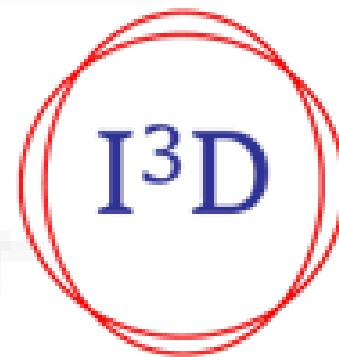




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Analyzing Eye Gaze of Users with Learning Disability

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Introduction

<http://en1neuro.com/wp-content/uploads/2018/03/LD2.png>
<https://s18670.pcdn.co/wp-content/uploads/Dysgraphia-Dyslexic-Resources.jpg>
<http://world.edu/wp-content/uploads/2019/02/dyscalculia2.jpg>
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Learning Disabilities

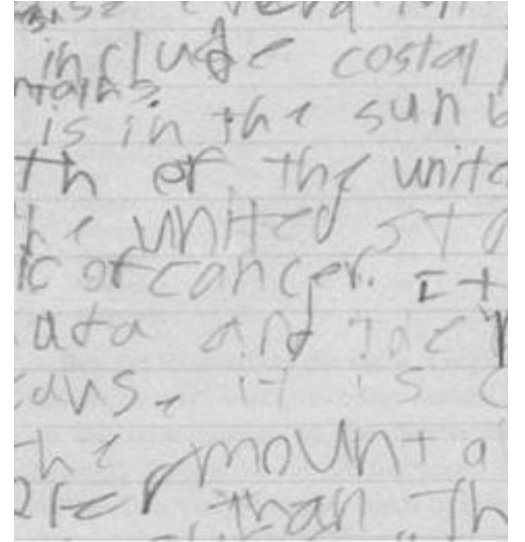
A number of disorders which may affect the acquisition, organization, retention, understanding or use of verbal or nonverbal information.

Impairments in one or more processes related to **perceiving, thinking, remembering** or **learning**:

- language processing
- phonological processing
- visual spatial processing
- Perceptual motor integration
- processing speed
- memory and attention
- executive functions

May interfere with one or more of the following:

- **oral language** (e.g. listening, speaking, understanding);
- **reading** (e.g. decoding, phonetic knowledge, word recognition, comprehension);
- **written language** (e.g. spelling and written expression); and
- **mathematics** (e.g. computation, problem solving).
- **Organization**
- **Social Skills**



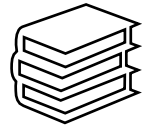
Introduction



Learning Disability



Dyslexia



Reading Ability



Eye tracking

Motivation

- Early identification of these disabilities can help in significant improvement of such children
- Eye movements of dyslexic readers are already found to be different from those of typical readers.

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Press Information Bureau
Government of India
Ministry of Science & Technology

14-October-2015 16:10 IST

Minister for Science & Technology Dr. Harsh Vardhan to Release Assessment Tools for Dyslexia – ‘A Learning Disorder’ in Indian Languages

Minister for Science & Technology Dr. Harsh Vardhan is to release assessment tools for dyslexia – ‘a learning disorder’ in Indian Languages. He will also release a book on Specific Learning Disorder (SLD) at a function in New Delhi tomorrow.

Learning disability refers to a cluster of symptoms which indicate difficulties in acquiring language skills such as reading, spelling, writing, comprehension during conventional classroom instruction. It is currently attributed to differences in brain structure and wiring. Learning disability makes it very difficult for a student to succeed academically in the normal instructional environment and in its severe form, qualify a student for special education or extra support services.

Dyslexia is the most common learning disability, and nearly 70%-80% of students diagnosed with LD have deficits in reading. It is characterized by a core deficit in reading that manifests despite normal intelligence, equal opportunity and adequate instruction. It has a worldwide incidence of 5-20%. The incidence of dyslexia in India is believed to be 15%. According to the Times of India, Jan 22, 2013, there are 228,994,454 students enrolled in recognized schools, which brings our count of dyslexic Indian children to nearly 35 million.

According to a recent ruling of the Delhi High Court (5th September 2012) all government, private and public schools are mandated to equip themselves to handle children with various disabilities including learning disability. In addition, Specific Learning Disability or SLD has been recently included in the Person with Disabilities Act and DSM V.

