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Effect of Text-to-Speech Tools on the Reading Comprehension of Students with Dyslexia

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Abstract

Dyslexia is a neurodevelopmental disease, and there is no way to overcome it. The application of auxiliary technology in teaching can reduce the influence of dyslexia on students, such as the wide application of the use of text-to-speech (TTS) technology, which can help students better understand written materials to a certain extent. However, as an auxiliary tool, its application may also bring some negative effects, such as students' distraction. Therefore, the effectiveness of text-to-speech tools application still needs to be further explored. In this study, through the exploration of common tools, theories and development principles of text-to-speech technology, the relevant studies were reviewed to explore whether text-to-speech tools can improve the reading comprehension of students with dyslexia. The results found that text-to-speech technology may help students' reading comprehension, but more research is needed to further explore the extent to which reading comprehension can be achieved.

Keywords: Dyslexia, Text-to-Speech Tools, Reading Comprehension

1 | Background

Dyslexia is one of the most common learning disabilities, with a prevalence of up to 5-10%. Individuals with normal intelligence and equal educational opportunities, but show low accuracy and fluency in vocabulary recognition and poor spelling, and have significantly lower reading levels than children of the same age[1]. Reading comprehension, defined as the ability to obtain information through reading texts, is crucial for students to achieve success in an educational environment, as a lot of reading is required in any area of learning[2]. For students with dyslexia, reading comprehension is often difficult, one of the main causes is difficult to read written text. Inaccurate and

slow vocabulary and sentence reading, make it challenging to understand the text, it has a direct negative impact on reading comprehension, reduce the accuracy and speed of vocabulary reading. At present, there is no way to completely overcome dyslexia, but its impact can be reduced through educational means and intervention training.

Dyslexia is a neurodevelopmental disorder, and despite potential educational opportunities, dyslexic students have serious deficits in reading and, such as decoding, fluency, and some students do not respond to appropriate training and intervention[3]. An effective strategy is to use assistive technology in educational teaching to help students with dyslexia develop their potential and compensate for the defects in reading ability. A study by Emily et al. (2021) reported that the most impaired groups were deaf, blind (74%), visually impaired (71.4%), and physically disabled (46.5%), followed by students with dyslexia, with the use of assistive technology reaching 19.2%[4].

In addition to the traditional paper form, the reading materials can also be presented orally. Orally presented formats, such as text-to-voice, reading pens, and audiobooks, eliminates the need for decoding reading materials and may therefore help students with dyslexia to better understand written text. However, it is uncertain whether the use of text-to-speech tools is really helpful to the improvement of reading comprehension among students with dyslexia. Some studies of students with dyslexia using text-to-speech and related reading tools reported improved reading ability among students with dyslexia, while others did not draw consistent conclusions[5]. Due to these inconsistent conclusions, this study will review the relevant literature at home and abroad, and the purpose is to analyze the impact of text-to-speech, and the use of related reading tools on the reading ability of students with dyslexia.

2| The application of text-to-speech tools

2.1 An overview of the text-to-speech tools

2.1.1 Concept and working principle of text-to-speech tools

Text-to-speech (TTS) system is a speech synthesis application that transforms the general language text into speech, and transforms the files or web pages stored in the computer into natural speech output[6]. The text-to-speech system can provide alternative ways of learning and participation, so as to reduce the obstacles of text reading, realize the function of replacing visual information with auditory information, and present information in an adjustable way (such as highlighting, volume adjustment, etc.) to help people learn and express. Text-to-speech provides students with a

synchronous visual and auditory representation of text, which is applicable to various learners, including students with special educational needs (e.g., students with dyslexia). Most text-to-speech tools allow users to adjust speed and volume, and some applications can highlight reading sentences or specific words. Students who do not like listening to talk to others can choose to turn off the volume. Following either spoken or highlighted text allows students to read the text without missing the location.

Text-to-speech tools can read words appearing on the screen and has become a recognized aid for students with dyslexia[7]. A study conducted by Meyer and Bouck (2014) found that middle school students with dyslexia like to use text-to-speech programs to read grade-level explanatory notes. Students felt that reading took less time and that when they used text to speech, they were more fluent and understood more material. Overall, the use of text-to-speech in classroom settings is increasingly used as a means of providing oral convenience to impaired students.

Modern technology has built text-to-speech into devices (e.g., laptops, tablets, smartphones, etc.) or installed special tools of text-to-speech for students with dyslexia. The text-to-speech tools work by translating text appearing on a computer screen into computerized speech[8]. Computerized speech is produced by matching the text to pre-programmed articulation rules. Text can be entered directly into speech synthesis programs or into other word processing programs compatible with the text-to-speech tools, or using the scanner and optical character recognition tools. Students can use the tool to read a specific vocabulary, or the whole line, the whole text, instant phonetic feedback allows students to correct their reading errors by clicking on the words they do not know, so as to hear the correct pronunciation of the vocabulary. The use of text-to-speech tools reduces the frustration of students with not accurately decoding, and is more conducive to their complete understanding of the text[9].

