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# DIGITAL TECHNOLOGIES FOR DYSLEXIA

Athanasios Drigas * and Athanassia Dourou

Net Media Lab Brain-Mind R & D, Institute of Informatics and Telecommunications, N.C.S.R. "Demokritos", Greece
* Corresponding Author

ORCID Details
Athanasios Drigas: https://orcid.org/0000-0001-5637-9601

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## ABSTRACT

This essay is an overview of the use of information and communication technologies (ICTs) in diagnosing, treating, and assisting people with learning difficulties, particularly those with dyslexia. Several research that use computerized methods or specially created apps for adults and kids with dyslexia are discussed here. Particular emphasis is placed on personalised strategies for diagnosis and treatment. Fuzzy systems, artificial intelligence, and other new technologies on general or specialized topics provide direct observation, measurement, and certification of the subject; as a result, they are incorporated on created software for diagnosis, screening, or intervention. Studies on learning disorders (particularly dyslexia) that have been made so far by researchers that have conducted extensive global study in the educational sector are presented below. These studies on psychological assessment, diagnosis, and intervention appear promising in light of recent technological advancements.

**Keywords:** ICTs technologies, Dyslexia, Diagnosis, Intervention, Assistance, Learning.

## 1 INTRODUCTION

This article is a research study that identifies the diagnostic, instructional support, intervention, multimedia, web, and e-learning technologies that ICTs can provide for a learning disorder (dyslexia). The European Dyslexia Association defines dyslexia as a neurologically based difficulty learning reading, spelling, and writing skills [21]. They can be caused by cognitive issues that interfere with working memory, phonological processing, quick naming, sequencing, or even a combination of issues that impair the automaticity of fundamental skills. There is no relationship between one's socioeconomic standing, amount of intelligence, or personal effort. However, socio-cultural origins, educational possibilities, the variety of languages spoken, and multilingual requirements all have a significant impact. Studies have examined the structure of the corpus callosum and the thickness of the cerebral white matter in relation to the diagnosis of dyslexia. Studies on intervention also concentrated on phoneme discrimination, working memory, phonological awareness, writing-reading-spelling abilities, and phonological awareness. Despite the fact that intervention is regarded as a sort of support, we reasoned that it might be presented as a separate category from learning assistance because programs were created for specific dyslexic impairments and utilized to advance a certain ability.

During the learning process, multimedia, mobile devices, and web applications were evaluated in a substantial way. Users are interested in the technology and are appropriately motivated to utilize it thanks to the interaction and multi-sensory elements. Following an investigation into the challenges they faced in synchronous learning and e-learning environments, they designed more user-friendly, tailored environments and made it easier for dyslexic users to access them. A computer-based application that offered individualized features, unique word processing settings, tailored presentation of reading materials, and the ability for users to edit the text was presented in research on learning support. Additionally, spelling checkers and multimedia settings were suggested to help with spelling problems. In this study, an effort was made to demonstrate the critical role that ICTs play in addressing dyslexia. People with dyslexia can approve their post cognitive talents and overcome literacy or social challenges while receiving individualized intervention. Regarding intervention, there are two key factors. First, how conventional methods were modified and computerized in the context of ICTs, and second, the creation and development of whole new instruments and methods. People with dyslexia may participate in the learning process, have their self-esteem increased, and may enhance their psychological state by using these programs and by adhering to these strategies. The relationship between ICTs and learning difficulties may also have an impact on other branches of science like psychology, social science, and education.

The importance of all various digital technologies in the field of education is highlighted in our introductory final point. ICTs support universal access to education, provide innovative approaches for effective teacher training, enhance learning retention, promote cooperation, increase openness, develop learner-centered approaches, and hasten the process of learning. Additionally, by using virtualization, mobilization, artificial intelligence, and new learning environments like virtual worlds, support educational activities and methodologies. More specifically, ICTs are very effective and productive in learning disabilities training, facilitating and improving assessment, intervention, and educational procedures via mobile devices that bring educational activities everywhere [27] and through a variety of ICT applications that serve as the backbone of education [28-31]. The use of AI, STEM, and robotics raises educational practices to new levels of flexibility, innovation, and performance [32-35], while games turn education into a multimodal, incredibly amiable, and pleasurable engagement [36]. Moreover, the adoption, improvement, and fusion of ICTs with theories and models of metacognition, mindfulness, meditation, and emotional intelligence cultivation [37-39] places the development of mental abilities at the center of educational procedures and policies, which accelerates and improves educational practices and outcomes, particularly in children with dyslexia domain and its procedures like assessment and intervention.