The assessment of Dyslexia is carried out using a series of age appropriate, culturally valid psychological tests on the child in the native language. Two primary reasons why dyslexia remains undiagnosed in India are:

1. Lack of sufficient awareness amongst school teachers and parents
2. Absence of appropriate standardized screening and assessment tools in Indian languages.

We have developed the Dyslexia Assessment for Languages of India (DALI) to address both these problems.

Since dyslexia is a learning disability, the teacher is the best person to identify it. DALI is a comprehensive screening and assessment battery for children with or at risk for dyslexia, between the classes of 1 to 5.

Two screening tools for dyslexia for school teachers have been developed

- JST (Junior Screening Tool) – classes (1-2) (5 to 7 years).

Literature Survey

Reading Ability with Eye Tracker	Early Identification of Dyslexia	Gaze Movements as estimation of Cognition
Eye movements of dyslexic readers are found to be different from those of typical readers [Benfatto et al 2016]	Detection and Diagnosis of Dyslexia [Benfatto et al 2016]	In-depth understanding of ongoing cognitive processes [Martos 1990]
Font size effecting the readability and the ability to understand text [Rello 2017]	Difficulties in literacy acquisition Affecting reading, writing, and spelling [Reid 2016]	Eye movement coordinates provide a literal account of the cognitive processes [Rayner 1998]
Eye tracking is a natural and silent way of capturing the responses as it does not rely on any overt response [Benfatto et al 2016]	Dyslexia grows with time in many ways and may be difficult to identify [Kamala 2015]	
Eye movement characteristics during reading reflect the difficulty that children have understanding written text [Rayner 1985]	Dyslexia Explorer is designed to screen for dyslexia by examining visual attention in reading Arabic script [Al-Edaily 2013]	
RADAR is a test that helps to analyze children with reading disorders like dyslexia in a group of school-age children ranging from 8.5 to 12.5 years [Smyrnakis 2017]	SVM binary classification and other machine learning methods have been used to identify dyslexia [Lustig 2016] [Rello 2015]	

