

Faculté de philosophie, arts et lettres

Text-To-Speech & Dys Vocal tools:

How can they enhance the reading skills of dyslexic students in L2?

Auteur : Laurie Radar
Promoteur(s) : Fanny Meunier
Année académique 2020-2021
Master en langues et lettres modernes, orientation germaniques, à finalité didactique

Acknowledgments

First of all, I would like to express my gratitude to my thesis supervisor, Professor Doctor Fanny Meunier. I sincerely thank her for her availability and her support towards me from the beginning, especially with the reorientation of the project. Her feedback and advice were particularly relevant and useful for the achievement of this master's thesis.

Then, I would also like to express my thanks to my friend Gilles Delaisse for his time and for helping me realise the three videos in the studio of his school, la Haute École Albert Jacquard - Campus infographique in Namur. A special thank for his teacher, Michel Roberti, for lending us the necessary equipment to shoot the videos and for his precious advice.

Furthermore, I would like to thank my classmate and friend Jeanne Maertens for always motivating me when I needed it, for believing in me and for giving me the inspiration to reorient the project due to the Covid situation.

Finally, a special thank goes to Liam Bird, my Erasmus friend from London, who helped me finalised this thesis and provided me fresh insight and feedback.

Table of contents

1. INTRODUCTION.....	1
2. STATE OF THE ART	4
2.1. DYSLEXIA	4
2.1.1. BRIEF HISTORICAL OUTLINE OF DYSLEXIA	4
2.1.2. PRESENTATION OF THE DIFFERENT LEVELS INVOLVED IN DYSLEXIA.....	6
2.1.3. DISABILITY, DISORDER OR LEARNING DIFFERENCE?.....	8
2.1.4. OVERVIEW OF THE VARIOUS DEFINITIONS OF DYSLEXIA.....	10
2.1.5. LEARNING MECHANISMS PRESENT IN READING COMPREHENSION	11
2.1.6. BEHAVIOURAL, COGNITIVE AND NEUROLOGICAL EXPLANATIONS OF DYSLEXIA.....	14
2.1.7. THE ROLE OF L2.....	17
2.2. DIFFERENTIATION IN EDUCATION	20
2.2.1. OVERVIEW OF THE DIFFERENT TYPES OF ACCOMMODATIONS.....	21
2.2.2. A MODEL FOR DIFFERENTIATION.....	25
2.2.3. THE MULTISENSORY STRUCTURED LANGUAGE APPROACH.....	28
2.3. TECHNOLOGY	32
2.3.1. TEACHING WITH TECHNOLOGY	32
2.3.2. TEACHING WITH TTS TOOLS	33
2.3.3. RESEARCH ON ASSISTIVE TECHNOLOGIES: TWO TOOLS.....	35
2.3.3.1. TEXT-TO-SPEECH DEVICES.....	36
2.3.3.2. DYS VOCAL SOFTWARE	39
3. METHODOLOGY	42
3.1. PROJECT REORIENTATION.....	42
3.2. RESEARCH QUESTIONS.....	43
3.3. HYPOTHESES	43
3.4. REALISATION OF THE LIST	44
3.4.1. CRITERIA SELECTION.....	44
3.4.2. TOOLS SELECTION	46
3.5. VIDEOS	46
3.5.1. REALISATION.....	46
3.5.2. DESCRIPTION OF THE THREE VIDEOS.....	47
3.5.3. SCRIPTS OF THE VIDEOS.....	49
4. TOOLS PRESENTATION.....	53
4.1. NATURAL READER.....	54
4.2. DYS VOCAL SOFTWARE	58
5. TOP FIVE TTS TOOLS LIST	64

6. CONCLUSION	72
7. DISCUSSION	79
8. BIBLIOGRAPHY	82

LIST OF ABBREVIATIONS

AD(H)D: TDA(H)

AT: Assistive Technology

CALL: Computer Assisted Language Learning (CALL)

EFL: English as a Foreign Language

ESL: English as a Second Language

FL: Foreign Language

ID: individual difference

IDA: International Dyslexia Association

L1: native language

L2: second/ foreign language

LIH: Language Interdependence Hypothesis

LTH: Language Threshold Hypothesis

MSL: Multisensory Structured Language

OCR: Optical Character Recognition

OER: Open Educational Resource

SAMR: Substitution Augmentation Modification Redefinition

SLA: Second Language Acquisition

SpLDs: Specific Learning Differences

TPACK: Technology, Pedagogy, And Content Knowledge

TTS: Text-To-Speech

UCL: Université catholique de Louvain

1. Introduction

The main objective of this master's thesis is to identify the benefits of specific digital tools, in particular Text-to-Speech (TTS) and Dys Vocal software and apps, which can assist L2 learners of English with dyslexia in reading comprehension, hence better understand how such tools can impact foreign language learning. This research is carried out with two specific and more applied aims: firstly, to help students better understand their reading difficulties and how reading-aloud assistance and creating a more dyslexia-friendly reading environment may help them; and secondly, to educate institutions and teachers by encouraging them to adapt their teaching methods and assessments to the reading comprehension needs of dyslexic students.

Dyslexia is a language disorder that is very complex to define and has, therefore, been the subject of many definitions. The absence of a single clear definition of dyslexia is due to the fact that the term has been, and is still in some cases, vaguely applied to a number of different cases of language dysfunction (Gregor & Newell, 2000). Dyslexia is a relatively common phenomenon that affects about one in ten people (Kormos, n. d.). The educational dimension of dyslexia is relevant to consider in this thesis as it will focus on secondary school students. In this context, the International Dyslexia Association (IDA) defines it as a language-based learning disability that can compromise students' academic success in the typical instructional environment (2017). Dyslexia also refers to a set of symptoms causing people to struggle with specific language skills, particularly reading. Moreover, it has been traditionally maintained that our reading skills are most proficient in the language with which we are most familiar (Miller-Guron & Lundberg, 2000). Since dyslexia involves reading problems in the first language, it suggests that these difficulties will be intensified in a foreign language. It implies that dyslexic learners may read more slowly and have more difficulties understanding the meaning of texts when reading in a different language from their mother tongue. (Kormos, n. d.) This idea leads to the assumption that dyslexia inhibits

proper development of foreign language proficiency. The debate on the classification of dyslexia persists today; should it be considered as a disability, disorder or learning difference? Depending on different factors, the terms differ. This question will be further developed in sections 2.1.3. and 2.1.4. According to Kormos (n.d.), dyslexia should not be considered as a disability anymore, but as a "difference in the acquisition of new knowledge and skills", i.e. a specific learning difference. Hence, dyslexic students need adjustments in their teaching process in order to facilitate their reading understanding in a foreign language.

