.5 years. Twelve of these children were diagnosed to be dyslexics in prior testing by an expert using DTLD [8] and Schonnell spelling test [9] . Three children who were not Dyslexics were used

for comparison and evaluation purpose. Their scores were not part of the result analysis, but instead used for guiding the design of the experiment. For the dyslexics, average chronological age was 9.67 years (var=0.76), average reading age was 7.1 years (var=1.3), and average spelling age was 6.8 years (var=1.2). All participants were secondary school students with an expected fourth-grade level fluency in English. There were three children in Group 1 (control with no intervention), three in Group 2 (manual intervention), and the remaining nine children were in Group 3 (software intervention).

Table 1. DTLD and Schonell Spelling Test Scores

Age(Mean)	Manualmasking	Read Aid
ChornonlogicalAge	9.44	10.6
Spelling Age	7	8
Reading Age	6	8

5 Stimuli

For measuring reading skills, a full page of text at the fourth-grade level was chosen. The text was reviewed and found appropriate by a fourth-grade teacher. Stimuli consisted of three stories [10]. The first story was used to conduct the pre-test. The second story was used for practice (in the manual intervention Group 2 and in software intervention Group 3). The control Group 1 received no intervention. The third story was used for the post-test.

6 Procedure

All three groups followed the same procedure. First, a reading task (the first story) was given, during which the student's voice was recorded on a Zoom H1 MP3 audio recording device for measuring the reading speed, reading errors and comprehension errors. Next, a test was given to evaluate the child's reading level. Then the children in each group were treated with their respective interventions. The intervention sessions lasted for three days with two hours a day. The second story was used for this. Finally, a reading task (the third story) was given, during which the student's voice was recorded for measuring the reading speed, reading error and reading comprehension.

The instructions for both pre- and post-tests were given to the participants verbally. Pre- and post-tests were similar, and they consisted of an equal number of recall retention questions based on the stimuli stories. The questions were presented in the multiple-choice format. Both questions and answers were read to the child, and the child's answers were recorded for subsequent analysis.

7 Retention and Recall Tests

For all three groups, there were only three interactions with the child. In the first interaction, the pre-test was conducted, in the second, the intervention treatment was conducted, and in the third, the post-test was conducted. Prior to doing the pre- and post-tests, a reading task was given by asking the child to read aloud a given piece of text. The audio of the read text was recorded for subsequent analysis. After the reading task, as part of the pre- or the post-test, the children were asked to answer a series of questions, which measured either the content recall or information retention. The recall and retention tests were verbally read to all the children after completion of their reading task. These two tests consisted of instructions, followed by multiple-choice questions. For the retention test, the instructions read to all the children were: *You will now hear four words. These words might be similar in sound, but only one was used in the paragraph that you have just read. Can you tell me which of these four words was read by you just now?*. After this instruction, the researcher starts with the first question, followed by the next question, and so on, until all the five questions are exhausted.

For the recall test, simple factual questions about the story were asked. The children were instructed as follows: Listen to the question carefully and identify the correct answer from a given set of four possible answers. Note that the answers might be similar but only one is correct. So pick what you believe to be the correct answer. Questions were phrased in the form of *Who entered Billy's room?* or *How did father feel when he saw the puppy.* Multiple-choice answers were given.

All the phrases and words were derived from the just-read text. The apropriateness of these tests was confirmed in two ways: First, a fourth-grade teacher was asked to review the tests and her suggestions were incorporated; and second, a non-dyslexic fourth-grade student was asked to take the test for comparison.

8 Results

Overall, eleven of the fifteen participants produced over 110 minutes of MP3 audio and 160 answers to the pre- and post-test questions. The MP3 audio was analyzed using BS.Player v2.62, and also with Audacity v2.02 equipped with a LAME MP3 encoder, to measure time, quantity of words read, and the errors made in reading. A judge (school teacher, who is not involved in the execution of the experiment) counted the words and errors in reading. Mispronounced words were not counted as errors. Only incorrect words and un-articulated words were counted as errors. In some cases because of the non-linearity in reading, the skipped words were harder to count.