2.1.2 Common text-to-speech tools for students with dyslexia

Text-to-speech technology is a kind of speech synthesis technology. The reading function of the text-to-speech tools is the instant synthesis of speech, which is different from the speech prerecording of traditional audiobooks. Research has shown that word recognition plays a key role in reading comprehension, and students with dyslexia have problems in decoding words. When errors occur in reading, the information that students get from the text is incomplete, which has a negative impact on information processing and understanding, thus affecting the reading comprehension ability[10]. In order to reduce the difficulties of students with dyslexia in word decoding,

text-to-speech and related reading tools have been widely used in teaching practice. This type of tools enable users to use both visual and auditory senses to read at the same time, so as to deepen students' understanding of the acquisition and meaning of text information[6]. Schneps et al. (2019) have proved that the use of text-to-speech technology can effectively improve students' reading speed[11].

In this study, through the induction and summary of relevant studies at home and abroad, the writer lists the following typical text-to-speech tools for students with dyslexia: ClaroPDF, TTSMaker, TextGrabber, Natural Reader, Voice Dream Reader, Balabolka, Read Aloud, Spoken Content, TextAloud, ReadPlease, Dyslexia APP, TXT Text Audiobooks, LE Reading, Text to Voice Assistant, etc. In addition to the text-to-speech function, such tools can also select a variety of timbre, control the reading speed, and automatically add visual enhancements such as highlighting to the content being read. For example, ClaroPDF can read a PDF file, and there are four different timbres to choose from. The synthesized speech in Natural Reader is very natural, the reading effect is good, and it supports English. Voice Dream Reader can read articles, documents and books aloud in many languages, and users can choose different timbres and reading speeds.

2.2 Development principles of text-to-speech tools

Intervention research for students with dyslexia, designed to improve students' reading ability independently of technology. Many scholars have done research and intervention on the cognitive defects of students with dyslexia. At the level of cognitive linguistics, research and intervention are mainly carried out from the aspects of phonological awareness, morpheme awareness, orthography, rapid naming, etc. The results of these aspects can predict children's reading ability [12]. From the perspective of cognitive deficits at the non-linguistic level, the research mainly focuses on visual processing deficits, auditory processing deficits, attention deficits, and memory deficits[13]. In contrast, compensatory learning tries to provide students with an aid to assist them in reading. Intervention-oriented studies use text-to-speech tools to improve unassisted reading skills, while compensation-oriented studies use text-to-speech tools to compensate for vocabulary-level skill deficits and access to written materials. But it is often not clear how to judge when the intervention failed and when students should start using compensation[14].

With continued technological advances, practitioners and educational researchers have been using text-to-speech tools since the 1980s to assist students with dyslexia. The

development concept of these tools is reflected in the following three aspects.

Firstly, the tools provide students with diverse ways to participate. Related tools are designed to present materials in various forms, such as images, sound and animation, and can provide a variety of functions and learning modes[15]. When students with dyslexia read stories on a computer using the text-to-speech tool, their decoding and word recognition skills were significantly improved[16]. The principle is to provide alternative ways of learning and participation, and to reduce the obstacles of text reading. Secondly, provides a diversity of characterization modalities. Each student has his own unique needs, and text-to-speech tools allow users to adjust the size of words, graphs, tables or adjust the contrast color between text and background, making the presentation of text information more personalized. Its principle is to replace visual information with auditory information, and the method of adjustment is to highlight or adjust the volume and so on.

Moreover, the tools provide a variety of behavioral expressions. In traditional classes, teachers require students to feedback their learning effects in the form of writing, but for students with dyslexia, writing is difficult. The tools help students convert text and speech, so that they are no longer limited to a single behavior[17]. The principle is to support students with dyslexia to use text-to-speech tools to learn.

3| Research on the application of text-to-speech tools

3.1 Text-to-speech tools has no obvious effect on improving the reading comprehension of students with dyslexia

Horney et al. (1996) found that pupils in higher grades (fifth and sixth grades) used text-to-speech tools more successfully than those in lower grades, perhaps because younger students needed more experience with text-to-speech tools to take advantage of the benefits it provides. Therefore, the effect of text-to-speech tools varies with the age and quality of the course[18]. Statistical analysis of scores in word comprehension and paragraph comprehension tests for the three grade students needs to be considered carefully, and the difference in mean scores in the reading grade may reflect more on grade level than a relative improvement in reading ability.

Li (2014) focused on two issues: the impact of reading tools in students with disorders and non-disorders, and the assessment of which factors affect the differences in the use of reading tools. The effects were explored through regulators (e.g., barrier status and content regions) and compared using hierarchical linear models[19]. Having

broad inclusion criteria, for example including quasi-experimental and experimental studies as well as published and unpublished studies, enables a regulatory analysis. The results showed that the mathematics reading was less affected by reading aloud, regardless of the degree of impairment of the students. In addition, compared with non-disabled students, the students did not improve in math reading.