Thanks to recent technological advances, a number of digital tools have become available in various fields over the last decade, also for educational purposes. Previous research has suggested that two types of technological devices are particularly likely to facilitate text comprehension. These are the TTS and Dys Vocal type tools. On the one hand, Košak-Babuder, Kormos, Ratajczak and Pižorn (2019) reported that reading aloud assistance would facilitate text comprehension. This type of assistive technology allows students to listen to a text while reading it simultaneously (Bone & Bouck, 2016). Text-To-Speech tools contain various features designed to improve reading comprehension, which, as stated in Wood, Moxley, Tighe & Wagner (2018), can have a significant influence on the effectiveness of the tool. These features include reading speed, voice quality, and dynamic highlighting among others. On the other hand, as the presentation of text has been found to have a significant effect on the readability of dyslexic learners (Appert & Truillet, 2016; Rello & Baeza-Yates, 2013; Rello & Baeza-Yates, 2015; Dyslogiciel, 2021), simplifying the visual presentation of material has been claimed to be conducive to reducing the cognitive load of dyslexics (French, Blood, Bright, Futak, Grohmann, Hasthorpe, Heritage, Poland, Reece & Tabor, 2013). It is in this perspective that the Dys Vocal software is meant to boost reading comprehension skills, by making small visual changes to text presentation.

In the contemporary context where teaching is adapting to and increasingly integrating new technologies, it seems important to analyse the benefits that those tools can provide to dyslexic students. Nevertheless, it is important to consider that the results of several literature reviews are not consistent, regarding whether some TTS tools can improve reading comprehension (Wood *et al.*, 2018).

Although there is an increasing number of studies investigating the effectiveness of new technological tools such as TTS and Dys Vocal ones, it should be borne in mind that the functionalities of these tools are constantly increasing and improving over time. Therefore, more research is needed to take these new features into account. Thus, no two tools are completely equivalent, as they all have their own specific characteristics. This can lead to results that are sometimes mixed or contradictory to what has already been argued in the literature.

In addition, there is a lack of studies in the L2 field focusing on improving reading comprehension with technology. This study is therefore novel in that it investigates the interactions between dyslexic L2 learners, TTS and Dys Vocal tools along with their impact on their reading comprehension. Yet this thesis aims to provide a potential list of the top five TTS tools in order to inform and assist secondary school language teachers and learners.

This thesis is divided into different sections, the next one being a contemporary summary of the literature about dyslexia and different components, differentiation in education, and technology. Next, the methodology of the thesis will be developed, in which the reorientation of the project, the research questions/hypotheses and the realisation of the list and videos will be described. Then, a section will be dedicated to the presentation of Natural Reader (TTS tool) and the Dys Vocal software, as well as a list of the top five TTS tools designed to help secondary school teachers use them. The last section will be a final discussion, with suggestions for future research.

2. State of the art

2.1. DYSLEXIA

2.1.1. *BRIEF HISTORICAL OUTLINE OF DYSLEXIA*

As mentioned in several studies (Frith, 1999; Kormos & Smith, 2012), dyslexia has long been problematic to define and explain, and this is still the case today. In fact, people perceive dyslexia differently. For instance, if you ask a non-specialist, s.he will tell you that dyslexia is a reading problem that children tend to encounter. A special education teacher will tell you that it is the fact that children are unable to read, despite adequate instruction. An educational psychologist would describe it as a reading difficulty – or disability for some, which is unexpected given the child's cognitive abilities (Kormos & Smith, 2012). The definitions of dyslexia actually vary across the domains, see section 2.1.4. for a detailed outline. Firstly, an historical overview of dyslexia is necessary in order to understand it.

It was in 1884 that the word “dyslexia” was first coined by Rudolf Berlin, a German ophthalmologist. The term referred to a neurological condition in which people lost their ability to read while all their other intellectual abilities remained intact as a result of brain damage. It was also called “word-blindness”. Such cases referred to ‘acquired dyslexia’. Then, a British physician reported the case of a 14-year-old boy who was unable to learn how to read regardless of his apparently good intellectual abilities. It was at this point that ‘developmental dyslexia’ i.e. problems in learning to read during childhood and a lack of achievement in the development of reading skills, began to be studied.

Systematic investigation of the subject began in 1917, when early attempts were made to describe the symptoms. Samuel Orton, a neurologist, identified the first symptom, related to his famous theory ‘strephosymbolia’ (Guardiola, 2001), namely

symbol twisting, i.e. the mixing up of letters (b and d) and the interchange of letters in words. Orton came to the conclusion that dyslexia was caused by visual processing problems. He also revealed that these deficiencies are family related, which is consistent with the genetic nature of the deficit. After his death, The Orton Society was established in the USA and later renamed Orton Dyslexia Society, to promote the study of the functional and social problems of dyslexics. This society has been and still is influential all over the world, by contributing to improving our knowledge about dyslexia, as well as the quality of life of dyslexics, by creating special attention and learning centres for dyslexics, and even by fighting for their legal rights. This society has developed considerably and has now become the International Dyslexia Association. This society has grown considerably over the years and has now become the International Dyslexia Association, which itself publishes a journal entitled 'Annals of Dyslexia'. (Guardiola, 2001).

Dyslexia was thus initially perceived as a medical issue. It was from the 1960s onwards that public awareness of dyslexia emerged in the USA and the UK and its research began to be carried out by educational psychologists. Around the 1970s, theories of dyslexia switched gradually from visual to linguistic explanations of the disorder (Guardolia, 2001). Phonological deficit was then identified as the main cause of dyslexia. Since the 1980s, research on dyslexia has expanded into several disciplines such as educational psychology, linguistics, developmental and cognitive psychology, neurolinguistics, neuropsychology and genetics. The study of dyslexia has become an interdisciplinary field, increasing the complexity of a good understanding of the phenomenon (Guardolia, 2001).

2.1.2. PRESENTATION OF THE DIFFERENT LEVELS INVOLVED IN DYSLEXIA

A further complex aspect of dyslexia is the fact that four different levels have to be taken into account in order to understand it, namely behavioural, cognitive, biological and environmental (Frith, 1999). These four levels greatly complicate the formulation of "correct" definitions of dyslexia.

At the behavioural level, there appears to be a consensus that dyslexia manifests itself in reading problems. However, this definition is not sufficient. Firstly, it is true that reading difficulties can emerge from dyslexia, but there are other factors that can cause reading difficulties. Therefore, a poor performance in a reading test is not a sufficient diagnostic criterion for dyslexia (Frith, 1999). Frith (1999) perfectly illustrates with a comparison the fact that dyslexia can simply not be restricted to a poor reading performance:

"To define dyslexia in terms of reading test performance is rather like defining measles as an increase in body temperature. Raised temperature, however, is merely a sign of the infection, not the illness itself. Decreasing the temperature is usually a good thing, but it does not cure the illness".
(Frith, 1999, p. 209)

Reading difficulties are therefore, according to his comparison, a sign of dyslexia, but dyslexia cannot be reduced to this alone. Improving one's reading skills will definitely help, but it will not cure dyslexia. As Frith (1999, p. 209) states in his article, training one's reading skills should be considered a symptomatic treatment rather than a cure. Furthermore, it is essential to add that dyslexia is not a temporary childhood illness, nor is it an illness that comes with school and disappears with adulthood; it is a lifelong burden (Frith, 1999) that has different degrees of severity. That is why the behavioural definition is problematic: it suggests that dyslexia, by referring only to reading disorders, implies that children overcome it as they grow up, which is obviously not the case at all. Besides, it is important to mention that the reading skills of dyslexics

are not static. Those skills can sometimes improve with age and practice while the severity of reading problems tends to decrease. Dyslexics consequently often have different profiles of strengths and weaknesses. It is thus inappropriate to make a generalisation and think that by training and improving reading skills, one becomes "less dyslexic", as there are no two similar dyslexic profiles.

