A Review of the Computer Science Literature Relating to Dyslexia Diagnostic and Education Activity

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Abstract

This study examines the effects, diagnosis, and treatment of dyslexia, a neurological disorder, on children. It aims to determine how to create the most beneficial educational content for children by comparing the software tools used. The study examines dyslexia in two different areas: health and software. The health side of the study is designed to observe children with this disorder better and discuss the disease's effects on children. The software side of the study examines the software used in diagnosing and treating this disorder and the projects that have been done so far. Our study will help you to understand better what dyslexia means for children, to evaluate the tasks done in this regard, and to learn about the diversity of software.

1. Introduction

Dyslexia is a neurological problem and is a disorder in which a person's reading and writing functions are negatively affected. Since this disorder is frequently encountered and experienced in the world and is not given much importance, sufficient diagnostic and healing practices have yet to emerge. Dyslexia, which has six types (Phonological Dyslexia, Surface Dyslexia, Visual dyslexia, Primary Dyslexia, Secondary (Developmental) Dyslexia, and Trauma Dyslexia), begins to be seen chiefly in childhood.

Dyslexia is caused by impairment in the language processing center in the brain's left hemisphere. Theories put forward to suggest that an individual with dyslexia has a genetic predisposition; that is, if family members also have dyslexia, the suspicion of dyslexia increases. The standard method used in diagnostic studies of dyslexia is Electroencephalogram (EEG). There are many treatment methods for dyslexia, and a few of them are vocabulary development, word prediction, text-to-speech, and pronunciation recording. These can be treated face-to-face or with applications on smart devices.

Many applications have been developed to identify or treat dyslexia. The algorithms used in these applications are classification algorithms and kNN algorithm-like algorithms. The common language used for such algorithms is the Python programming language. Python is a programming language because it has built-in machine learning algorithms and is also open source. These applications are educational games developed to support individuals' learning processes and are designed to motivate them and attract their attention. Such applications are made considering the participation of various stakeholders such as teachers, students, psychologists, software engineers, and more. When we look at the various mobile applications designed to diagnose children with learning disabilities in the mobile application world, the most downloaded and voted on are the Dyslexia Quiz, Reversals For Dyslexia, and Smartex. Innovative Exercises are Dyslexia AI, Auto Train Brain, Read&Write Gold, Speechify, Dyslexia Quest, Writing Wizard, and Simplex Spelling Light.

2. Dyslexia from a health perspective

2.1. What is Dyslexia?

Dyslexia is a neurodevelopmental disorder characterized by slow and inaccurate word recognition. Dyslexia has been reported in every culture studied, and

mounting evidence draws attention to cross-linguistic similarity in its neurobiological and neurocognitive bases [1].

2.2. What Causes Dyslexia?

The causes of dyslexia are not fully understood. It could be related to hereditary factors or other factors that affect brain development. It could relate to impairment of the brain's ability to process phonemes. It is not due to intellectual disability and has a neurobiological origin. Olson examined the addition of regular genetic and environmental conditions to dyslexia and found no obvious cultural or apparent biological (i.e., brain damage) constraints [2]. Like all behaviourally defined disorders, the cause of dyslexia is multifactorial and is associated with multiple genes and environmental risk factors. Dyslexia is familial and moderately heritable and has been linked to nine risk loci (DYX1–DYX9) through replicated linkage studies, although not every study has replicated these results.

The main advance in the genetics of dyslexia since the previous Lancet Seminar has been identifying six candidate genes [3].

2.3. Which Types of Dyslexia Have?

There are six different types of dyslexia. These;

1. Phonological Dyslexia: In this type of dyslexia, people may have difficulty pronouncing some words. In this type of dyslexia, visual processing problems come to the fore rather than auditory.
2. Surface Dyslexia: It is the type of difficulty in recognizing and writing words.
3. Visual dyslexia: Difficulty in reading caused by visual problems (due to physical causes) or visual processing disorders (cognitive/neurological reasons).
4. Primary Dyslexia: The most common type of dyslexia. It is a functional disorder that occurs in the left cerebral cortex side of the brain and does not change with age.
5. Secondary (Developmental) Dyslexia: Secondary dyslexia is caused by problems in brain development during the early stages of fetal

development. Developmental dyslexia may decrease as the child grows.

6. Trauma Dyslexia: It develops in adults or children due to damage to the brain due to trauma or disease.

2.4. Age Groups Affected by Dyslexia

Dyslexia begins to be classified chiefly in childhood. Reading disability affects a sizable minority of the child population. Prevalence rates vary depending on the criteria used to define the disorders, the measures used to assess reading skills, and environmental factors. Prevalence rates of dyslexia vary between 3% and 15% of school-age children. Several epidemiological studies have reported that dyslexia is slightly more frequent in males than in females. However, a meta-review including all these studies showed that dyslexia is diagnosed more often in men than in women, and studies of the cited samples found the ratio of men to women to be up to 6 times higher. This overrepresentation of males in referred specimens has often been attributed to a higher frequency of comorbid behavioral disorders, such as attention deficit hyperactivity disorder (ADHD), in males with dyslexia than in females with dyslexia. Fewer studies have investigated prevalence rates of poor comprehensives. However, recent studies suggest that this reading disability affects between 7.5% and 10% of primary school children in unselected samples. In contrast to dyslexia, reading comprehension impairment appears to affect similar numbers of males and females. Of course, dyslexia and reading comprehension impairment are best-considered extremes of the normal distribution of reading ability rather than distinct categories; hence, prevalence rates depend on the arbitrary cut-off points used to define the disorder [4].

2.5. Effects of Dyslexia?

Dyslexia does not have significant effects, but it still has minor effects. Even if someone with dyslexia recognizes speech sounds, they have difficulty learning their relationships with letters or words. Often observed as a reading disorder, dyslexia can also affect attention and memory and the areas of the brain that process language.

Individuals with dyslexia have average intelligence and usually do not have problems with their vision. Most dyslexic children can do well in school with tutoring

or a unique education program. Emotional support plays a significant role in coping with dyslexia.

Although there is no specific treatment for dyslexia, early diagnosis and intervention provide the best results. However, in some cases, dyslexia goes undiagnosed for years and remains unrecognized until adulthood. However, it is never too late to get help and support for dyslexia.

2.6. Essential Metrics of Dyslexia

The above are the total essential metrics of dyslexia

1. Hearing and Speech Metrics,
2. Vision, Reading, and Spelling metrics,
3. Writing and speed ability metrics,
4. Arithmetic and time managing metrics,
5. Memory and cognition metrics,
6. Behavior, health, development ,and personality Metrics, and
7. General characteristic metrics.

Figure 1. Dyslexia metrics [5]

3. Diagnosis of Dyslexia from a health perspective

First, to summarize, dyslexia or reading difficulties is a learning disorder that occurs when an individual experiences significant difficulties with the speed and accuracy of word decoding. Cognitive difficulties of people with dyslexia include problems deciphering speech, recognizing and manipulating basic sounds in a language, language memory, and learning the sounds of letters.

Dyslexia is a neurological condition with a genetic basis. Dyslexic individuals have abnormalities in their brains. The brain is divided into two hemispheres (lobes): the left with the verbal and arithmetic hemispheres and the right with the spatial hemisphere [6]. The cause of dyslexia is caused by the brain's left hemisphere, according to the deterioration in the language processing center [7].

There are also differences in the electrophysiological and structural characteristics of the brains of people with dyslexia. Many current theories search for the causes of dyslexia at the biological level, especially genetic predispositions. Some neuro-functional and neuroanatomic differences have also been reported between individuals with dyslexia and those who do not show any learning disabilities.

Every individual (child or adult) who doubts subjects such as reading, math problems, and focusing should receive an assessment. This assessment is usually carried out in schools, higher education institutions, and psychological counseling. The evaluation should include a comprehensive measurement of reading, spelling, and arithmetic skills. As recent research in the field has shown, an intelligence test or IQ score is not required.