Methodology

- **Participants**

- Group 1 Users**

- Age: 21-30 years

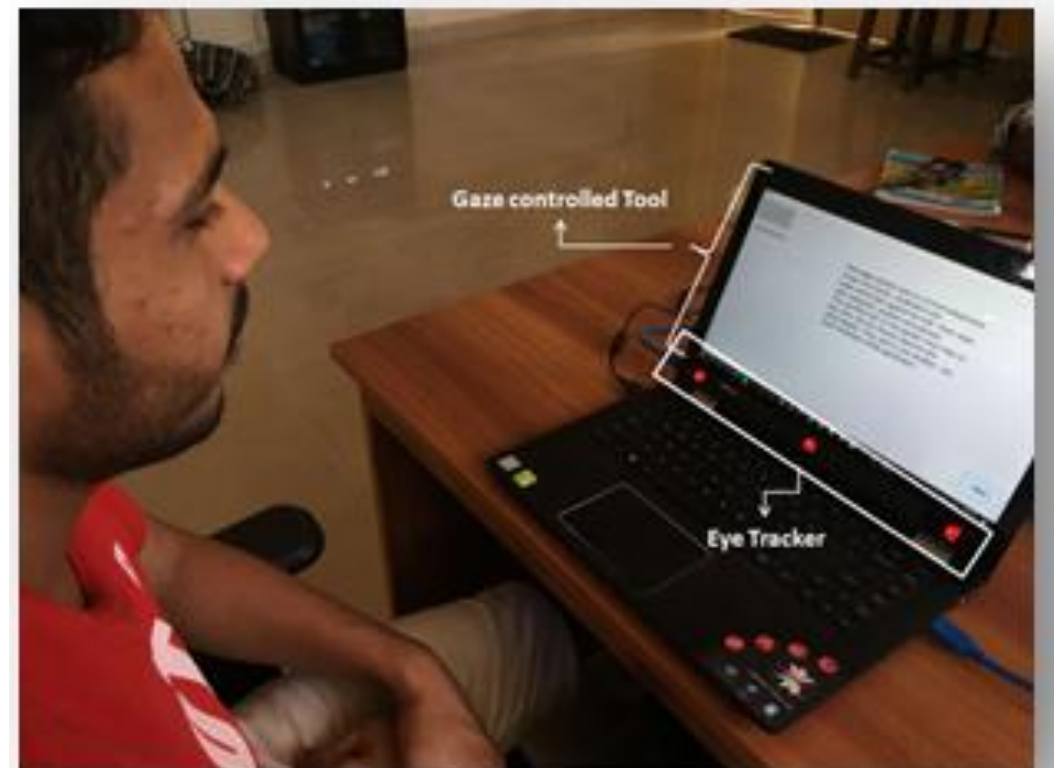
- 10 participants – 8 Male 2 Female

- Group 2 Users**

- Age: 8-10 years

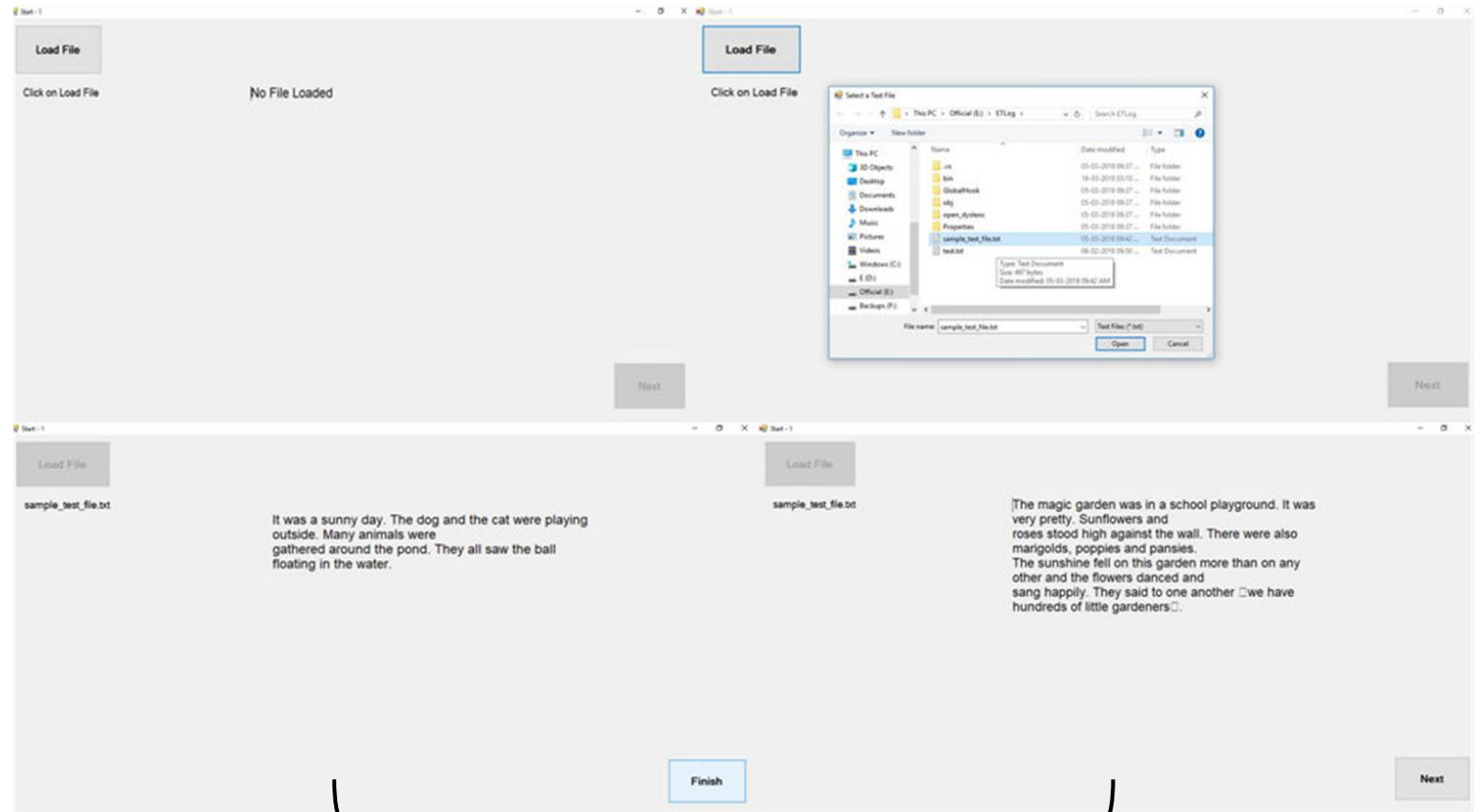
- 20 participants – 9 Male, 11 Female

- **Subjective rating (0 to 5)**



Methodology

Software Used to Record Data



Gaze in Play

Sample Data

Untitled - Notepad