At the cognitive level, explanations for reading problems need to be presented. It is necessary at this level to be able to distinguish between the different types of Specific Learning Differences (SpLDs). Those differences refer to differences, difficulties people encounter with specific learning aspects. The Department for Education Working Group in the UK (2005) proposed the following definition for SpLDs:

"SpLDs have particular difficulties, which may include spelling, acquiring fluent reading and writing skills and/or manipulating numbers which may indicate their performance is well below their abilities in other areas. They may also have problems with working memory, organisational skills, receptive and expressive language or oral and auditory skills, maintaining concentration and co-ordination." (SpLD Assessment Standards Committee, 2005)

The most common SpLDs are dyslexia, dyspraxia, attention deficit disorder (ADD), attention deficit hyperactivity disorder (ADHD), dyscalculia and dysgraphia (SOAS University of London, 2021). All SpLDs include severity levels ranging from low to moderate and severe. There exist common patterns of behaviour and experience, but the effects vary from one individual to another. SpLDs are not influenced by intellectual ability nor socio-economic background. However, it is worth noting that SpLDs do not prevent academic potential. Steven Spielberg, Daniel Radcliffe, Tom Cruise, Albert Einstein, John Lennon, Pablo Picasso and Jennifer Aniston have all suffered, or are currently suffering, from dyslexia, among others. They have all succeeded each in their respective domains. This must not always have been easy, as the path to success is much more difficult and may require greater effort (usually invisible) and a distinct set

of skills for dyslexic people, but it is not insurmountable. In an educational environment, the challenge is to be aware of these specific differences and to experiment with a variety of methods and techniques to facilitate optimal learning (SOAS University of London, 2021).

At the biological level, further research into the neurological/genetic causes of differential cognitive functioning is necessary in order to understand the primary cause of dyslexia and to provide effective support tools. This research is particularly crucial because, for a long time, dyslexia was only diagnosed when children were unable to learn how to read, but not in other cases. This means that this waiting time before children experience failure can result in emotional and social problems, and lead to poor academic performance. Early remediation and support are thus of crucial importance, since precious time could be wasted if adequate screening methods based on neurological findings are not expanded upon.

Exposure to print, attitudes to literacy in the family and the effectiveness of reading instruction are three environmental factors that should also be taken into account in order to dissociate the effects of social, cultural and economic status and inadequate teaching on reading behaviour from the effects of 'developmental dyslexia'.

2.1.3. DISABILITY, DISORDER OR LEARNING DIFFERENCE?

Before presenting the different definitions of dyslexia, it is important to consider the different labels for dyslexia and their impact. According to literature, the labels' variance is partially linked to a question of social context (Gregor & Newell, 2000; Kormos, 2017) and perception (Frith, 1999), depending on whether SpLDs are studied in psychology or education. From a legal and educational point of view, Kormos (2017, p. 1) argues that SpLDs constitute "a type of disability". The way people describe and label disabilities, as well as the terminology they use, reflects the way they perceive them, but also influences the way people relate to and behave with people with disabilities.

In this sense, there are two models on disabilities. Deficit models view disabilities as deficiencies and a series of obstacles in the lives of individuals. The focus is on meeting the individual needs of children and little attention is paid to how the child's environment itself creates barriers to successful learning. In the interactional view of disability, it is believed that disabilities hinder full participation in society because the impairments of individuals interact with barriers in the environment. By adopting this perspective, L2 researchers can describe the strengths and weaknesses of young learners and multilingual individuals with SpLDs, as well as investigate the complex interactions between individuals and their contexts (Kormos, 2017).

The different conceptualisations of dyslexia further derive from different geographical and professional contexts (Kormos, 2017). Kormos gives an overview in her research. In the 5th edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5 APA, 2013), the term "specific learning disorder" (*trouble spécifique de l'apprentissage*, in French) is employed. In psychological research and legislation in Canada, Australia and the UK, the terminologies "learning disability" and "learning difficulty" are used. The labels "learning disorder" and "learning disability" are applied in biological, medical and psychological settings in which researchers seek to discover the exact nature and cause of SpLDs. In UK education, individuals are often described as having "specific learning differences". In other words, the labels depend on the purpose for which the definitions are used.

In the context of SLA research, Kormos (2017) claims that the label "specific learning difficulty" (SpLD) is most appropriate as it reflects an interactionist stance in which the aim is to understand how the individual characteristics of children and the barriers of the educational system jointly influence the processes of multilingual language development. In addition, this label is one of the most widely accepted and empirically supported conceptualisations of dyslexia (Kormos, 2017). For these reasons, the term SpLD(s) is employed for the purpose of this thesis.

2.1.4. OVERVIEW OF THE VARIOUS DEFINITIONS OF DYSLEXIA

These four levels must therefore be considered in order to establish a correct definition of dyslexia, as this has not always been the case (as can be seen in the following definitions):

In 1968, the World Federation of Neurology described dyslexia as a disorder in children who, despite conventional classroom experience, do not achieve the language skills of reading, writing and spelling corresponding to their intellectual abilities (Kormos & Smith, 2012). This definition was based on the gap between students' abilities as measured mainly by IQ tests and achievement tests, but criticisms were raised because they were found to under-identify dyslexic students and because of the biased nature of IQ tests towards certain ethnic and social groups. Another flaw in this definition was that the difference between the IQ test result and the reading test result had to be large enough to allow a reliable diagnosis of dyslexia. As a result, dyslexic learners whose IQ score was in the lower range of normally developing children may have missed identification.

After careful reflection, specialists sought a solution to identify reading difficulties without referring to general intellectual abilities. They then thought of introducing the concept of the unexpectedness, i.e. that dyslexia can occur despite adequate cognitive skills, appropriate socio-economic circumstances and high-quality literacy education. In this sense, it was assumed that unexpectedness was linked to the inability of students to respond to appropriate and high-quality education. According to Kormos & Smith (2012), the definition of the American Psychiatric Association (1994) illustrates this approach:

“Developmental dyslexia, or specific reading disability, is defined as an unexpected, specific and persistent failure to acquire efficient reading skills despite conventional instruction, adequate intelligence and socio-cultural opportunity”. (American Psychiatric Association, 1994).

This definition is more detailed than the previous ones but remains very behavioural and does not include any reference to the cognitive and neurological aspects of dyslexic people. More recent definitions, such as that of IDA (2002), aim to integrate the four levels of description: biological, cognitive, behavioural and environmental.

