the dyslexic children need to invest significant conscious resources for monitoring balance, and thus their performance is adversely affected by any secondary task which serves to distract attention from the primary task. This need for “conscious compensation” suggests that for dyslexic children the skill of motor balance is poorly automized. It is possible, therefore, that many of the reading deficits of dyslexic children are merely symptoms of a more general learning deficit-the failure to fully automize skills.

**1. A TEXT ACCESSIBILITY MODEL FOR PEOPLE WITH DYSLEXIA**

A. GOAL OF THESIS: To make text more accessible for people with dyslexia by combining HCI validation methods and natural language processing techniques.

The author examined how people with dyslexia identify errors in written text.

The author concluded that the written errors by dyslexics were related to presentation and content features of text. To provide evidence to these conclusions, the authors conducted experiments using eye tracking to determine the conditions related to improved readability and comprehension.

A lexical simplification system was then implemented using the relevant parameters for text presentation and content modification.

Finally a model called DysWebxia is created which is a result of the investigation and resources created through this research.

The authors discovered that there was no previous work on automatic language modification techniques. Then to find out what kinds of language modifications could be done automatically, the authors reviewed Natural Language processing (NLP) literature. They did this by finding out the linguistic difficulties of dyslexics and connecting them to potential solutions by using Natural Language Processing methods. However, from previous NLP methods they could not find relevant solutions for dyslexics.

During the experiments, two aspects were tested.

1. Presentation of text

2. Content modification using Automatic lexical simplification

During the evaluation of algorithm it was discovered that presenting simple synonyms was more important than lexical simplification itself.

The author discovered that substituting complex words with simple synonyms was not useful and counterproductive, but when these synonyms were shown on demand the text became subjectively easier to read and comprehend. This is why they implemented a new algorithm that would rank simpler synonyms of a word to show the simplest ones for people with dyslexia.

Finally, the recommendations obtained from all the experiments were combined to form a language resource of simpler synonyms which can be integrated into other applications.

Therefore, there are only two applications for people with dyslexia that are also capable of TEXT CONTENT MODIFICATIONS. These two applications are TEXT4ALL and DYSWEBXIA.

In this research, the author tests two aspects for dyslexics:

1. Reading performance

2. Writing errors

Eye tracking was used to discover reading errors while reading internally changed letters in sentences such as: (Do you hvae dexiysla?)

The writing errors of dyslexics were analyzed and the presence of dyslexic written errors in English and Spanish web were measured.

**Eye tracking was used to address the best strategy to show simpler synonyms for people with dyslexia.**

**Lexical simplification algorithm was also developed for people with dyslexia.**

**Technologies developed to help Dyslexics are:**

**1. Eye Tracking**

Eye movements of people having dyslexia is different from those without dyslexia in terms of:

1. Longer Fixations, 2. More Fixations, 3. Shorter Saccades, 4. More Regression

Author concludes that Dyslexics have a language processing deficit and eye movements simply reflect their difficulty in processing language.

**2. Text Accessibility**

A tool which can change color, size and font types is developed called SeeWord tool for MS Word.

Another tool called MultiReader is used to enrich documents with interface adaptations, text to speech, multimedia elements such as subtitles and sign language interpretation for audio and video, audio description of video materials.

Mozilla Firefox extension called Firefixia is a tool that allows readers with dyslexia to customize websites to improve readability. Firefixia provided customization options for:

1. Font size, 2.Font type, 3.Color, 4.Character Spacing, 5.Line Spacing, 6.Column Width

**3. Natural Language Processing:**

Current researches in NLP are of two types:

1. Writing

2. Reading

1. Existing NLP researches focused on Writing Output of dyslexics are related to spellcheckers.

2. All existing applications for Reading, just alter the design of the text (not the content) such as: SeeWord, Claro Screen Ruler Suite, Color Explorer or Penfriend XL, or use text to speech technology such as Claro Read, Reading PenTS Oxford or DiTres.

NLP techniques which can be useful for people with dyslexia are:

**a. Orthography**

**b. Phonography:**

Metrics such as Phonix, Soundex and Metaphone compare words with regard to their phonetic similarity.

**Soundex:** It indexes words by sound so each letter is encoded according to it pronunciation. Letters with similar pronunciations such as <b>, <p> are grouped together while those with different pronunciations<m>,<n> are placed in another group.

Algorithms such as **Soundex, Phonix and Signum are all designed for English language.**

**c.Morphology and Lexicon:** NLP methods related to paraphrasing and lexical simplification. There are three types of paraphrases in broad terms:

1. Lexical paraphrases when individual lexical items have the same or similar meaning

2. Phrasal paraphrases when there are phrasal fragments sharing the same sematic content

3. Sentential paraphrases when two sentences represent the same semantic content

Automatic methods to generate paraphrases are successful already for example the auto-correct option in MS Word. The target text is transformed into an equivalent text that is more understandable for a given user.

Text simplification is beneficial for many groups of readers such as non-native language learners, low literacy people, aphasic readers or deaf people. For example: Text simplification methods were applied to simplify newspaper texts and online materials for people with aphasia and Down syndrome.

KeyPhrase extraction can be used as metadata for refining NLP applications, such as summarization or text ranking.

Complexity of text can be measured using various complexity measures such as:

1. Automated Readability Index (ARI)

2. Coleman-Liau Index(CLI)

3. Flesch-Kincaid Grade Level Readability Test(FK)

These indexes take into account the number of words per sentence or number of letters per word.

**Text Presentation:**

a. Font Type:

b. Text and Background color

c. Font Size

d. Spacing

e. Column Width

**Text Content:**

**a. Graphical schemes:** People with dyslexia are strong visual thinkers and use of graphical schemes such as mind maps can be used.