The diagnosis of dyslexia is made by evaluating the child's reading, writing, and pronunciation skills. A speech and language therapist or a special education teacher usually makes the diagnosis. There are several criteria for the diagnosis of dyslexia:

- Assessment of the presence of similar problems in family members
- Intelligence level
- Evaluation of speech skills
- Word recognition
- Evaluation of fluency related to speaking and reading
- Reading comprehension
- Evaluation of vocabulary
- Evaluation of understanding and reading new and different words
- Evaluation of the functioning of a person's brain in terms of phonological (pronunciation).

Diagnosis can be facilitated by comparing the results with the survey and test results. If family members also have dyslexia, the suspicion of dyslexia increases.

At the same time, since the diagnostic criteria for developmental dyslexia are various language difficulties — i.e., accuracy in word recognition and difficulties in fluent speech, poor spelling, and solving abilities — the primary approach in studies investigating the path mechanism of the disorder is the role of linguistic processes. The most documented hypotheses focusing on the functioning of auditory language are:

1. The phonological deficiency hypothesis, which examines the difficulties in representing, storing, manipulating, and receiving speech sounds
2. The double deficit hypothesis, which looks at deficits in both phonological processing and naming speed

3.1. Electroencephalogram (EEG)

Electroencephalogram (EEG) can be used in such studies to describe the brain's electrical activity that is collected from the EEG's scalp via the metal electrode and, therefore, to detect dyslexia.

- Signals resulting from EEG can be compared with other tools like functional magnetic resonance imaging (fMRI) [8].
- Accordingly, EEG is counted to be safe and easy to use. The signal produced by EEG can be classified into
    - delta (δ)
    - theta (θ)
    - alpha (α)
    - beta (β) and
    - gamma (γ) bands.

These bands based on frequency ranges are shown in Table 1. Nowadays, (EGG) is being used in cognitive and neuroscience, and it is also employed as the best tool for diagnosis, helping, analysis, observation, and understanding of the inner workings of the human brain.

Table 1. EEG Bands and Description

Bands Type	**Frequency Ranges**	**Bands Description**
Delta (δ)	0-4 Hz	This individuality can be recognized during deep sleep phases.
Theta (θ)	5-7 Hz	Enhanced through sleep mode.
Alpha (α)	8-13 Hz	Performed through restlessness, relaxation, and mind inactivity conditions.
Beta (β)	14-30 Hz	Distinguished when the mind is alert.

Gamma (γ)	36-40 Hz	Observed when the brain responds to specific things or does complex tasks.

4. Treatment of Dyslexia from a health perspective

In treating Dyslexia, it is necessary to identify the disorder at the very beginning, determine the symptoms of the child's symptoms, and take a path according to the signs. The treatment to be performed depends on the severity of Dyslexia and psychological symptoms or simultaneous disorders. Drug therapy is not helpful for Dyslexia. But if a dyslexic patient has attention deficit hyperactivity disorder (ADHD), medication for ADHD can also improve their ability to learn inside and outside of school.

4.1. Dyslexia treatment methods

The multilevel model of Dyslexia calls for two causal and two symptomatic levels, which are superimposed in time. Some specific methods and strategies used to treat Dyslexia include:

4.1.1. To propagate reading features

- Change the temperature and color of the text.
- Adjust line spacing
- Place highlights and text components
- Text-to-speech reading
- Word guess
- Vocabulary development

4.1.2. To propagate writing features

- Spell check and grammar check.
- Word guess
- Vocabulary development
- Writing style improvement

4.1.3. To improve pronunciation skills

- Read aloud
- Pronunciation record
- Feedback

4.2. Other Methods that Are Effective in the Treatment of Dyslexia

4.2.1. The Orton-Gillingham Method in the Treatment of dyslexia

Samuel Ortan realized in his study that neurological problems that exist in people cause people to confuse letters and create reading problems [9]. Deciphering reading, writing, and speaking as language teaching, Orton has designed an instructional method to establish a connection between symbols and sounds used in colloquial language [10]. In this method, visual, auditory, and dynamic stimuli are put to work simultaneously. In addition to voicing and visually presenting words in teaching, analyzing each sound contained in the phrase individually tracking the spelling directions of letters with fingers can be expressed as one of the program's main features.

In the method, the students first create sound awareness, and each sound contained in the word is analyzed individually. Then, vowel and consonant letters are put to work, and new comments are taught to students. After this stage, syllabic studies are performed, and the writing stage can be started. The points that should be focused on in teaching are instant and abundant feedback, reading speed, and the realization of good reading.

The Orton-Gillingham Method Example:

1. Assume the child wants to be taught the letter 'm'. The letter M is written on the card, and the sound of the letter is made.
2. He then asks the child to make the sound of the letter after going over the letter. It is done again until the child learns the symbol and sound of the letter.
3. After this stage, the child writes the letter first in the air and then on paper. It performs the sound of the letter that performs the writing job at the same time.
4. When the number of letters learned increases, the letters of the Deciphered words are asked to the child one after the other.
5. Then, words are formed with mixed letters. This step is repeated by forming words with different letters.
6. The printed words are taught to the student by spelling.

7. The words in the book, determined under the teacher's guidance, are read to the student.

4.2.2. The Fernald Method in the Treatment of dyslexia

This method, developed by Grace Maxwell Fernald, is a method for children with dyslexic and excessive reading difficulties, where visual, auditory, mobile, and tactile senses are put to work, which differs from other multisensory methods in terms of teaching words as a whole [11]. The Fernald method, which is incredibly successful by students over the age of 8, helps the child recognize the letters and words necessary for learning to perform reading activities, as well as helps to eliminate inversion errors and symbol confusion during reading over time [12]. This method can be applied in developing reading and writing activities and other courses where students' interest is concentrated [13].

The Fernald Method consists of 4 steps:

1. The word the child chooses is written on paper using a colored pencil. While reading the word, the child is made to follow the talk with his finger by touching the paper. Then, he is asked to write the comment in his notebook by looking at the word written on paper. The process starts again if the child makes a mistake while watching or writing the word. The situation that should be noted is that the word is always written as a whole.
2. The child reads by looking at the handwritten word and writes from his mind without looking at the word. Correctly spelled words are put into the file alphabetically according to their initials. If he makes a mistake in spelling the word, the first step is repeated. Adding comments to the file continues until a story is created from words. After these operations, the child makes a story with the words he adds to the file and writes the story.
3. In this step, the child has reached the level of learning the words that have been written. For this reason, the process of writing sample words in handwriting is abandoned. The child reads the words he wants to learn by looking at the letters, and

then learns by writing. Now he can perform the activity of reading from a book. When there is a word that the child cannot read, it can be helped.

4. In this last step, the child looks at the printed words, repeats them, and can write the comment without looking at the word. He can learn new words from similar terms. The student has now reached a level where he can develop himself.

4.2.3. The Warnke Method in the Treatment of dyslexia

Specialists who have applied empirical research to clinical practice have mostly been interested in detecting the symptoms of developmental Dyslexia. Using analysis in practice has led to the development of an effective system for diagnosing certain learning disorders and the creation of reliable diagnostic tools [14]. Creating a comprehensive intervention and diagnostic assessment system for children with developmental Dyslexia has become a priority [15].

The method aims to train central auditory and visual processing, emphasizing auditory-motor timing, automatic balance retention, and acoustic selection reaction time, especially since it is essential in reading and writing.

4.3. The Brain-Boy Universal Professional (BUMP) device

The Brain-Boy Universal Professional (BUMP) device allows the accurate assessment and training of central auditory and visual processing in the tasks listed below. All jobs are performed by the child while wearing headphones. Based on the initial assessment results, a training program tailored to the individual needs and abilities of the child is proposed.

The Brain-Boy Universal device is mainly used for training skills. The usage plan (the ranking and number of games played in each session and the difficulty level) is based on the evaluation results conducted with the BUP device. The device has eight games and options to adjust the difficulty level according to the user's performance.

Central auditory and visual processing measured using Warnke Method tasks The Warnke Method [16] requires the use of specialist devices, namely headphones and the following equipment:

1. The Visual Brain-Boy game
2. The Auditory Brain-Boy
3. The Klik-Boy game
4. The Sound-Boy game
5. The Sync-Boy
6. The Speed-Boy
7. The Trio-Boy
8. The Long-Boy game

5. Algorithms and techniques used in diagnostic applications in dyslexia

Many computer applications have been developed to diagnose dyslexia, which has dramatically helped diagnose this disease.