“Dyslexia is a specific learning disability that is neurological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction” (International Dyslexia Association, 2002)

This is one of the most appropriate definitions of dyslexia today, but there are also other elements that could be added. However, it should be kept in mind that dyslexia can also take many different forms and is not limited to a single 'dyslexic profile'. There are children who are only slow in reading, and thus have differences in speed. There are children who decode words accurately but have problems with phonological processing, and there are children who have both problems simultaneously. There are also other learning differences frequently associated with dyslexia, such as attention deficit (ADHD or ADD), which can also influence the severity of reading problems. In addition, there are also educational factors, such as a high-quality catching-up programme and a favourable family environment in which literacy activities are greatly encouraged, which can alleviate the manifestations of dyslexia.

2.1.5. LEARNING MECHANISMS PRESENT IN READING COMPREHENSION

Understanding dyslexia requires familiarity with the basic cognitive mechanisms involved in reading processes. Understanding what is meant by reading comprehension is therefore crucial. Shanahan, Callison, Carriere, Duke, Pearson, Schatschneider & Torgesen (2010, p. 5) defined it as “the process of simultaneously extracting and constructing meaning through interaction and involvement with written

language". Standard reading ability presupposes adequate comprehension of the language and fluent word identification (Vellutino, Fletcher, Snowling & Scanlon, 2004).

Reading is a highly complex skill in which several processes must run in parallel - and automatically - to facilitate the decoding of information (Kormos & Smith, 2012). Reading skills are hierarchically structured so that low-level reading processes such as word recognition and sentence comprehension must be automatized before readers can be expected to understand the overall information of a text. Firstly, the major component of lower-order reading processes is fast and efficient word recognition. It is a lexical research process that implies the visual recognition of a set of uniquely ordered letters as a familiar word and the implicit retrieval of the name and meaning of this word from memory (Vellutino *et al.*, 2004). The reader must combine different processing mechanisms to be able to identify words, namely orthographic processing, phonological processing, access to semantic and syntactic information related to the word, and lastly morphological processing (Kormos & Smith, 2012). Secondly, higher-order reading processes consist of creating a text model, which deals with the information content of the text, and a situation model, which helps the reader to interpret the information presented in the text according to the relevant background knowledge. Readers should then be able to identify sentences. Next to word identification, adequate language comprehension is needed in order to be able to read and understand texts correctly (Vellutino *et al.*, 2004). Language comprehension is the process of integrating the meaning of spoken or written words in such a way as to facilitate the understanding and integration of sentences into a spoken or written text with the aim of understanding the broader concepts and ideas represented by these sentences. In other words, reading is a gradual process, which means that it has to be done step by step.

In line with current views on dyslexia, it is thought that problems with phonological processing are at the heart of the reading difficulties encountered by dyslexic pupils (Kormos & Smith, 2012). Since these problems mainly occur at the stage

of word recognition, a more in-depth description of the word recognition processes is important to consider. In fact, there are two approaches to word recognition: the sub-lexical route and the lexical route. In the first case, the reader accesses the meaning of the word by converting the letters into sounds and assembling the sounds to form the phonological (spoken) form of the word. In other words, the written word is decoded letter by letter. This is the most common reading process for novice readers and for those reading unknown words. By contrast, the lexical route avoids phonological analysis. In this analysis, readers perceive the visual form of words as a whole unit and recognise the form of words without having to analyse it segmentally. This is often how skillful readers distinguish familiar written words.

With regards to understanding reading difficulties, another approach is to focus on how children acquire reading skills. The most influential model for learning to read has been developed by Frith (1986), according to which the process of acquiring reading skills in an alphabetic language involves three stages. The first stage is called the '*logographic stage*', consisting of children learning to read a few words as a whole unit, such as their name or the names of places or supermarkets on the roads they frequently use. Children are not yet familiar with the alphabet at this point and visually treat the words as a single unit. The following stage is the '*alphabetic stage*', during which children learn to segment the visually perceived word forms into letters and convert the letters into sounds. It is a letter-sound by letter-sound analysis. Children learn to combine letters to create the phonological form of the word. Each letter is important and so is the order. To be able to proceed to the final stage, children require a high level of automatism in these first two processes. As mentioned above, children will first acquire alphabetic knowledge through explicit classroom instruction. Then, through practice, they will systematise their knowledge and automatically be able to use it. It is precisely this stage of learning to read that is the most challenging for dyslexics, since they inherently struggle with phonological processing. They therefore require greater exposure to explicit explanations, along with more practice before they

can successfully move on to the final stage of reading. The final stage is the '*orthographic stage*', in which children analyse words in larger units, such as sequences of letters (morphemic parts of words), and convert them into syllables. In this stage, readers should use their knowledge of how written (spelling) words are built from larger chunks, such as morphemes, prefixes and suffixes. Dyslexics may also encounter difficulties at this stage due to their reduced level of syllabic awareness.

2.1.6. *BEHAVIOURAL, COGNITIVE AND NEUROLOGICAL EXPLANATIONS OF DYSLEXIA*

Now that the process of learning to read has been detailed, it is worth considering the behavioural, cognitive and neurological aspects of dyslexia to reveal where the learning difficulties of dyslexic students come from (Kormos & Smith, 2012).

During childhood, the most common behavioural manifestations of dyslexia are reading and spelling difficulties combined with problems in memory and organisation. Nevertheless, it is likely that these dyslexia manifestations vary in severity and that not all dyslexics develop all of the same symptoms (Rello & Baeza-Yates, 2015), especially since dyslexia is culture-specific. Reading disorders essentially involve word recognition and are typically caused by difficulties in converting letters into sounds, which is why dyslexic children tend to struggle to identify existing words and decode the non-words, i.e. words that are not recognized or accepted as legitimate, as one produced by a spelling or typographical error (Collins, 2021). Following Frith's theory (1986), inaccurate word-recognition occurs in the last stage of the reading process, namely the '*orthographic stage*', and more specifically in the phoneme-to-grapheme mapping process, which engenders the most severe difficulties for dyslexic people (Velutino *et al.*, 2004). This can lead to slow and/or inaccurate word-recognition.

In addition, the language itself in which children learn to read is another important factor affecting the nature of dyslexic difficulties (Kormos & Smith, 2012).

According to Rello & Baeza-Yates (2015), the degree of consistency and regularity of the different language orthographies may contribute to the variability of the manifestations of dyslexia. On the one hand, there are languages, such as Italian, Spanish or German, that have relatively simple letter-sound conversion rules and a predictable writing system, that are called transparent/shallow orthography (Vellutino *et al.*, 2004). On the other hand, in some other languages, such as English and French, phoneme-to-grapheme mappings are more complicated and sometimes unpredictable, so that acquiring these spelling systems can lead to considerable problems for dyslexic children. These languages are said to be opaque/deep (Vellutino *et al.*, 2004). In opaque/deep languages, many exceptions exist. (Rello & Baeza-Yates, 2015). Given those differences in the two different writing systems, reading difficulties may translate differently from one language to another. This language issue will be further developed in the next section.