File Edit Format View Help

X	Y	time
499	150	352484
498	152	352500
493	152	352515
492	152	352546
490	152	352562
491	150	352562
490	147	352578
492	142	352593
491	143	352609
494	146	352625
496	148	352640
504	151	352671
500	149	352687
502	154	352703
500	152	352718
503	150	352734
512	147	352750

Analysis

Cluster Based

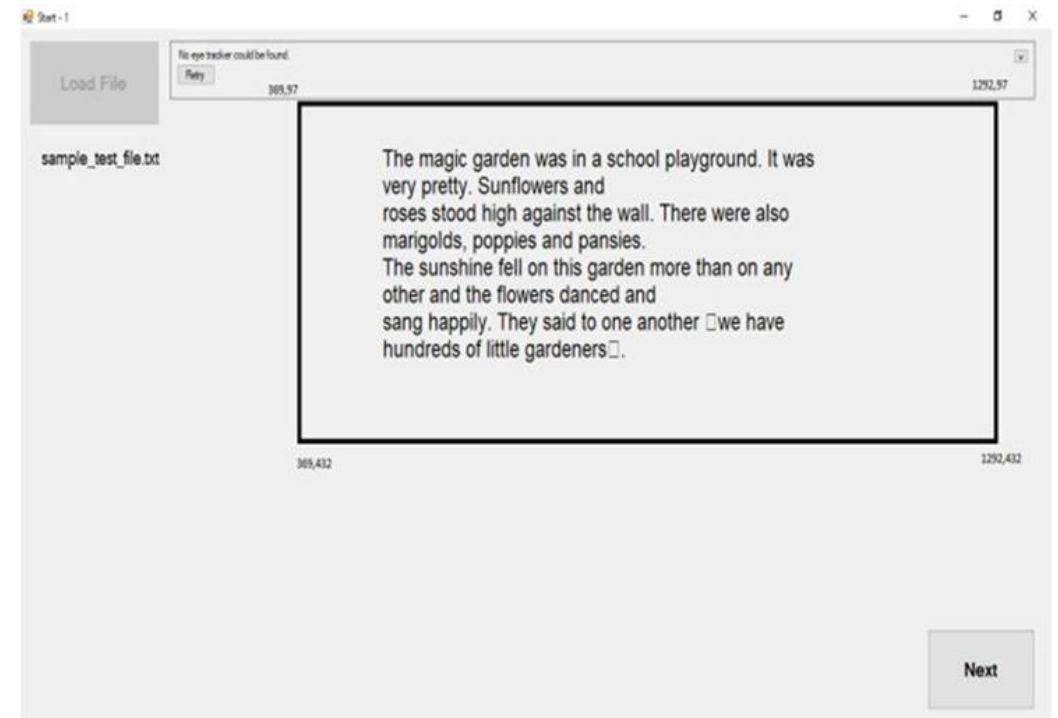
- Spatial distribution of raw gaze points