5.1. Dyslexia Diagnosis and Classification System

Research has been done in Malaysia, a relatively young nation with a population of 31.66 million in 2016. 4-10% of students have been found to have signs and symptoms of dyslexia. The University of Malaysia has developed a machine-learning classification algorithm that helps diagnose dyslexia at an early age. They compiled data from 857 primary school students [17].

5.2. The Algorithm

The classification algorithm analyzes the input data and generates an output. As a supervised task, classification needs a predefined target for each sample. The goal is that the algorithm will learn enough to match the prediction of a new model with the marks as much as possible.

kNN (K Nearest Neighbors Classifier) algorithm was selected based on its better accuracy for this particular data, and supervised learning was used. kNN classifier is best suited for binary classification [18].

There are three categories of machine learning for classification:

- Statistical pattern and recognition [19]
- Machine learning techniques for induction of decision trees or production rules [20][21]
- Connectionist [22]

Python programming language is selected as a tool since it has built-in machine learning algorithms and is open source.

Scikit-learn provides algorithms for machine learning tasks, including classification, regression, dimensionality reduction, and clustering [17]. It also provides modules for extracting features, processing data, and evaluating models.

TKinter graphical user interface of Python is used to design the system's user interface.

5.3. Mobile Application to Support Dyslexia Diagnostic and Reading Practice

The main goal of this work is to present an application developed to provide dyslexic users with reading practice to improve their diction of words in the Portuguese language and, besides, as a tool to support health professionals in diagnosing potential cases of dyslexia. Therefore, it can validate if the user's reading follows a predefined set of drawbacks dyslexic people commonly face when reading Portuguese. The verification of the developed tool regards its assertiveness, sound interference, and use with dyslexic people [23].

This application can randomly generate one word at a time for the user to read. The application verifies if the word spoken corresponds to the word presented. A new word is given after five trials if the response is the opposite.

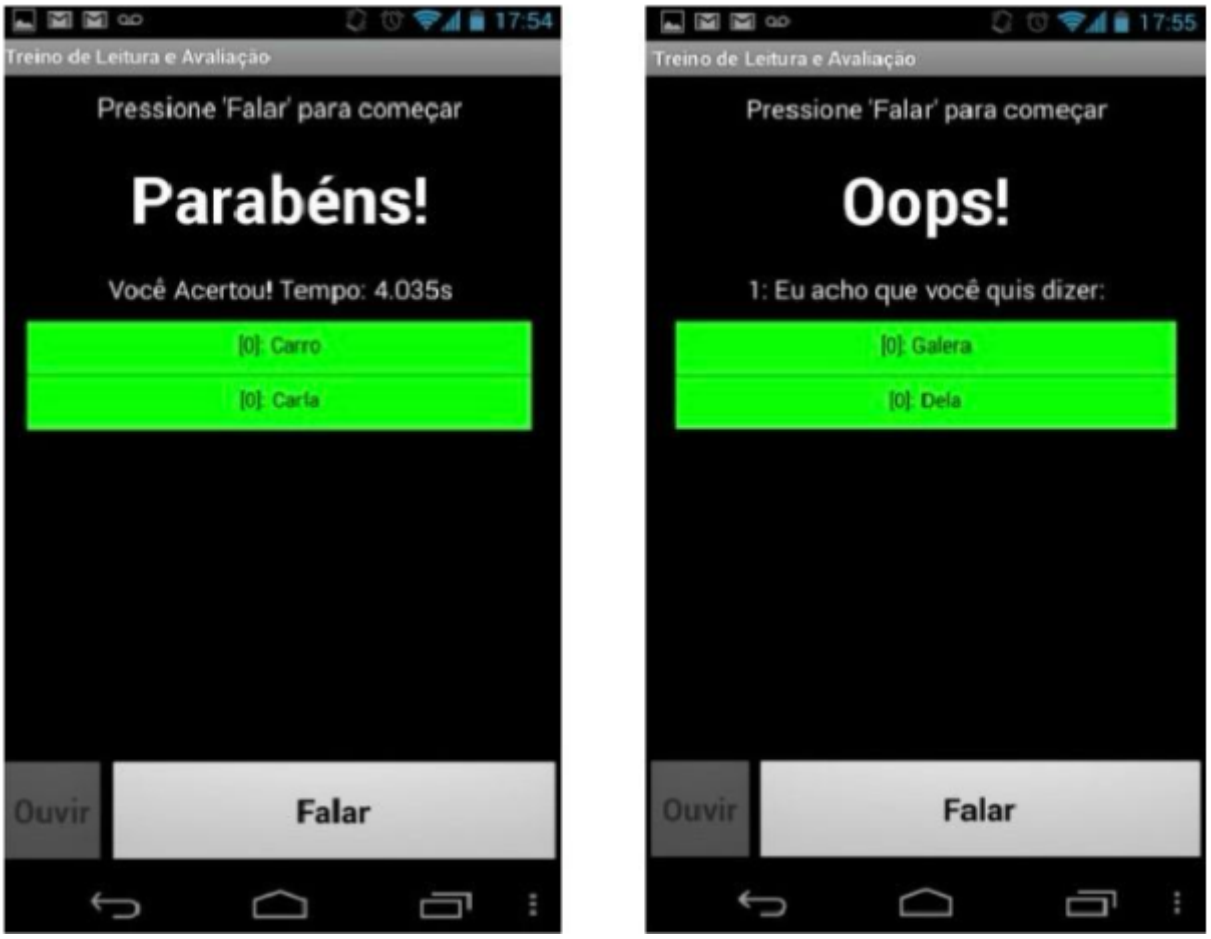

Figure 2. Speaking exercise pages of the application

The application was developed using a prototyping-based methodology, within which each step was reviewed and incremented. It was initially designed for Android mobile devices, using Android SDK(Software Development Kit), Java, and applying the Nuance voice recognition tool Dragon Mobile SDK(Software Development Kit).

5.4. New Method to Diagnosis of Dyslexia Using 1D-CNN(1 Dimensional Convolution Neural Network)

Electrooculogram(EOG) is one of the methods used to detect eye movements. In this study, a new method was proposed for the diagnosis of dyslexia. EOG signals were recorded while healthy and dyslexic individuals were reading four different texts prepared in the same font and four different font sizes. Recorded EOG signals were classified using a 1D Convolutional Neural Network for classification [24].

6. Software Applications For Dyslexia Treatment

In the world of mobile applications, developers design various mobile apps to diagnose learning difficulties in children. Furthermore, technological solutions such as mobile devices and artificial intelligence-based assistants have garnered significant interest in addressing these children's educational and learning needs. This review focuses on using artificial intelligence to diagnose individuals with dyslexia, enabling their educational progress through interactive games that cater to their specific needs and the design principles of applications specially crafted for children.

One study involving 114 children aged between 4 to 7 years provided evidence that children can learn from mobile apps. However, to maintain their interest, these apps should be developed with fresh content, reduced waiting times, engaging activities, incentives, goals, and parental involvement [25].

6.1. Machine Learning for the Identification of Dyslexic Individuals

Cognifit developed games for testing dyslexic individuals, as shown in [26, Figure 3] and [27, Figure 4]. Children's accuracy is determined based on their in-game actions. Additionally, these games aim to enhance the areas where children may have deficiencies.