Yet, a further challenge faced by dyslexic children is spelling (Kormos & Smith, 2012). Spelling difficulties may in some cases even be the only signs of literacy problems. Just like word recognition, spelling involves the segmentation of spoken words into phonemes and the conversion of these phonemes into letters. Although visual compensatory processes like the recognition of the word as a unit and various other contextual cues may compensate for a lack of phonological awareness in reading, they are unfortunately not present in writing. Consequently, spelling problems are very typical of dyslexia and can often be detected in readers who fail the diagnostic criteria for dyslexia according to their reading performance.

Furthermore, phonological processing, which plays a role in the segmentation of words into letters and in learning the sound-letter correspondence rules, is not only involved in reading and writing. Such a process is also concerned with the perception and production of speech (Kormos & Smith, 2012). According to Bowers & Swanson's research findings (1991), dyslexic people demonstrate significant differences in both the accuracy and speed with which information presented orally can be processed.

There is evidence that dyslexic children score considerably lower than their non-dyslexic peers in sound-discrimination and in word repetition tests (Kormos & Smith, 2012). Each of these tasks requires phonological short-term memory, which contributes to keeping verbal information active for future treatment. Baddeley, a psychologist renowned for his significant work on human memory, has created a model of working memory to give a more accurate description of short-term memory. He claims in his work that phonological short-term memory has a crucial role to play in the learning of new words because it stores unfamiliar sound patterns while long-term representations are being constructed (Kormos & Smith, 2012). This therefore implies a direct link between short-term memory and long-term retention of vocabulary. Short-term phonological memory and phonological processing impairments usually result in delayed speech, slower speech rate with sometimes indistinct pronunciation, and a narrower range of receptive and expressive vocabulary (Kormos & Smith, 2012). The amount of vocabulary that dyslexic children master is often smaller than that of their peers, but dyslexics may also be slower at identifying words when naming pictures. Here is an overview of the most common linguistic challenges faced by dyslexic people, adapted from Kormos & Smith (2012, p. 32) and Gregor & Newell (2000, p. 86):

- Problems in segmenting words into phonological units
- Problems with phoneme-grapheme correspondences
- Problems in number-, letter-, punctuation- and word-recognition
- Slow reading speed
- Spelling problems
- Smaller range of vocabulary
- Slow word retrieval
- Slow speech
- Articulation problems
- Letter reversals
- Problems in keeping verbal material in phonological short-term memory
- Fixation problems

- Poor comprehension

Parallel to these linguistic problems, some cognitive difficulties may also be encountered by dyslexics. Here is an overview of the non-literacy difficulties that might appear but are not related to language itself. Nevertheless, these symptoms are also significant and can also seriously affect dyslexic people (Kormos & Smith, 2012, p. 33):

- Smaller span of working memory
- Problems with arithmetic and memorizing multiplication tables
- Difficulties with handwriting
- Gross motor-coordination problems
- Problems with sustained attention
- Difficulties in time-management and organizing work
- Difficulties in automatising new skills

2.1.7. *THE ROLE OF L2*

By understanding the mechanisms of learning to read, it is thus possible to determine exactly where the difficulties of dyslexics come from. We will examine the impact of L2 on reading comprehension to get the full picture.

Previous studies on L2 have raised the important question of whether L2 reading should be considered a reading or a language problem (Chun & Plass, 1997). The two most common crosslinguistic hypotheses associated with this issue are clearly in conflict, but often seen as inseparable (Villacañas de Castro, 2016). On the one hand, the Language Threshold Hypothesis (LTH) asserts that language is the key factor in reading, as a certain level of L2 proficiency must first be achieved in order to read in that language. On the other hand, the Language Interdependence Hypothesis (LIH) considers that reading performance in a L2 is largely shared with reading ability in the L1. The idea is that once reading ability has been acquired, it can be transferred to L2 (Chun & Plass, 1997). In the case of L2 dyslexic learners, both reading skills and

language play a role in their (poor) reading comprehension, as their reading skills are problematic and struggle to learn additional languages (Kořak-Babuder *et al.*, 2019).

Later studies consider the major issue concerning L2 reading, which is obviously its relationship with L1 reading comprehension (Jeon & Yamashita, 2014). Some have shown that L2 reading ability relies on L1 reading ability (Chuang, Joshi & Dixon, 2012), leading to the assumption that L2 reading difficulties are related to existing L1 reading difficulties (Miller-Guron & Lundberg, 2000). Indeed, the language itself in which children are reading is an additional key factor impacting the reading difficulties. Children use a very common phenomenon, namely language transfer, which is the use of knowledge in the mother tongue (L1) to perform in the new, second or target language (L2). In this way, children would – at least partially - transfer the reading strategies learned in their native language to another language being studied (Schneider & Evers, 2009). Moreover, it has been traditionally maintained that the reading skills of normal readers are most efficient in the language with which they are most familiar. In fact, people's L1 skills provide essential foundations for L2 development (Kořak-Babuder *et al.*, 2019). In other words, since dyslexia already involves reading problems in the L1, it suggests that these difficulties are likely to be intensified in a foreign language (Miller-Guron & Lundberg, 2000). Some studies have also demonstrated that children with SpLDs generally struggle to learn additional languages and to develop L2 literacy skills. (Kořak-Babuder *et al.*, 2019).

Those ideas lead to the assumption that dyslexia inhibits proper development of foreign language proficiency and, in this particular case, reading skills. Unfortunately, there is relatively limited knowledge about how the reading difficulties vary from one language to another, since comparative research on dyslexia between languages is rather rare (Vellutino *et al.*, 2004). One thing is certain: languages differ widely from one another. Consideration should therefore be given to transparency, an important criterion in the learnability of languages (Hengeveld & Leufkens, 2018). According to

Hengeveld and Leufkens (2018), transparency is the one-to-one relation between units of meaning and units of form. It is important to note that languages are never completely transparent, since it is rare to find a systematic one-to-one relation between form and meaning. What is more, transparency should not be assimilated to simplicity because languages can be complex while being transparent, and simple while being opaque. In fact, languages share to some extent both transparent and less transparent characteristics, leading to a more straightforward categorisation of 'transparent' (regular) and 'opaque' (less regular) languages. (Hengeveld & Leufkens, 2018). Opaque languages, like English or French, would appear to pose a much greater challenge to readers (Vellutino *et al.*, 2004). In contrast, the reading process in transparent orthographies such as Italian or German would be generally faster, with a correspondingly faster development of phonemic awareness. In a transparent language, the phoneme-grapheme correspondence is said to be straightforward, which seems to be less of a problem for dyslexic people (Miles, 2000). Nevertheless, it is generally believed that the basic phonological deficits of dyslexia are harder to detect in children who have learned to read in transparent orthographies (Vellutino *et al.*, 2004). There is also a fundamental problem of equating diagnostic criteria between languages. In fact, languages diagnose dyslexia differently. For instance, in English, the diagnosis of dyslexia is made on the basis of the discrepancy between reading accuracy and age (or, in some cases, IQ). In transparent writing systems, where levels of accuracy are generally high, the same criteria cannot be applied. In such systems, the criteria are likely to focus on speed and fluency rather than on error rate. Consequently, it is perfectly conceivable, albeit surprisingly so, that different people meet the criteria for dyslexia in one language but not in another. One example includes the case of a bilingual boy who was able to read normally in Japanese, but who displayed many of the reading behaviours typical of dyslexia when reading in English (Vellutino *et al.*, 2004). In this sense, transparent orthographies promote learning to the point where dyslexia can be 'hidden' in most cases, while opaque ones can aggravate the situation.