## 2 DIGITAL TOOLS FOR DYSLEXIA ASSESSMENT AND DIAGNOSIS

### 2.1 Brain analysis –based Diagnosis

Studies on the brains of dyslexics have been undertaken in order to better diagnose the disorder [1] [2]. Dyslexic individuals have aberrant cerebral white matter anatomy, according to neuropathological research, which also looked at the quantitative shape analysis of CWM (Cerebral White Matter) gyrifications on 3D Magnetic Resonance Images (MRI). The steps in their strategy are as follows: employing a deformable 3D border to segment the CWM on a 3D brain image, extract gyrifications, and perform shape analysis to gauge the thickness of the extracted gyrifications. The results are separated into those who are dyslexic and those who are not, which appears to be a very valuable analytical tool. The early diagnosis of dyslexia is done concurrently using a brain cortex examination. The special basis functions (spherical harmonics - SHs) are combined in a spherical harmonic analysis for the 3D surface of the brain supported by the unit sphere [3]. These procedures are followed when conducting this kind of analysis: Three-dimensional brain cortex segmentation, creation of a 3D mesh model of the brain cortex surface, mapping of this model to the unit sphere, computing SHs on the surface, and figuring out how many SHs to use to delimit the brain cortex. By combining this description of the brain's shape complexity with a new shape index, it is possible to classify dyslexic and non-dyslexic brains.

### 2.2 ICTs-Based-Diagnosis

The DEST exam, the most reliable pre-school dyslexia screening assessment, has been created as a computerized test [4]. Early age diagnosis of dyslexia is accomplished by utilizing carefully crafted tests on facts that are supposed to be independent of reading because theoretical diagnostic methods fail to define dyslexia before a kid is able to learn to read. Additionally, the findings produced by the latest generation of computers are unbiased and trustworthy, and when combined with well created programs, they demonstrate their validity by mirroring the outcomes of more conventional approaches. According to a study on visual stress, which refers to unpleasant visual sensations that readers feel, dyslexia is still unrelated [5]. ViSS, a computerized visual stress screener with visual search that resembles reading, has been introduced. Children that struggle with reading are reported to be far more vulnerable to both critical and non-critical symptoms, as well as visual stress. Furthermore, research suggests that children with dyslexia may experience visual stress more frequently than children without. Using artificial neural networks is another methodical strategy for identifying dyslexia in children and classifying possible instances more precisely and conveniently [23]. In areas other than literacy acquisition, dyslexia symptoms might vary, making it difficult for traditional diagnostic tools to provide an accurate diagnosis. According to this method, a successful distinction between dyslexic and non-dyslexic people is achieved when using MLP (Multi layer perception) neural network architecture for the correct classification and the input of evaluation tests including testing of reading ability, phonological coding skills, and an IQ test. Children must complete a non-writing based graphical test to diagnose dyslexia in the early stages of development [24]. Due to the complexity of artificial intelligence approaches and the fact that some symptoms are consistent with more than one condition, experts have projected that the results may give rise to disagreements. A linguistically intelligible, rule-based classifier has been created utilizing a genetic cooperative algorithm to improve the accuracy of this test inasmuch as genetic systems may leverage the information in uncertain data sets. This algorithm is a component of an online pre-screening program. When they notice a symptom and want to get a professional's opinion on further testing, parents can use it.

## 3 DIGITAL TOOLS FOR DYSLEXIA INTERVENTIONS

### 3.1 Computer-Based tools

The use of educational technology to support phonological awareness that may endure despite intervention is of great interest [6]. To aid dyslexic readers by teaching them phonological awareness, the hypermedia program PHAES, or "Phonological Awareness Educational Software," was created. Additionally, it has been made to be appealing to kids, with basic graphics, avoid cognitive overload, straightforward navigation, and the ability to run on any computer. Additionally, since the age range is not clearly defined, it can be utilized with or without supervision while still being a helpful and supportive teaching tool. This application has shown to be instructive and serves as an illustration for additional research in the field. Heredity concerning dyslexia appears to be a factor and therefore a study examines early prevention during pre-reading ages [7]. Therefore, pre-reading children who are genetically at risk receive a home-based and computer-assisted training on phonemic awareness and the relationship between letter sounds, which has been based on Beck's original "Word Building" technique. These kids develop their reading abilities more than kids without familiar risk who have also received additional training, and they maintain the typical progression of phonemic awareness more than kids with familiar risk who haven't received any training. According to the studies mentioned above, home and school-based instruction up through the first grade is recommended in order to have the best effects.