**b. Keywords:** Highlighting keywords to make them more visible and accessible

**c. Verbal paraphrases:** People with dyslexia have special difficulties with short and functional words so these words must be reduced by using verbal paraphrases

**d. Word frequency and word length:** Dyslexics find it difficult to understand and read infrequent and long words.

**e. Numerical expressions:** People with dyslexia have mathematical learning difficulties due to problems with recognition and recollection of numbers.

**TEXT PRESENTATION:**

HOW TO PRESENT TEXT IN SUCH A WAY THAT IT CAN BE BETTER UNDERSTOOD AND MAKE IT MORE COMPREHENSIBLE FOR DYSLEXICS

**2. EYE MOVEMENTS IN READING AND INFORMATION PROCESSING: 20 YEARS OF RESEARCH**

**1. Continuous eye movements while reading books or watching a scene is called “SACCADES”.**

**2. Between “SACCADES” our eyes remain relatively still during “FIXATIONS” for about 200-300 ms.**

**3. SACCADES are rapid movements with high velocities as 500° per second**

**4. Some studies have suggested that some cognitive activities are suppressed during saccades.**

**5. People are normally not aware of the pauses because SACCADE durations are so brief any disruptions might not be particularly salient.**

**6. SACCADES need to be distinguished from three other types of eye movements: pursuit, vergence and vestibular eye movements.**

**7. Dyslexic readers like beginner readers make longer fixations, shorter saccades, more fixations and more regressions than normal readers.**

**3. Integrating multimedia technology, Knowledge Based system, and speech processing for the diagnostic and treatment of developmental dyslexia**

SICOLE – Software environment to help tutors of dyslexia children with diagnostic and treatment tasks.

Three important elements :

1. A multimedia interface

2. An inference module

3. A database

SICOLE is not designed to work with dyslexic child without the supervision of a human tutor. However, constant and strict supervision is not needed.

**Database** – MYSQL

**Interface** – Macromedia Authorware 6.0 and Flash 5.0

Media production – Macromedia Fireworks, Corel Draw and Corel Photo Paint.

**Inference** – CLIPS

**Interface between CLIPS and database** – Developed with Microsoft Visual C++ 6.0

**An Active X object based on Microsoft Agent Technology is also develop to guide and motivate students**

**How does SICOLE work ?**

1. Evaluation module:

a. First of all the user is categorized as one of the three types of dyslexics (Phonological, surface or mixture dyslexia)

b. Phonologic dyslexics have problems reading pseudowords or unfamiliar words

c. Surface dyslexics have problems reading irregular words but reads pseudowords and unfamiliar words

d. Naming task is used to ask users to pronounce a sequence of words and pseudowords.

e. Words are shown in screen one after another. A blank screen is shown for 200ms and another word is shown alerting with sound. The word is shown in the middle of the screen surrounded by rectangle.

f. The word is read and the computer store the pronunciation and the reaction time (RT).

g. Recorded sound is analyzed with speech processing techniques for voiced and unvoiced segmentation.

h. To identify an accurate RT, signal processing techniques are used to calculate parameters as the Short Time, Energy and Zero Crossing Rate values.

i. Once the type of dyslexia is identified, SICOLE starts the functional evaluation process to determine the cause of low reading performance using three modules:

Lexical Processing, Perceptual Processing and Syntactic-Semantic Processing

**ASR (Automatic Speech Recognition)**

**CSLU toolkit** is selected as the ASR environment for **SICOLE.**

The user is presented with words which are read by the user. The utterances are analyzed by the prototype showing the most likely phonemes recognized, time parameters and confidence of recognition. Each word can have several ways of utterances. Therefore, these different ways of utterances must be considered. Dyslexics especially pronounce words in different ways.

**4. Fusing eye gaze and speech recognition for tracking in an automatic reading tutor – A step in the Right Direction**

To automatically assess reading proficiency as well as provide feedbacks some level of reading activity must be detected.

There are three modalities which can be used to this end:

a. Eye-gaze tracking

b. Speech recognition

c. Manual Feedback requests

In this paper, the focus is on adult dyslexic read speech.

Tracking the reading progress of people with dyslexia is challenging as they produce more miscues than people without dyslexia

Reading is normally progressive but sometimes reader returns to previously read words in order to revise or remember what was read

This trend is more prevalent in those people with dyslexia.

An ART (Automatic Reading Tutor) must be able to anticipate which word the user is supposed to read next an provide assistive feedback if necessary.

**Eye Gaze tracking method:**

1. While reading eyes move in a sequence of fixations and saccades

2. Saccades usually move from left to right but sometimes they do the opposite – for example, when the reader revises what was previously read

**Gaze Events:**

There are a number of categories for gaze events:

1. Fixation

2. Glissades

3 Saccade

4. Smooth Pursuit

5. Blink

For this paper we will focus on fixations as they are anchor points for gaze events

**Tobii Fixation Filter** is used for eye gaze tracking

There are possibilities for errors while eye tracking. There are three sources of errors:

1. The quality of setup

2. Drift of calibration

3. Biological characteristics of eye

An example of this error is the offset plus noise on the gaze points. This error is explained as: The reader is reading the upper line but the eye gaze tracker maps the gaze on the lower line

**Speech Recognition and tracking:**

A language model which allows children to jump back and forth in the text works better than forcing a child to strictly read from left to right.

In this paper, the language model which allows for jumping back and forth in the text is considered.

**Fusing gaze and speech for tracking:**

There will always be a non-deterministic delay from the time the reader focused on a word to when it was uttered. This delay is caused by the time it takes for the reader to see, interpret and utter the word. This delay is normally 430 and 920 msec. In this paper, the gaze points are delayed by 430 msec as **the word probabilities are calculate from the gaze points.**

**Word probability from gaze points**