2.2. DIFFERENTIATION IN EDUCATION

The brains of dyslexic people function differently from those of other people, which does not mean that their brains are dysfunctional, but simply that they function in a different way. Taking this distinction into account is fundamental in education. An inclusive learning environment is therefore crucial to help compensate for these shortcomings, and differentiated instruction with curriculum modifications are often necessary (Schmitt, Hale, McCallum, & Mauck, 2011). This is precisely where education has an indispensable function to play in society, to include all learners, regardless of their SpLDs (Cambridge University Press, 2020). Kormos (n. d.), from Lancaster university, depicted in an interview how it feels like to be dyslexic:

“Learning to read for dyslexics is like running a race where only the dyslexic students have invisible hurdles on the track. The others complete the race easily and quickly while the dyslexic students fall when they first hit the hurdles. As the hurdles cannot be seen, nobody understands why they fall. And all those standing by can say is try harder. The dyslexic runners can only succeed if someone notices the hurdles and teaches them how to jump over them”. (Kormos, n. d.)

It is therefore important not to neglect their difficulties and to propose effective strategies to assist them in the best possible way. This is exactly one of the main objectives of differentiation: to promote the success of all students by adjusting its pedagogy (Fédération Wallonie-Bruxelles, 2018). The idea behind differentiation is “to introduce paths adapted to the needs, profiles, types of relationship with knowledge, and motivations of students so that, through different routes, all students can appropriate the same knowledge” (Fédération Wallonie-Bruxelles, 2018). In other words, it enables all students to achieve common objectives through different means. Differentiation encompasses different aspects and actors which will be expanded upon theoretically in the following subsections, such as institutions and more concretely teachers who need to provide accommodations for dyslexic learners, the multisensory

structured approach to language which is strongly recommended to use in education, and a concrete model for helping teachers to differentiate.

2.2.1. OVERVIEW OF THE DIFFERENT TYPES OF ACCOMMODATIONS

In the context of differentiation, it is first important to present what is required of educational institutions from a legal point of view. First of all, it should be made clear that education systems are required by law to adjust to the needs of students with SpLDs (comprising dyslexics) in order to optimise their chances of success. Institutions are therefore responsible for initiating changes and adapting methods, curricula, materials and procedures to make them appropriate (Cambridge University Press, 2020). There have been several regulations that have been established and clarified over time. In the UK, for instance, the Rehabilitation Act of 1973 was the first major legislative attempt to create a level playing field for 'disabled' people, including all kinds of disabilities. Hence, the intention was to provide equal opportunities to all, both 'disabled' and non-disabled students. (Harrison, Bunford, Evans & Owens, 2013). A few years later, in 2010, an approved law was published in the UK requiring special support for people with disabilities (including those with learning difficulties) so that they are not disadvantaged compared to non-disabled students. In Belgium, the first law on special support was adopted in 2008. The French Community decree stipulates that a refusal to provide reasonable accommodation to a person with a disability is considered discrimination. One year later, the "United Nations Convention on the Rights of Persons with Disabilities" was published, a law that gives all students with disabilities (physical, sensory, intellectual, learning or behavioural, with a chronic illness) the right to reasonable accommodation. A new decree of the Francophone community on inclusive higher education was then promulgated in 2014. This decree states that institutions must adapt their infrastructure, equipment, teaching methods and teaching staff to ensure that all students are accommodated, regardless of their specific needs. Finally, in 2018, a "decree on the reception, support and retention in basic and secondary education of pupils with special needs" was introduced, obliging institutions

to accommodate all pupils with special needs by providing them with “reasonable accommodations” (a translation of the French “aménagements raisonnables” concept presented in the documents).

A suitable definition of reasonable accommodations is the following one, by the American Psychological Association (2012):

“Reasonable accommodations are modifications or adjustments to the tasks, environment or to the way things are usually done that enable individuals with disabilities to have an equal opportunity to participate in an academic program or a job” (American Psychological Association, 2012).

The aim of the accommodations is therefore to ensure equal access to a complete school experience for students with SpLDs (International Dyslexia Association, 2020) by offering classroom accommodations, which aim to eliminate “construct-irrelevant variance” by adding or removing stimuli that are typically needed to access material or demonstrate learning (Schmitt *et al.*, 2011, p. 37). More importantly, accommodations do not change academic standards or expectations: a test must still measure what it aims to measure without altering the teaching content, giving students an unfair advantage over other students, or changing the skills or knowledge that a test aims to measure. Appropriate accommodation should be an integral part of the normal teaching and testing cycle and should never be restricted to evaluation periods only. Hence, they are provided both for testing and for instruction throughout the year, specifically in the classroom. Both aspects are important to consider; on the one hand, test accommodations allow students to demonstrate their abilities (not their disabilities) in tests or examinations by making modifications to assessment materials or procedures. On the other hand, classroom accommodations enable them to demonstrate their learning through full participation in the classroom environment.

In the literature, three terms are often used interchangeably: accommodation, modification and intervention. Still, it is relevant to note that they differ in meaning. These definitions are based on the contributions of Harrison *et al.* (2013) and the International Dyslexia Association (2020).

- **Modifications** can be defined as changes in school practice that alter, lower or reduce learning expectations to compensate for a disability. They modify the nature of instruction and assessments and reduce performance expectations of students. For instance, a modification to a homework assignment would consist of lowering the level of math knowledge-skill. The use of text in audio-format for a reading comprehension would be considered an assessment modification.
- **Interventions** refer to changes that are systematically proposed in order to develop and improve students' knowledge, skills, behaviour, circumstances or emotions. For instance, a student with reading problems could be given systematic remedial assignments in order to improve his/her reading skills.
- **Accommodations** are changes in practice whereby all learners face the same requirements, but which offer a practical advantage to learners with disabilities so that everyone can access general education. Accommodations do not reduce learning or performance expectations. For instance, the same test could be given to all students in the classroom but would be read out loud to students with reading difficulties. Accommodations rather change the manner or setting in which information is presented or the manner in which students respond.

To sum up, the change will be considered a modification if the validity of a test item or the content of instruction is affected or altered. Otherwise, it will be an accommodation (International Dyslexia Association, 2020).

There are furthermore four categories of accommodations, still based on the works of Harrison *et al.* (2013) and the International Dyslexia Association (2020):

- **Presentation** accommodations are changes in the visual format of assignments, instructions and assessments. For instance, students do not receive double-sided assignment forms, but only one side, with enlarged handwriting if needed.
- **Response** accommodations refer to adjustments that enable students to respond to a particular task, with organisational tools to assist students in formulating their responses. For instance, students may receive an oral assessment instead of a written one.
- **Timing/scheduling** accommodations change the length of time allowed for completion of an assignment, test or examination. For instance, students may be given an extra 30 minutes for an evaluation, or two extra days to study or hand in an assignment.
- **Setting** accommodations change the location of tests or the conditions of the assessment setting. For instance, students can carry out assessments in a quiet classroom environment without any distraction.