### 3.2 Digital media

An analysis of DTV-based dyslexia rehabilitation Children in Italy have been exposed to and addressed by digital television [8]. For those who are familiar with television but lack Internet connection or the necessary skills to use it, this is a type of ICT-based service. T-health's T-islessia study involves six-year-olds at risk for dyslexia who regularly practice rehabilitation exercises at home or at school. This initiative created the "Magicabra" interactive service, which offers incredibly dynamic activities to improve reading and writing skills. Results have been satisfactory, and learning levels have increased as sessions have become more engaging. In the UK, there is more research being done on how computer-based media affects dyslexic people's learning outcomes [9]. Ineffective working memory is a characteristic of dyslexia, according to the DCT (Dual Code Theory) theory upon which the research was based. According to processing findings, the understanding of dyslexic learners has significantly varied depending on the media combinations used.

### 3.3 E-learning and dyslexia

It is clear from reading the Special Education Needs and difficulties Act (SENDA) introduction that learning websites and educational materials must go through reasonable changes to accommodate individuals with learning difficulties. [10][11]. Thus, research into how e-learning and online learning activities address issues for students with dyslexia beyond accessibility and web design has started. The three main phases of this research are theory development, theory testing, and theory extension. Results show that synchronous learning activities like reading, spelling, sentence construction, transposition, memory, organization, time management, and confidence are difficult for kids with dyslexia. Given that those with dyslexia experience specific challenges while engaging in e-learning activities, a research [12] was created in a tailored e-learning setting that aids dyslexic students. The phenomenological approach to learning is implemented, the learning process is tailored to dyslexic students, learning activities are focused on developing reading ability, learning activities with learning resources, and collaboration capabilities for e-learning environment production are all features of the framework for creating a computer-based personalized environment. By merging learning resources from all accessible databases and using specific models, this framework gives educators the ability to create a range of learning units. Another research has developed a framework of adaptable e-learning environment in order to achieve personalized e-learning facilities for dyslexic pupils [22]. It is an open agent-based framework that facilitates automated production composition and usage of ontology-based learning capabilities, as well as management, reuse, and retrieval of outside resources. It features Knowledge Expert Agents, Teacher Agents, Dyslexic Learner Personal Agents, Collaboration Agents, Evaluator Agents, Web Search Agents, Mapping, Annotation Agents, and External Resource Agents. In conclusion, this reuse platform architecture offers an effective and efficient e-learning environment since it makes use of the flexibility and semi-automation offered by semantic and agent-based technologies.

### 3.4 Games, multimedia tools, and web

A multimedia-based learning object called IMLO (Interactive Multimedia Learning Object) has been developed by several researchers who have incorporated multimedia components as a key component of strategies, activities, and environment [13]. Its technique has been modified to follow a think-allowed procedure, which urges users to speak their thoughts out loud as they carry out a series of certain tasks. Its main goal is to present this subject using an engaging, narrative format. Children with dyslexia have been used to test its usability, and qualitative methods have been employed. The results are adequate given that their goal is to comprehend how multimedia elements are used in the context of dyslexia to enhance learning. According to a study on computer-based learning games, dyslexic pupils have the chance to overcome some challenges and a lack of desire [14]. The software that has been designed and its adaption to meet specific demands have an impact on how much this influence is felt. A project called Caldys2 has been created, and it includes a number of activities that could be used to instruct dyslexic foreign language learners in the English language. The Learning Games Education Evaluation Rubric, which consists of 19 questions focused on learner interface, pedagogy, sustainability, and technological factors, was designed because there is no way for evaluation. This project's goal was to provide efficient learning software for all students, dyslexic or not, and it was accomplished.