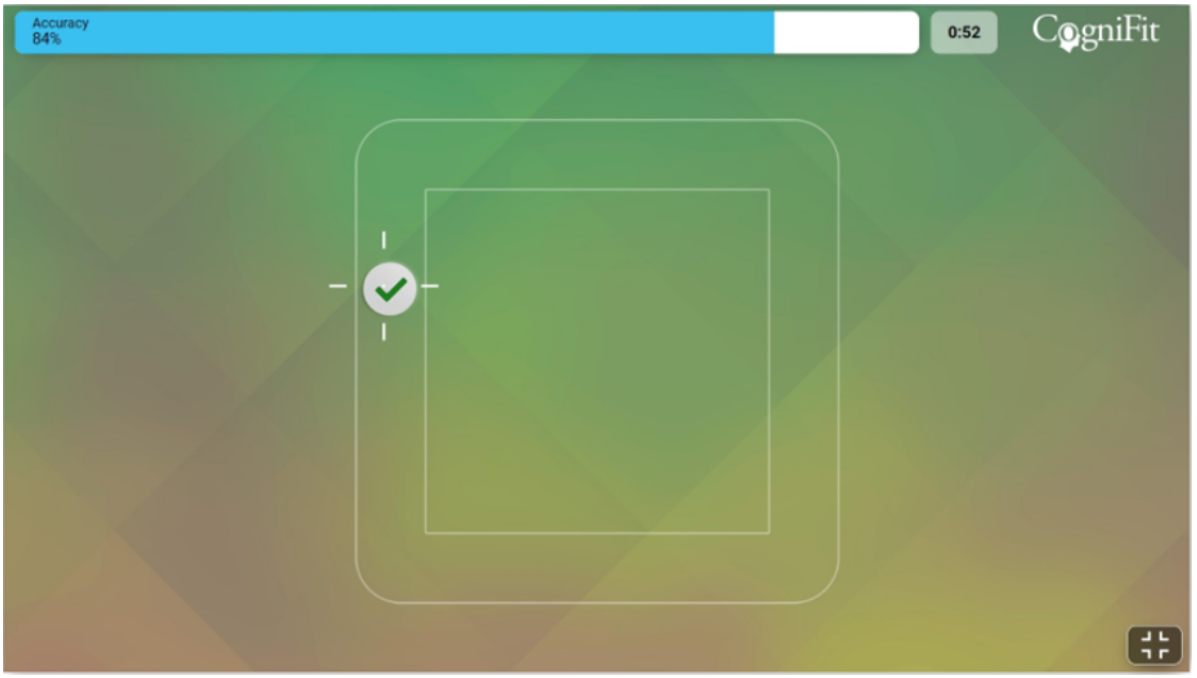

Figure 3. Eye-Hand Coordination Test example with accuracy measured

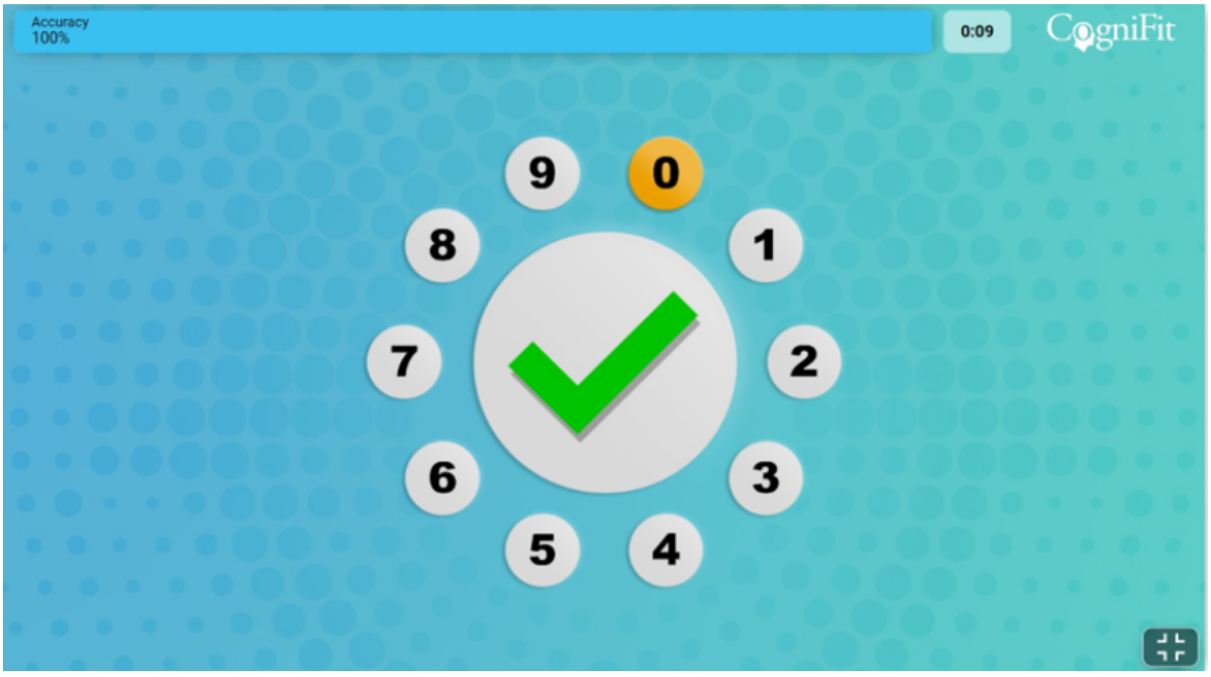

Figure 4. Digit span test example with accuracy measured

6.2. Educational Games for Dyslexic Individuals

Developers design educational games to support the learning processes of dyslexic individuals, aiming to motivate and capture their attention. These games, in particular, should possess the ability to provide customized content for children's education and make the learning process enjoyable. To address the learning needs of dyslexic children, we recommend proposing a software development process model as a solution for creating educational applications. Such models should embrace a user-centered approach, considering the involvement of various stakeholders like teachers, students, psychologists, software engineers, and more [28]. Research indicates that developing educational applications requires different perspectives from stakeholders such as teachers, psychologists, programmers, students, and IT analysts. [29]. Thus, it is crucial to have a software engineering process that integrates analysis, design, development, evaluation, and more.

6.3. Artificial Intelligence-Based Assistants

Artificial intelligence-based assistants aim to provide personalized learning experiences for dyslexic students. These assistants utilize various data sources to determine strategies and tools tailored to the needs and learning styles of dyslexic students. Student surveys, clinical analyses, and other data sources are fundamental in operating artificial intelligence modules. These studies aim to assess the performance and effectiveness of AI-based assistants.

According to a project, artificial intelligence and virtual reality were used to identify the challenges faced by dyslexic students. In preparation for this project, a comprehensive dataset was collected and preprocessed. The first experiment to demonstrate the performance of the proposed artificial intelligence tool used a dataset obtained from Italian universities. This dataset consists of responses from 719 dyslexic students to 52 questions. Among these questions, 12 address various problems caused by dyslexia (comprehension difficulties, writing challenges, concentration issues), 17 investigate the usefulness of specific learning support tools (concept maps, differently colored words), and the remaining 22 explore different

learning strategies and activities for students. The answers to these questions were collected and analyzed using a Likert scale. We evaluated various algorithms such as Random Forest (RF), k-nearest Neighbors (kNN), Support Vector Machines (SVM), and Logistic Regression to determine the best model and configuration for predicting each tool and strategy from this dataset.

When examining the results presented in Table 2 [30, table 2], we can observe that the top three models with the best performance are SVM Linear with a score of 0.9761, SVM RBF with a score of 0.9633, and kNN with a score of 0.9538 when K=7. On the other hand, the model with the lowest score is again SVM RBF with a score of 0.7246. When evaluating the results, it is evident that the same models yield different scores. As a result, factors such as the threshold value, input type, and data consistency may contribute to different predictions from the same model (SVM RBF). Further analysis is required to determine the precise factors influencing the best results.

Table 2. Best Model to Predict each Support Tool

ID	Best Model	Thr	Input	Cons	Score
T1	SVM RBF	4	Numeric	Yes	0.7443
T2	RF, 50 estimators	4	Numeric	No	0.9433
T3	SVM Linear	1	Binary	No	0.9111
T5	SVM RBF	1	Binary	Yes	0.8852
T6	KNN K=7	1	Binary	No	0.9538
T7	SVM Linear	1	Binary	No	0.9761
T8	KNN K=11	1	Numeric	No	0.9325
T9	SVM RBF	1	Binary	No	0.9298
T10	SVM RBF	1	Binary	No	0.9436
T11	SVM RBF	4	Binary	Yes	0.7246
T12	SVM RBF	4	Binary	Yes	0.7410
T13	KNN K=9	1	Binary	No	0.9449
T14	SVM RBF	1	Binary	Yes	0.9633
T15	SVM Linear	1	Binary	No	0.9354
T16	RF 50 estimators	1	Numeric	No	0.9279
T17	SVM linear	1	Binary	No	0.9367

6.4. Design of Customized Educational Applications

The design of customized educational applications for children facing learning difficulties like dyslexia demands a user-centered approach. People should understand that the level of interest does not solely revolve around entertainment and games; instead, it should be based on the learning perspective in interactive educational aesthetics tailored to a specific age group. Such an environment aims to capture children's attention towards the design of cognitive applications based on their abilities, needs, and learning ease [31]. Application design should align with the age and skills of children and the objectives of the application. User-centered design, especially regarding the user interface design for any cognitive application targeting disabled children, is a fundamental aspect of Human-Computer Interaction (HCI) [32]. The application interface should be user-friendly, focusing on user satisfaction and ease of use.