It should also be noted that these accommodations need to be integrated into classroom practice before being used in assessment situations. Moreover, they are only useful if learners are able to use them effectively. In other words, practice is the key to effective use of accommodations. On the theoretical basis of what accommodations are and what accommodations exist, several concrete models to help schools and teachers 'differentiate' through accommodations have emerged. The next section illustrates one of them.

2.2.2. A model for differentiation

Given the different laws on accommodations, it is interesting to have concrete examples to draw on as a teacher. Indeed, it may seem a huge challenge to try to accommodate learners' differences in the classroom (Nijakowska, 2013; Košak-Babuder, Jazbek, 2019). Hence, a number of strategies and differentiation techniques are available to guide teachers in this regard. Based on Luyer-Tanet's model (2020), differentiation can be achieved in education by considering four dimensions: supports, guidelines, tasks/activities and implementation conditions:

SUPPORTS

- **Nature:** paper, audio-visual, audio
- **Presentation:** font (size, dyslexia font, color blind font), organisation on the page, visual aspects with colours, +/- illustrations (useful or decorative?), graphics, diagrams, spacing,...
- **Page format:** length, height
- **Level of difficulty:** accessibility, complexity
- **Quantity** of documents to be processed
- **Volume** of information per support

INSTRUCTIONS

- **Language:** French, English, translated guidelines
- **Channel:** written, audio recorded, visual support
- **Presentation:** font, size (adaptation for dyslexics and colour blind people), organisation on the page (justified text, spaces), visual aspects with colours, +/- illustrations, spacing, underlining, highlighting, bold characters,...

TASKS/ ACTIVITIES

- **Nature:** simple/ complicated task, research/production activity, varied/ deliberately repetitive tasks
- **Type of language activity:** written/oral production, without/with interaction, written/oral reception
- **Status:** compulsory/ optional (possibility for those who wish to do so, can skip a step, process the exercises in a different order,...)
- **Type of questioning:** open/closed questions, fill-in-the-blanks, MCQs,...
- **Type of production expected:** written, oral, digital (slide show), graphic (poster, brochure, mind map), etc.

IMPLEMENTATION CONDITIONS

- **Time allocated:** possibility of accommodation
- **Context:** part to be done outside the classroom in advance/ as an extension/ to deepen, fix, enrich,...
- **Tools:** computer, tablet, smartphone, other digital tools,...
- **Resources:** paper/online dictionary, digital resources, personal notebook, manual,...
- **Help:** lexical input, toolbox, response prompts, visual aid, other forms of support
- **Personal support/autonomy:** human help (teacher, peers), on request/systematic, with this or that type of pedagogical interaction, with this or that teaching posture, ...
- **Location:** classroom(s), (spatial organisation: different areas), multimedia room,...

Through these four dimensions, teachers can try to adapt their teaching methods to meet the students' needs. Many techniques can be easily applied in regular classroom teaching (Cambridge University Press, 2020). It is important to note that differentiation will not only benefit dyslexic learners, but all learners (Cambridge University Press, 2020), as each language learner is unique and has personal characteristics and experiences that are both different and special (Cambridge University Press, 2020). It is worth noting that a large number of studies confirm that individual differences (IDs) play a role in Second Language Acquisition (SLA) (Meunier & Paquot, 2019-2020; Zafar & Meenakshi, 2012), more specifically on L2 reading comprehension (Chun & Plass, 1997). It is important to take these into account within the classroom itself. IDs include for example: linguistic competence, prior knowledge, learning styles, cognitive styles, abilities, strategies and affective factors, such as interests, motivation, and attitude, among others (Chun & Plass, 1997, p. 64).

Some techniques may be more effective than others depending on the learners, so it is essential for the teacher to get to know the students and try out different techniques. As far as dyslexic learners are concerned, it is preferable that the presentation causes them as little visual stress as possible because they may find it difficult to concentrate on too many elements at once (Cambridge University Press, 2020). As shown in the table, there are many techniques to be implemented. For instance, visual adaptations of written material are highly recommended. For instance, a dyslexia-friendly font that is larger can be most appropriate for instructions. The importance of visual aspects for dyslexic learners will be developed in section 2.3.3.2.

Moreover, differentiation also consists of adapting the students' tasks and activities. Instead of requesting a written production after a reading comprehension exercise, the teacher might for instance ask dyslexic learners to make a mind map. The teacher can also leave the adaptation of the activity to the students. In terms of implementation conditions, dyslexic learners may be given extended time to complete

a test, exam, task or assignment. The addition of audio-visual tools, such as subtitled videos or TTS devices that allow students to read a text while listening to it simultaneously can also benefit dyslexic students by improving their understanding of texts (Cambridge University Press, 2020). In this sense, reading comprehension programmes are particularly useful in helping them to overcome their difficulties for in- and out-of-class practice. Luyer-Tanet's (2020) model is a useful starting point to help institutions and teachers use differentiation in various ways. It is up to them to try out these techniques and adjust their lessons. Some differentiation techniques are considered as accommodations within schools and should therefore be implemented.

Nevertheless, it might not be as simple as it seems for teachers to differentiate. As reported in section 2.2., education systems are legally responsible for adapting methods, curricula, materials and procedures to meet the needs of all students. Consequently, foreign language (FL) teachers are also obliged to recognise and address the needs of dyslexic learners (Nijakowska, 2013). However, this obligation seems to be rarely fulfilled in the classroom. It is not surprising to observe this, as adapting teaching to dyslexic learners represents a challenge for FL teachers (Kořak-Babuder, Jazbec, 2019; Nijakowska, 2013). In fact, FL teachers do not usually master the relevant teaching techniques and methods to support the language learning processes of dyslexic students because, while they may be familiar with dyslexia, they do not sufficiently understand its nature and the difficulties it causes in FL learning. This is apparently most often the result of a lack of adequate instruction in SpLDs (including dyslexia) during their professional training (Nijakowska, 2013). Additionally, FL teachers may feel very confused when searching for information themselves due to the huge amount of conflicting research findings, competing theories and alternative treatments suggested in the research on dyslexia. In this sense, their reluctance and doubts about how exactly they should approach FL learners with dyslexia may be legitimate (Nijakowska, 2013). This implies that teachers' lack of specific and in-depth knowledge about adapting teaching and assessment has led them to consider the least intensive learning support

as sufficient (Kořak-Babuder, Jazbec, 2019). However, FL teachers are increasingly keen to receive training on the subject and report a need for comprehensive guidance on how to work with dyslexic FL learners (Kořak-Babuder, Jazbec, 2019; Nijakowska, 2013). The fundamental concern therefore seems to be raising awareness of dyslexia among all parties involved in the creation and operation of the educational environment, implying specialised training for FL teachers teaching dyslexic students.