## 4 LEARNING ASSISTANCE

### 4.1 Reading Assistance

Children who have dyslexia have unique learning abilities, and most of the time, only institutions with specific programs can help them with their reading issues. As a result, a study [15] on reading support was started, and software called AGENT- DYSL, which influences the learning process, was created. This technique suggests a customized reading program for dyslexic kids that uses specially prepared reading materials. It uses age-appropriate and dyslexia-sensitive user interfaces, connects with the educational setting, and considers the learning context in order to be more acceptable. The primary distinction between this software and other programs is the individualized help. As it integrates speech recognition, state recognition via picture, and error type profiling via adaptive and individualized support, it has been shown to be very beneficial for kids with dyslexia. Since reading is a problem for dyslexics, an intelligent tutoring system project called the R2aft tutor (Repeated Reading Adaptive Fluency Tutor) was created [16]. Its goal was to help dyslexic children read more fluently. It inspires kids and teaches them proper decoding techniques. The TASA (Text And Story Assembler), an engine that creates texts to be read, was initially developed. TASA consists of three different sorts of facts: user-model, story-world, and lexicon, and it is a set of rules in the Clips expert system shell (by Giarratano and Rilley). Another aspect is that the interactive story that is constructed and allows students to make plot decisions that affect how the story develops motivates them. Although more evaluations of the method are planned for the near future, its use is successful for dyslexic pupils. Studies on dyslexic persons' implicit learning capacities have produced some ambiguous results. A recent study [25] takes a different tack and uses the serial response time task (SRTT) and artificial grammar learning (AGL) to evaluate implicit learning capacities involving the motor system. They are considerably distinct in terms of motor requirements and the cerebellum's primary function in learning, but they are also very similar to the cognitive process involved in implicit learning. Two groups of twelve adults who are native German speakers and are either dyslexic or not take tests. Researchers have identified potential discrepancies in the fundamental processes of SRTT and AGL using common neurophysiological measures of reading comprehension, attention, and executive functioning. SRTT tasks are then performed, in which participants are shown a structure display and their learning is assessed by comparing their response times (RT) to those of a random structure sequence. In AGL, letter strings adhere to a Markovian finite state grammar, and players must evaluate new letter strings in light of their grammar composition. According to the aforementioned studies, implicit learning in dyslexia is an intact quality that may need to be taken into account when developing training programs. Following the previous research, another one on implicit learning has been developed this time for primary school children (9-12 years old) with developmental dyslexia using artificial grammar learning AGL (task) [26]. youngsters with dyslexia and generally developing youngsters were included in the test groups since implicit learning may be impacted by developmental variations between them. Due to reports that students with developmental dyslexia associate deficits with both explicit and implicit processes, two AGL experimental conditions are studied. Implicit instructions are the emphasis of the first experiment, while explicit instructions are the focus of the second experiment. In trial one, the usually developing children's group was impacted, and a grammatical improvement was seen in both studies. Due to the possibility of it interfering with other cognitive developmental factors, children with developing dyslexia were unable to demonstrate their performance on the AGL.

### 4.2 Spelling Support

Numerous research have been conducted on the topic of spelling assistance for dyslexics. One of them introduces BABEL [17], a software program that serves as a spelling checker for writers who struggle with dyslexia. It incorporates a model of each user's spelling patterns and can handle multiple errors. The operation of the user model is based on the creation of rules and is similar to the example given by Young and O'Shea. This method models and derives from Patterson and Shewell's cognitive model only the bad rules. They represent transfers of errors made by dyslexic authors and are more sophisticated. The accuracy of the system has been evaluated and enhanced by researchers using decisions taken from a list of suggestions as feedback. Evaluation and testing have concluded that there is successful correction and detection of errors and user model allows correcting diverse errors more effectively. Another development of a computerized environment for dyslexic children has been presented, [18] which encourages them to construct their own rules for the words they have spelling problems with. This study is built on the SelfSpell environment, which enables 'point and click' interaction as well as the integration of text, pictures, and synthetic speech. The major objective is for the youngster to be able to use it most of the time without assistance, with just limited support from a parent or teacher. A program within the environment has been created as a result, and all buttons are now programmed to "say" their names when the mouse pointer is over them. Additionally, some highlighted words are now also spoken via a speak button. The study of groups of dyslexic students, who were on average 13 years old, revealed that this program is effective and motivating and that spelling has improved.

### 4.3 Mathematical Skills

Since dyslexia is thought to be a cognitive impairment, several researchers have started developing methods to help dyslexic students. The construction of cognitive tools for improved performance on mathematical tasks is presented in this study [19]. As 'Spatial Math Tutor', an online tutoring environment, has been created, tested, and made use of these tools. The "face-to-face" interaction, which has been shown to be helpful for kids with learning challenges, is its key innovation. The graphical SMT representation and the handling of CG objects have helped elementary school kids with dyslexia. Taking into account all the supportive 3D graphic technology and interactive tutoring, SMT might be a useful tool for users with dyslexia who experience difficulty with their mathematics skills. For students who are dyslexic, there are additional challenges outside just reading, writing, and spelling [20]. The most effective assistive technologies for mathematical terminology, symbols, and graphic representation have been studied. The major goal is to provide a tool that enables users to read technical and scientific papers, comprehend the spatial organization of formulas and matrices, and write technical and scientific articles. LaTex was the proper text language for the researchers to use. Additionally, using a speech synthesizer and a LaTex parser, each mathematical item may be linked to its equivalent in mathematical language. Finally, this software shows to be quite beneficial for students' homework and to teachers as well.

## 5 CONCLUSIONS

Concluding, the importance of all digital technologies in the field of education is highlighted in our final point. ICTs support universal access to education, provide innovative approaches for effective teacher training, enhance learning retention, promote cooperation, increase openness, develop learner-centered approaches, and hasten the process of learning. Additionally, by using virtualization, mobilization, artificial intelligence, and new learning environments like virtual worlds, support educational activities and methodologies, especially for dyslexic's children.

## STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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The Authors proclaim no conflict of interest.

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