Research has shown that there are various multimedia cognitive learning applications previously designed. [33, Table 3] presents the main components, frameworks, and algorithms used in these applications for dyslexic children. This table lists the components used in various applications [34].

Table 3.Components used in various applications

Application Name	Features
Dyslexia Baca	Developed in Malaya language, assist alphabet recognition, motivated then to learn and read, repetitive activities of game, reward pages and based of ADDIE model.
MyLexic	Developed in Malaya language, dual coding theory and scaffolding instructional technique has been used and courseware prototype is used
EasyLexia 1.0	Content, activities, course, motivation, word finder games, choose it game, sound finder game, text legible, avoid background stimuli, achievements.
Improve Writing with mobile Application for dyslexia	A mobile app, Writers Learning Algorithm (WLA), text legible, significant multimedia elements, avoid background stimuli. User profile, the progress of the user.

According to research, applications emphasize content and educational software over user interface design. If the flow of the designed application is user-friendly and motivates the user to interact with the system enjoyably for cognitive learning, learning outcomes can be improved [35].

6.5. Example of Applications

6.5.1. Dyslexia Quiz

The software application facilitates a comprehensive understanding of the impact of dyslexia on children aged 5-11 in an engaging manner. It proves exceptionally advantageous for parents and educators seeking insights into the experiences of children with dyslexia. The 4-minute test incorporated within the application encompasses 50 potential symptoms of dyslexia. The application effectively illustrates the ramifications of dyslexia on a child's performance in reading, writing, memory tests, and planning. These activities

help children discover how many symptoms of dyslexia they have. [36, Figure 5] displays the interfaces of the Dyslexia Quiz application.

Figure 5.a. Introduction and reading exercise page of the application

Figure 5.b. The writing and memory exercise page of the application

Figure 5. 'Dyslexia Quiz' application interfaces

6.5.2. Reversals For Dyslexia

It is an application that includes activities based on preventing confusion of letters such as b-d, p-d-b, and numbers 6-9, which are common symptoms of dyslexia, and reducing these problems. Within the application, users can choose between letters or numbers and engage in activities where they can flip them vertically or horizontally. [38, Figure 6] displays the interfaces of the Reversals For Dyslexia application.

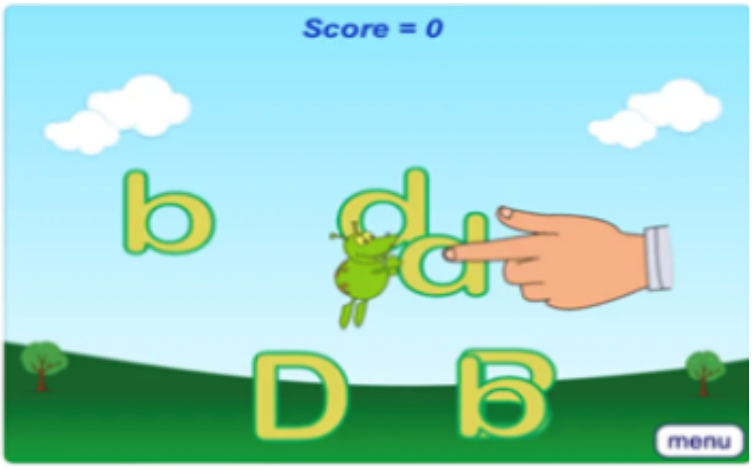

Figure 6.a. Game example of the application

Figure 6.b. Game example of the application

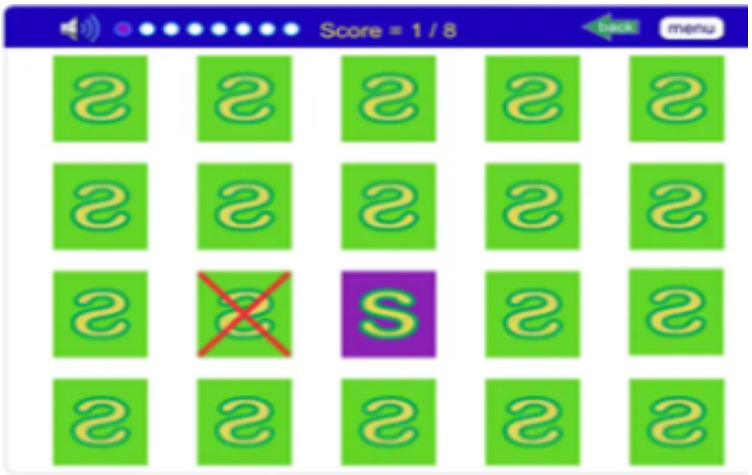

Figure 6.c. Game example of the application

Figure 6. Reversals For Dyslexia application interfaces

6.5.3. Smartex Akıllı Alıştırmalıklar (EN: Smartex Smart Exercises)

Developers created the application to address neurological issues such as dyslexia, dysgraphia, dyscalculia, and speech-language disorders. It incorporates activities such as letter matching, picture matching, word puzzles, and auditory puzzles, allowing users to listen, comprehend, and match. The application aims to address the challenges faced by children with this type of neurological disease through games, which are tailored based on the child's performance. The application is ad-free and free.

Gains provided by the application:

- Development of Phonological Awareness Skills
- Development of Attention and Focus Skills
- Development of Visual Perception Skills
- Development of Reading and Writing Skills
- Development of Auditory Perception Skills
- Development of Optical Discrimination Skills
- Development of Mathematics Skills
- Development of Articulation Skills
- Development of Language and Speech Skills
- Development of Memory Skills

Smartex Smart Exercises application interfaces are given [39, Figure 7].