Velocity Based

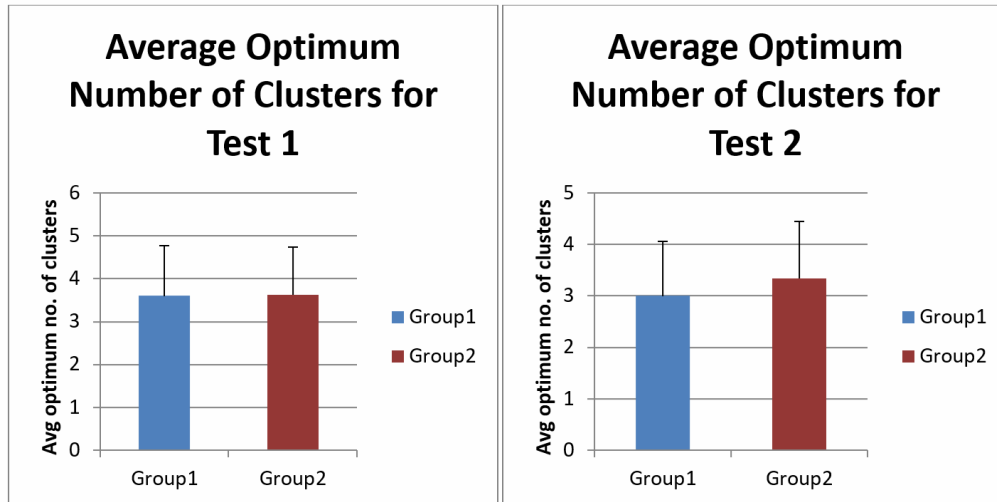
- Fixation AND Saccades
- Regression

Cluster Based | Analysis - I

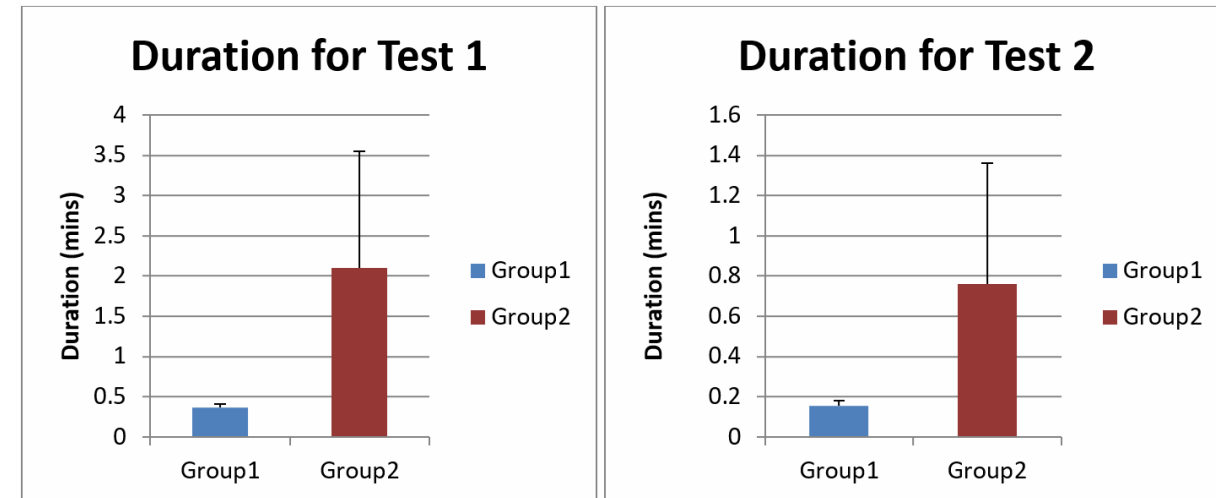
- EM Algorithm
- Xie-Beni(XB) Indexing
- Results
 - Optimum Number of Clusters