Reading speed was calculated by extracting the number of words read, the number of errors made in reading them, and the time taken to read them. It was calculated as $ReadingSpeed = (wordsread - errorsmade)/time$ For this experiment, the reading speed for Groups 2 and 3, respectively, was 13.1% and

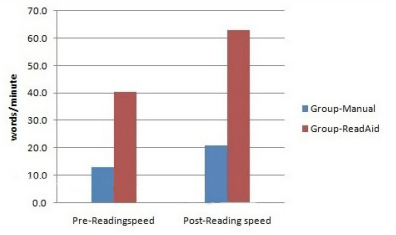

Fig. 3. Reading-Speed

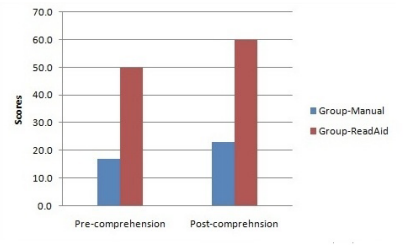

Fig. 4. Reading-Comprehension

40.3% in pre-tests, and 20.9% and 62.9% in post-tests (Fig. 3). It is important to mention that one set of dyslexics (Group 1) could not even read one word in the allocated five minutes. So, their speed was counted as 0 for our pre-test calculations. Reading errors were calculated by dividing the number of errors made by the overall number of words read. *ReadingError* is represented in percentage. $ReadingError = (number - of - words - read - erroneously/all - words - read)$

The reading error for Groups 2 and 3, respectively, was 40% and 16% in pre-tests, and 36% and 7% in post-tests (Fig. 4). Because the children in Group 1 struggled to read, and could not even read a small portion in the allocated five minutes, so their error was set at 100 for the pre-test.

Improvement in the comprehension scores was calculated by summing up the correct answers given to the recall and retention questions posed in the pre- and post-tests.

$ComprehensionScores = (Recall + RetentionScores)$

The values of reading comprehension for Group 2 and 3, respectively, were 5.5 points and 4 points for pre-tests, and 7 and 4.4 points for post-tests (Figure 4). For Group 1 that struggled with the reading task itself, the recall and retention tests were overwhelming and unanswerable. Their scores were set to 0.

9 Discussion

Based on the results of the experiment, we found that with intervention there is a definite improvement in the reading speed, and reading comprehension scores,

and the reading errors go down. With manual intervention the reading speed was observed to improve by approximately 41%. With Read-Aid Tool intervention, there is a further 3% increase. So, dyslexic children do benefit with either the manual masked-text approach, or with the ReadAid Tool approach. Amongst the two techniques, ReadAid is showing more improvement at 62.9%, a post-test value, which is a 44% improvement over the score of 40.3%. When it comes to reading errors, there is a 57% drop for the participants who used ReadAid Tool. That is, the Group 3 score dropped from a value of 16 to a new post-test value of 7. This is better than Group 2 (manual intervention) changes. For Group 2, the values also dropped, but not as much as the Group 3. Here the reduction for Group 2 was from 40% to 36%, which is a change of 9% Reading comprehension scores also showed a similar trend. The manual intervention and ReadAid Tool interventions showed a jump of 2.7 points and 2.2 points respectively. The Group 2 of 5.5 points improved to 7.7 points, and the Group 3 went from 4.0 points to 4.4 percent. However the overall result appears to be statistically significant ($F = (46.52, 37.17) = 5.632$ and $p = 0.026$).

10 Conclusion

Taking the overall pattern of measurements into consideration, we can clearly see that manual masked-text intervention yields an improvement over the control group (Table 1). Results also indicate that Read-Aid Tool intervention yields an improvement over the control group. With this we reject the null hypothesis H2, which states that a software implementation of a similar masked-text technique also does not provide an improvement for reading skills for Dyslexics. And finally, based on the collected data we see that Read-Aid Tool does show better results over the manual approach. With this we reject the final H3 hypothesis, which states that the quantum of improvement in reading skill for software technique is worse than the manual approach.

11 Future Work

This pilot study was designed primarily to explore the potential and promise of the Read-Aid Tool. As the results are promising, we feel that next steps would be to (1) repeat the experiment with more subjects, (2) do the treatment for a longer duration, and (3) do eye-tracker studies to establish the improvement in reading pattern. The current version of the tool is intended as a prototype. It can be further improved to contain more color control and text-to-speech features.

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