Figure 7.a. Smartex Application Main Page

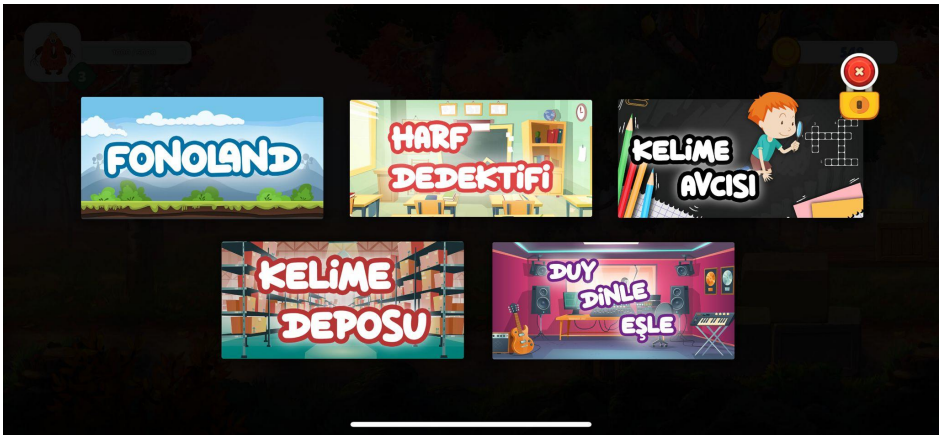

Figure 7.b. Game in dyslexia (TR:Disleksi) part of application

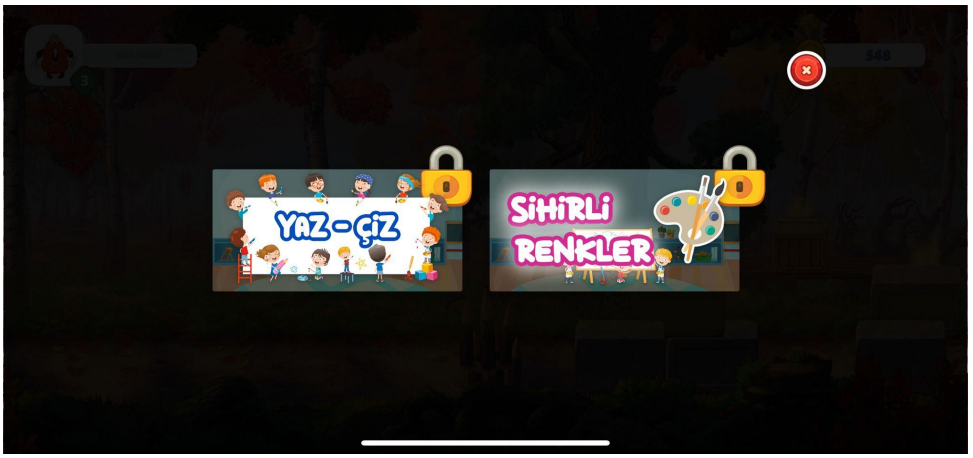

Figure 7.c. The games in the dysgraphia(TR:Disgrafi) part of the application

Figure 7.d. The games in the dyscalculia(TR:Diskalkulia) part of the application

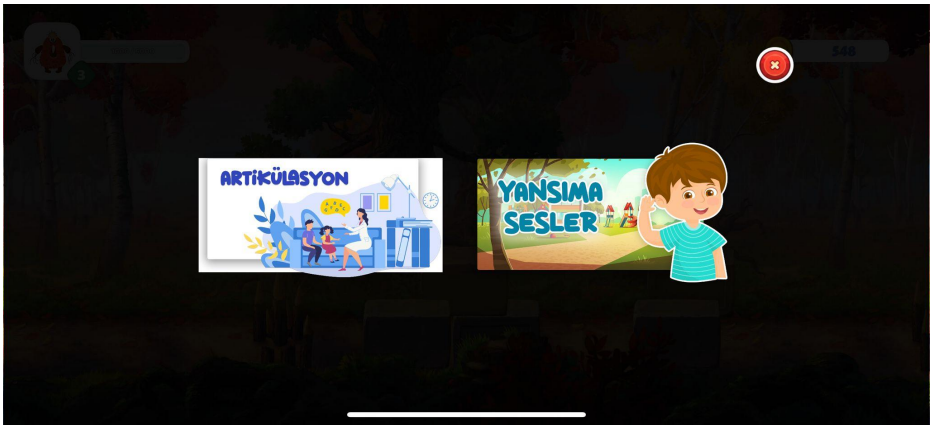

Figure 7.e. The games in the dyscalculia(TR:Diskalkulia) part of the application

Figure 7. Smartex Smart Exercises application interfaces

6.5.4. Dyslexia AI

The application's design aims to enhance the reading and spelling skills of children with dyslexia. The application puts children to the test with unique games. These games include features such as categorizing words according to their phonetics, making sounds of words, and artificial intelligence-supported voice recognition, and the rewards won from the game are displayed with augmented reality. [37, Figure 8] illustrates the interfaces of the Dyslexia AI application.

Figure 8.a. Text & Speech part of the application

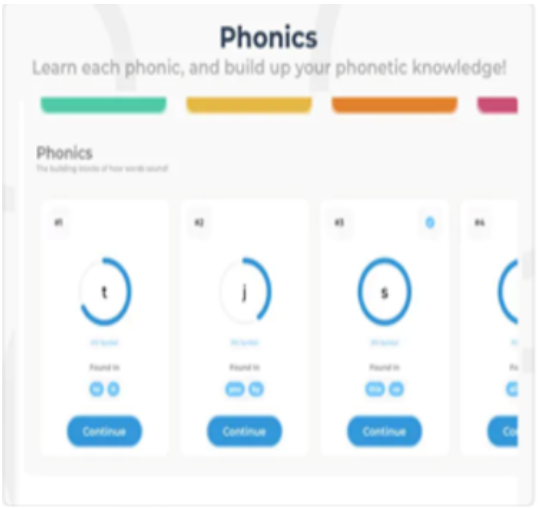

Figure 8.b. Phonics part of the application

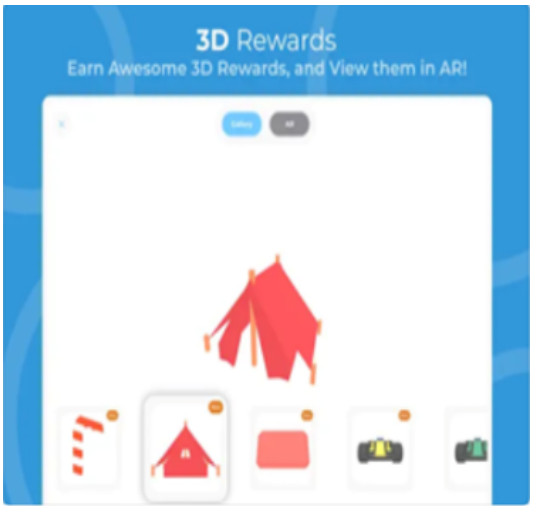

Figure 8.c. 3D Rewards part of the application

Figure 8. Dyslexia AI application interfaces

6.5.5. Auto Train Brain

The first software was the dyslexia application called AutoTrainBrain, developed by Günet Eroğlu, a PhD student at Sabancı University. Believers argue that using this software increases children's reading speed and reduces the likelihood of errors. AutoTrainBrainde completed the testing process with 100 individuals and received support from TÜBİTAK. The statement mentions that the annual subscription fee is $250. [40, Figure 9] displays the Auto Train Brain application interfaces.