Buzick and Stone (2014) conducted a meta-analysis to explore the impact of reading tools on test scores and whether the reading tools can improve test performance compared with non-disabled students[20]. Their inclusion criteria were stricter than those used by Li (2014), and thus the number of compliance criteria was small. The results support Li's finding that the application of reading tools has less impact on mathematical reading.

The above studies did not subdivide the types of disorders, generally divided into students with disorders and non-disorder students, which focus on large-scale standardized testing. That is, these tests were not specifically conducted for students with dyslexia, and therefore did not address the impact of text-to-speech and its related tools on reading comprehension among students with dyslexia.

3.2 Text-to-speech tools can improve the reading comprehension of students with dyslexia

Understanding of textual information is helpful when it is available both visually and aurally. In a study by Montali (1996), 18 regular students and 18 students with dyslexia performed reading exercises on a computer. Each student's reading task is divided into visual, auditory, visual and auditory simultaneous presentation (the text on the screen is presented while read aloud on the computer). Under the condition of visual and auditory presentation, students with poor reading ability reached the understanding level of ordinary students who read silently[9]. In the case of controlled understanding, Schneps et al. (2019) using the combination of auditory text conversion into speech and accelerated visual enhancement method, students with dyslexia and ordinary readers have reached the highest reading speed. And students with dyslexia achieved a comparable reading speed to the average reader who uses paper, visual or auditory methods, with no difference in comprehension[11].

Torgesen et al. (1995) found that students had a significant improvement in vocabulary recognition and speech decoding ability after using books with speech reading[21]. A two-year study by Edith et al. (2010) found that the application of text-to-speech tools could significantly improve immediate and long-term reading

performance among students with dyslexia. Thus, text-to-speech tools can minimize the negative effects of dyslexia and maximize the potential of students' reading ability[22]. Wood et al. (2018) conducted a meta-analysis of the influence of text-to-speech technology and related reading tools on reading comprehension of students with reading difficulties. The results showed that the application of text-to-speech technology could help students improve their reading comprehension.

The above study confirmed that the text-to-speech tool has a positive effect on improving the reading ability of students with dyslexia, but the mechanism is unclear. Using the text-to-speech tools can motivate students by providing a more successful reading experience[9]. Improvement in reading skills (e.g., speech decoding and word recognition) and overall reading ability are more likely[23]. Thus, using text-to-speech tools in the classroom can help students with dyslexia become more independent readers, thus helping them achieve greater success in reading comprehension.

4 | Discussion

4.1 Impact of text-to-speech tools on reading comprehension among students with dyslexia

Since the 1980s, the application of text-to-speech tools has begun, and this study has found a small number of studies from the 1990s. With time and technology updates, there is a growing body of relevant research, the number of studies using computer text-to-speech reading tools is increasing, which also reflects the trend of more widespread use of text-to-speech technology. The overall quantity and quality of the effectiveness of text-to-speech and related reading tools for reading comprehension are increasing. However, the quality of existing studies is uneven, for example, some studies have not conducted randomized controlled studies. Ideally, the number of samples should be large and uniform to allow for the best assessment of the effects of the text-to-speech tools. However, most of the existing studies are small samples, with about a dozen subjects. Relevant research on text-to-speech tools should be conducted in an educational context to cope with the diversity of classroom situations and apply relevant tools more specifically.

Through a retrospective analysis of the influence of text-to-speech tools on reading comprehension among dyslexic students, this study found that text-to-speech technology may help students' reading comprehension, but more research is needed to further explore the degree of improving reading comprehension. And there may be some

potential effects for the application of text-to-speech tools, so better study designs are needed to control these potential effects.

4.2 The application of text-to-speech tools in China and suggestions

This study summarized and concluded the research on the application of text-to-speech tools at home and abroad, and found that the existing text-to-speech tools are mainly in English versions, such as Natural Reader. Although it is free to use, for Chinese students with dyslexia, software localization or redesign is needed[24]. Although other similar tools have corresponding localized versions, they are designed by domestic developers to help Chinese students with dyslexia, such as the dyslexia auxiliary training APP "Reading Disabilities Gang" designed by Qinhua Li [25]. The proportion of such applications is small, so there is much room for developing such applications. In practice, the auxiliary technology system for dyslexic children in China has not been systematically established. *The Regulations on the Education of Persons with Disabilities* (2017) mentioned that the government and its relevant departments should “ supporting research and production of specialized instruments and equipment, teaching aids, learning aids, software and other aids for the education and teaching of persons with disabilities” , but there is still some room for the development of relevant policies. In the future, a systematic special education auxiliary technology system should be established, and relevant policies should be established to ensure that students with dyslexia receive adequate and professional technical support.

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