Cluster Based | Analysis - I

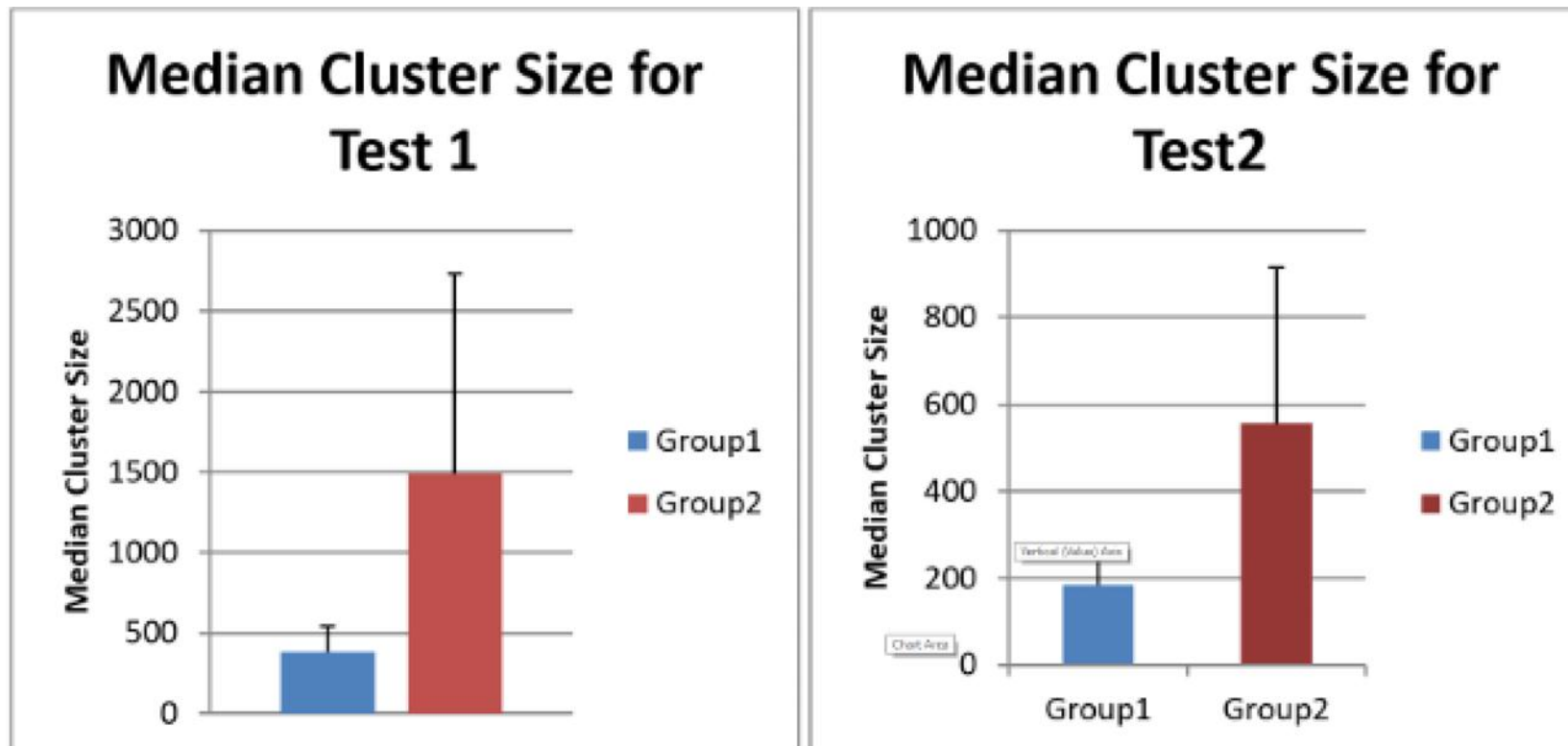


Optimum number of clusters for both groups of users



Total time taken to read each of the paragraphs by both groups of users

Cluster Based | Analysis - I



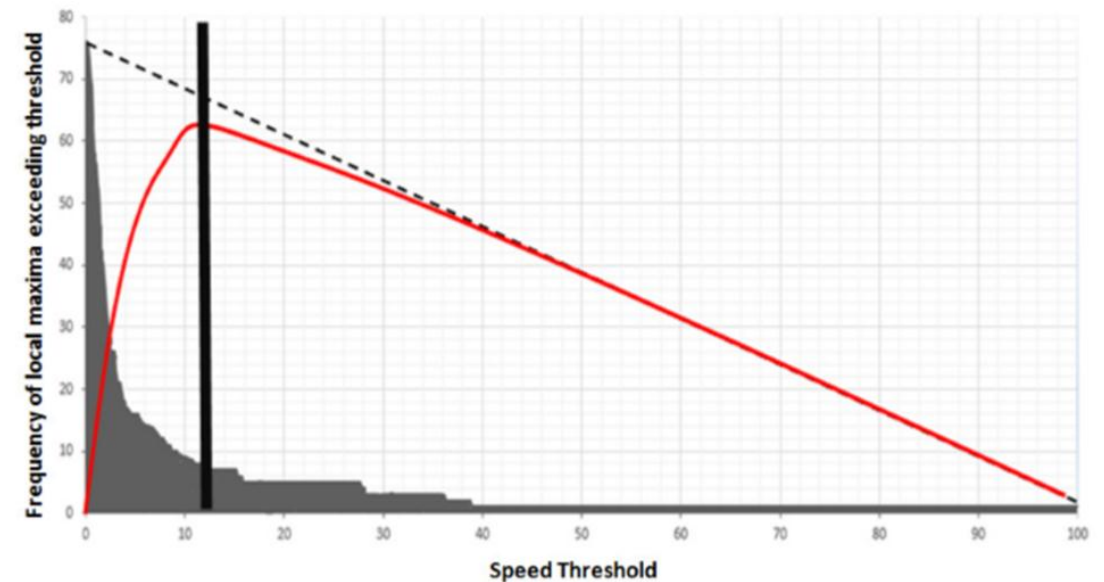
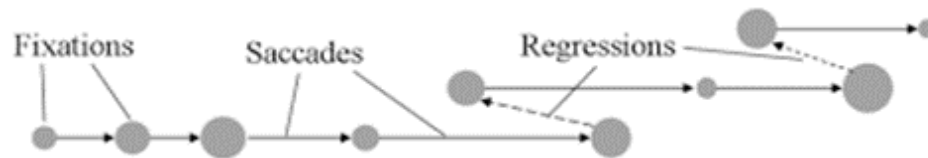
Median Cluster Size for both groups of users

Velocity Based | Analysis - II

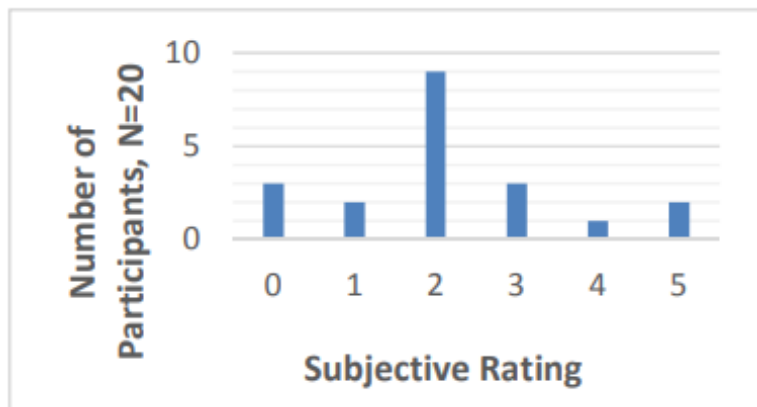
Classifying Fixation and Saccade

- Record the gaze values from the eye $GAZE_POINT(x_i, y_i, t_i)$, and x, y are the gaze coordinates at time instant t
- Calculated Point to Point velocities between the successive gaze points.
- Calculating individual threshold for each participant

Calculating Regressions



Finding threshold to classify fixation and saccade



Subjective Rating for Group 2 Users

Correlation between subjective rating and other parameters (N=20, df=(20-2)=18). **Indicates $p < 0.05$

Description	Score
Fixation threshold value	-0.76**
Avg. no. of Fixation	-0.76**
Regression	-0.58**
Median Cluster Size	-0.53**
Total time taken	-0.76**

Velocity Based Function Analysis

Results

We correlated the following parameters with range of reading abilities of users:

- Average number of fixations for each participant
- Percentage of backward directed eye movement
- Regression
- Subjective rating (Likert scale from 0 to 5) based on participant's performance

Conclusion & Future Work

- No significant difference found in the number of optimum clusters between and within different groups of users.
- Students with poor reading ability took significantly longer time to read the same length of text than others.
- Sizes of clusters are significantly bigger for students with poor reading abilities than others.
- Significant correlation has been noted between **number of fixations, backward (right to left) eye gaze movements** and subjective rating.
- Poor reading ability stay focused in one region of the text longer and make more back-and-forth gaze movements than other students with better reading abilities.
- By calculating the density of raw gaze or fixation points or number of regressions within an area of textual information, we should be able to **indicate the reading ability of students within a short time**.
- We propose to use these metrics to develop an automatic system to detect early signs of dyslexia.

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Thank you !