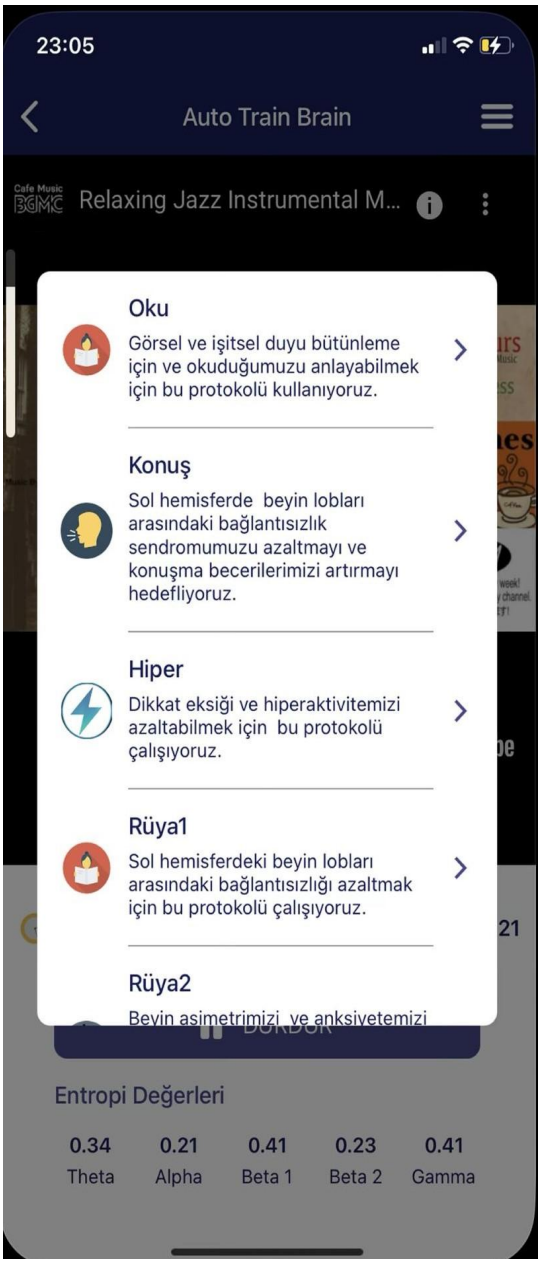

Figure 9.a. Information protocols used in the application

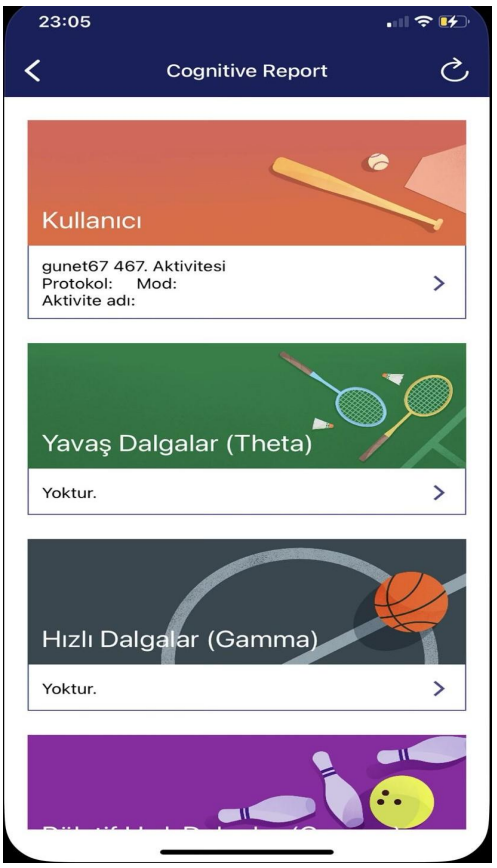

Figure 9.b. Application Cognitive report section

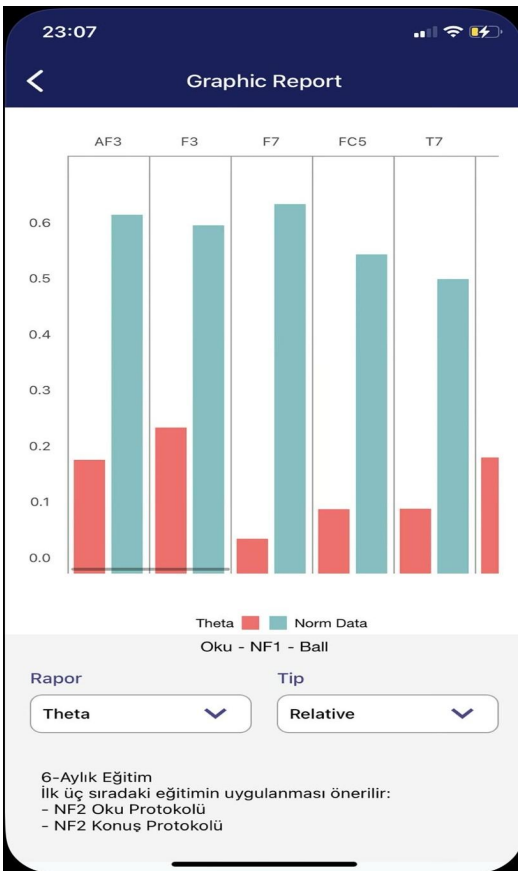

Figure 9.c. Application Graphic report section

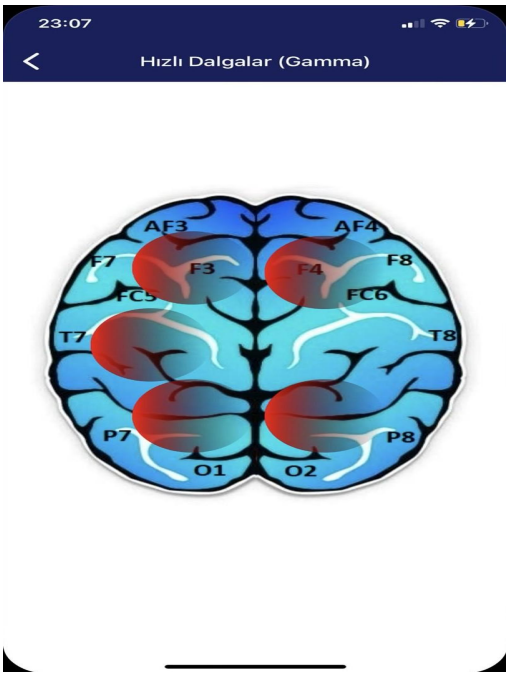

Figure 9.d. The results of the tests performed show in the brain

Figure 9. Auto Train Brain application interfaces

6.5.6. Read&Write Gold

Texthelp developed Read&Write Gold, an easy-to-use software that users can access from a computer or phone. It attempts to alleviate dyslexia and other learning disabilities by reading text typed on the screen or any text aloud. It increases the individual's self-confidence by reading bold or double-colored areas aloud with the add-ons available in the application. If we count the features it includes, these are Listening to Speech by Reading Text, Guessing/Filling in Words, and Translating Words. It is a type of software that is easy to install and start using. [41, Figure 10] illustrates the interfaces of the Read&Write Gold application.

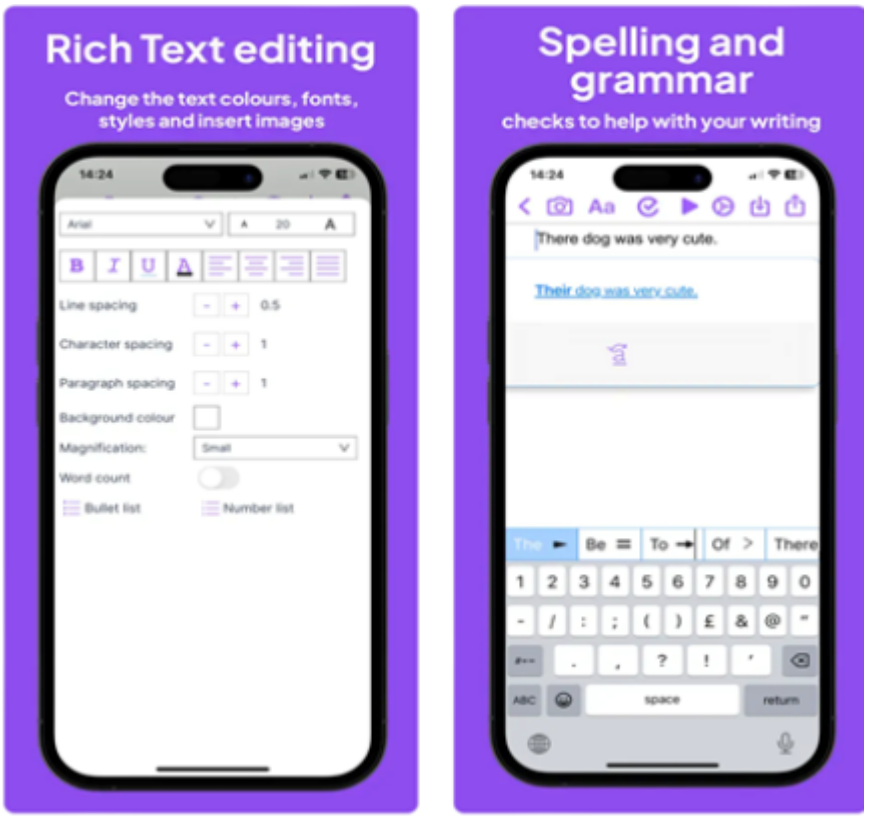

Figure 10.a. Rich text editing Spelling & Grammar Part of Application

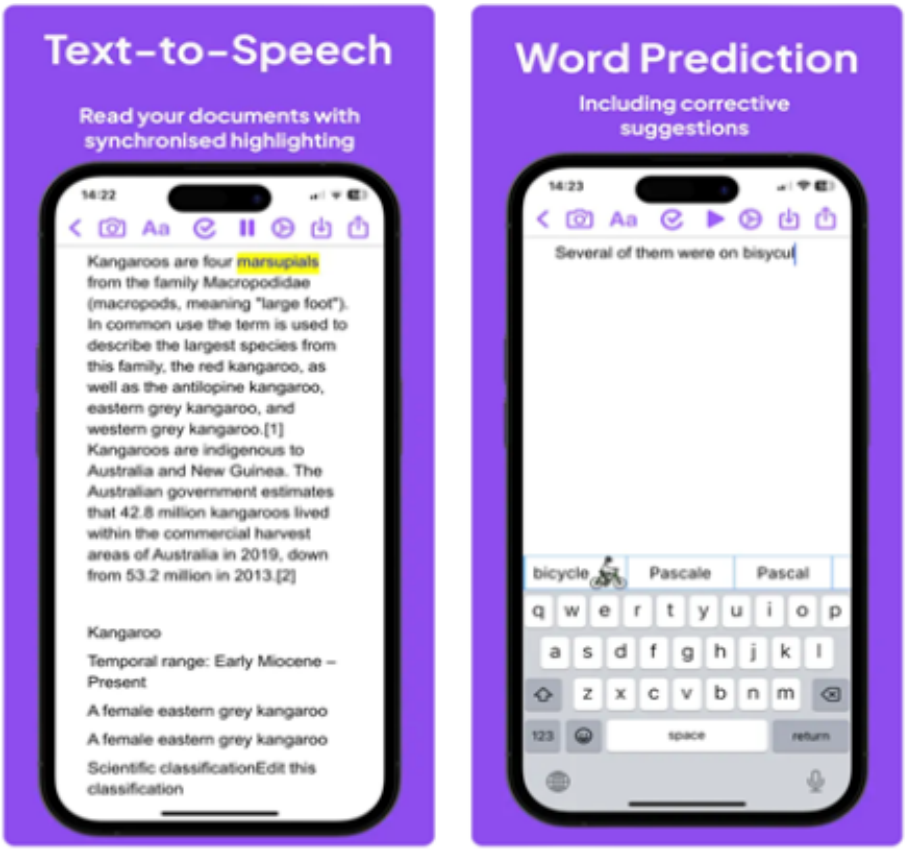

Figure 10.b. Speech-to-Text & Word Prediction Part of Application Figure 10. Read&Write Gold application interfaces

6.5.7. Speechify

It is a software application that can help people with dyslexia and others with ADHD, autism, and other learning disabilities. Through the translation of text into speech and the highlighting of text, the application enhances the perception of letter sounds. It promotes focused attention on words, thereby facilitating improved fluent reading. The incorporated software enables enhanced text comprehension, fostering an increased interest in reading. This software application, compatible with most browsers, is accessible and usable at no cost. [42, Figure 11] displays the interfaces of the Speechify application.

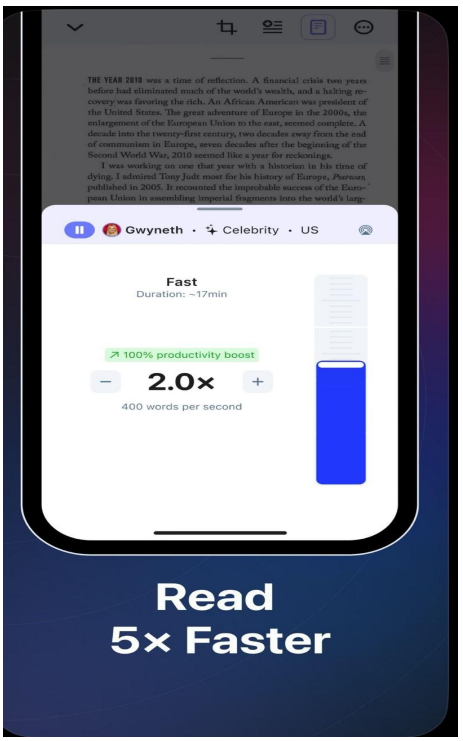

Figure 11.a. The effectiveness of measuring and improving the reading speed of the application

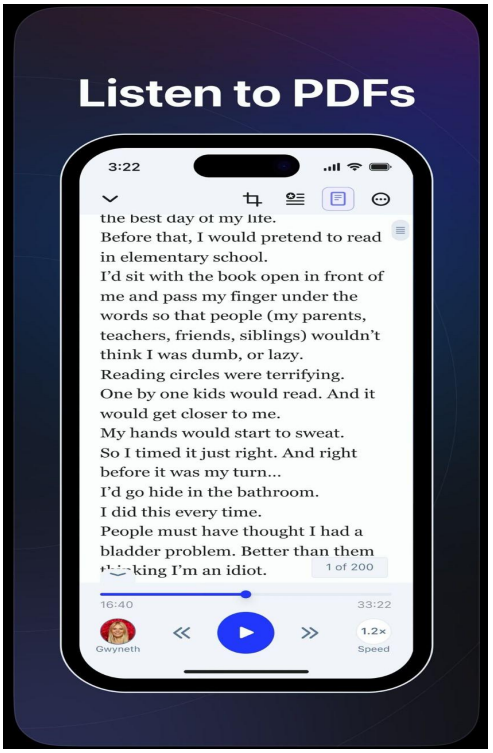

Figure 11.b. Listening and reading exercise

Figure 11. Speechify application interfaces

6.5.8. Dyslexia Quest

This application, which targets children between the ages of 5-11, helps overcome dyslexia with game-based tests. Developed at the Bristol Dyslexia Center, the software is accessible via the browser without downloading. Under adult supervision, it completes a game called Elimination Yeti Mountain within 20 minutes, without children realizing they are in a test, thus determining whether the child is at risk of dyslexia. In [43, Figure 12], the Dyslexia Quest application displays its interfaces.

Figure 12.a. Application number sorting game

Figure 12.b Application character matching game

Figure 12. Dyslexia Quest application interfaces

6.5.9. Yazı Sihirbazı (EN: The Writing Wizard)

The software application facilitates writing style editing and enhances writing speed by passing over letters, words, or sentences with one's finger. This application is free for download on Google Play for ages 5-11. [44, Figure 13] illustrates the interfaces of the Yazı Sihirbazı application.

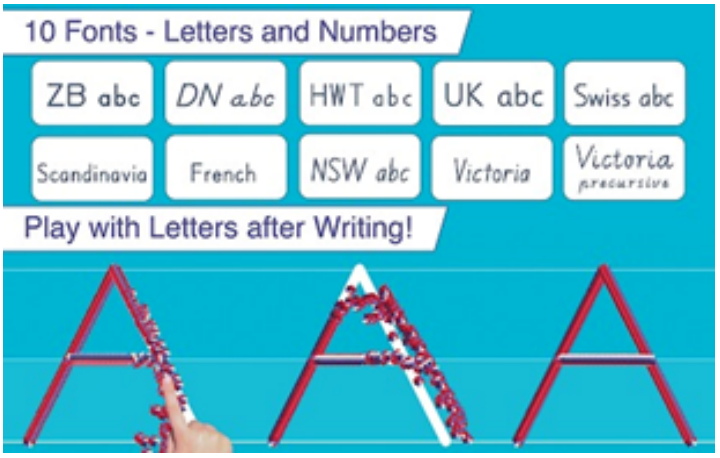

Figure 13.a Matching activity by typing numbers and letters

Figure 13.b Finding the right word according to the number of letters of the word

Figure 13. Yazı Sihirbazı application interfaces

6.5.10. Simplex Spelling Light

Designed to enhance writing and reading skills in a fun and interactive way, it utilizes 'Reverse Phonics.' The prevention of word memorization in

over 1000 languages, coupled with the facilitation of fluent speech through spelling and repetition with provided clues, comprises vital features of this application. A success message is displayed upon the correct pronunciation of a word, encouraging users to attempt to find the correct word with hints. This software application, exclusively available on IOS, is downloadable and usable at $4.99. [45, Figure 14] displays the interfaces of the Simplex Spelling Light application.

Figure 14. Simplex Spelling Light application interfaces

7. Conclusion

The study examined the effects of dyslexia on children in general and the diagnosis and treatment of dyslexia. Researchers have examined which software tools are typically used to diagnose and treat dyslexia. The study describes the diagnostic and treatment aspects of dyslexia in two different areas: health and software. Researchers examined the methods used to diagnose and treat children with dyslexia and standard techniques. Researchers examined the software used to diagnose and treat dyslexia and the projects that have been developed to date. Researchers have conducted many studies on dyslexia in children. These reviews have helped us learn more about the disorder in both software and healthcare, and our work has helped you better understand what dyslexia means.

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