2.2.3. THE MULTISENSORY STRUCTURED LANGUAGE APPROACH

In addition to the accommodations that are worth exploiting as a teacher, there is also a pedagogical approach that is strongly recommended for use with students, especially dyslexic students. As stated in the previous sections, dyslexic students need to be taught how to jump over invisible hurdles, which is why they need adjustments in their teaching process, enabling all students to access the curriculum on an equal footing (Kormos & Smith, 2012). Therefore, a particular type of approach has been adopted by many researchers, namely the MSL approach (Multisensory Structured Language). The method is based on the dyslexia remedial programme of Gillingham and Stillman, and later developed by Sparks, Ganschow, Kenneweg & Miller (Kormos & Smith, 2012). Gillingham and Stillman found inspiration from the work of Orton, one of the first researchers to design a systematic programme of reading instruction for dyslexic students. According to the Orton-Gillingham (OG) approach, children receive explicit and direct teaching through sound-letter correspondences while activating various sensory channels simultaneously. This approach is also highly structured, occurs in small, cumulative steps and provides dyslexic learners with sufficient opportunities for practice and revision. It aims to develop children's phonemic, morphological and syntactic awareness, enabling them to develop their reading and spelling skills. Orton himself was influenced by the kinesthetic method of Fernald and Keller and argued that the kinesthetic-tactile reinforcement of visual and auditory associations could compensate for this tendency that dyslexics have to confuse similar letters and to

transpose the sequence of letters when reading and writing (International Dyslexia Association, 2014).

According to Crombie (2017), this approach seems to be the most appropriate for poor language learners, including dyslexics. Moreover, another study in progress (Consortium, 2021, article in progress) is actually showing that multisensory learning positively influences the integration of new foreign language information. The IDA defines it as follows:

“Multisensory learning involves the use of visual, auditory, and kinesthetic-tactile pathways simultaneously to enhance memory and learning of written language. Links are consistently made between the visual (language we see), auditory (language we hear), and kinesthetic-tactile (language symbols we feel) pathways in learning to read and spell”. (International Dyslexia Association, 2009, p. 1).

In other words, dyslexics need a different approach to learning language from that used in most classrooms (International Dyslexia Association, 2014), in which no channel of learning is excluded (Crombie, 2000). However, it is important to note that teaching languages to students with SpLDs does not necessitate methods and techniques radically different from those used in conventional language classrooms. Instead, the aim is to improve the quality of education and make it suitable and accessible to all. The main difference with conventional education lies in the emphasis on explicit teaching of language structures, a slower rate of progression and frequent revision (Kormos & Smith, 2012). There are 6 major principles that are important to consider in this MSL approach and The International Dyslexia Association (2014) summarised them as follow:

1. *Simultaneous, Multisensory (VAKT)*

Teaching involves all of the brain's learning pathways simultaneously or sequentially to enhance memory and learning. VAKT stands for Visual, Auditory, Kinesthetic and Tactile (Kamala, 2014).

2. *Systematic and Cumulative*

The organisation of materials in multisensory language teaching must follow the logical order of the language. It should start with the simplest and most fundamental concepts and progress methodically to more difficult content. Each concept must also be based on those already learned and the concepts taught should be systematically reviewed to strengthen memory.

3. *Direct Instruction*

The Inferential learning of any concept should not be considered as acquired. Multisensory language teaching implies the direct teaching of all concepts with continuous interaction between student and instructor.

4. *Diagnostic Teaching*

Teachers must be able to provide flexible or individualised teaching as the educational programme is based on a careful and continuous assessment of individual needs. The content covered must be handled step by step in order for students to make progress.

5. *Synthetic and Analytic Instruction*

Both synthetic and analytical instruction are integrated into the multisensory and structured language programmes. On the one hand, synthetic instruction introduces the parts of the language and then teaches how these parts work together to form a whole. On the other hand, analytical instruction presents the whole and teaches how it can be decomposed into its constituent parts.

6. *Comprehensive and Inclusive*

All levels of language should be addressed, usually in parallel: sounds (phonemes), symbols (graphemes), meaningful word parts (morphemes), word and phrase meanings (semantics), sentences (syntax), longer passages (discourse) and the social use of language (pragmatics).

Although perfection in reading and writing may be unattainable for dyslexics, it cannot be over-emphasised that learning through hearing, seeing, speaking and writing can offer the best chance of success, especially when these processes interact simultaneously (Crombie, 2000). In this way, students benefit from learning alphabetical patterns and words with the engagement of all learning modalities (International Dyslexia Association, 2014), and this active use of the senses even makes learning a memorable and enjoyable experience, while simultaneously helping to anchor the information in the brain (Kormos & Smith, 2012). Additionally, as Crombie (2000) points out, this method has already proved its worth for first language learning. There is further considerable research evidence that supports the effectiveness of MSL teaching (Kormos & Smith, 2012), namely by the National Institute of Child Health and Human Development (NICHD) (International Dyslexia Association, 2014). Regarding reading comprehension, the use of sounds, images and moving pictures or videos alongside the text has been shown to play an important role in the global understanding of the text and is an undisputed component of language learning materials (Chun & Plass, 1997). Some studies (Schmitt *et al.*, 2011; Chun & Plass, 1997) also encourage the use of verbal (written or spoken) and pictorial (illustrations, photos, videos) images to improve learners' ability to create coherent mental images in working memory, thereby increasing learning outcomes. A last observation is that such an approach not only benefits students with SpLDs (dyslexics), but benefits all students, even those with no apparent learning difficulties (Crombie, 2000; International Dyslexia Association, 2014; Pfenninger, 2015).

2.3. TECHNOLOGY

2.3.1. *TEACHING WITH TECHNOLOGY*

With the rise of technological advances, new and emerging digital technologies emerged and are more and more adapted for FL pedagogy (Golonka, Bowles, Frank, Richardson & Freynik, 2014). In this digital age, the use of technology in education is even widely “accepted to be an integral and expected part of the teaching and learning experience (Tunjera & Chigona, 2020, p.126). However, it is not always simple for teachers to integrate appropriate technologies into their lessons, partly because teacher preparation programmes have struggled to get teachers to actively integrate appropriate technologies, or because some teachers have not learned the content in online environments and do not have the knowledge to provide students with online learning opportunities (Niess, 2011). Another reason could be that the field of Computer Assisted Language Learning (CALL) is developing at such a pace that it is almost impossible for language trainers to keep up with it (Meihami & Hussein, 2014). These observations have led to the current focus on teachers' knowledge of technology and how it is integrated into the curriculum in teacher education research (Tunjera & Chigona, 2020).

In this perspective, TPACK model aims at exploring teachers' knowledge required for teaching in the 21st century (Niess, 2011). Many scholars have suggested thinking about the integration of technology, content and pedagogy and came with the TPACK framework, e.g. the “total package required for teaching” (Niess, 2011, p. 301) which integrates: Technology, Pedagogy, And Content Knowledge. While mainly focusing on the integration of technology, content and pedagogy, TPACK does not necessarily predict the outcome of this integration (Tunjea & Chigona, 2020). Therefore, the TPACK model is often used in parallel with the SAMR model, which forecasts the integration of technology at different levels and produces certain results

TPACK is thus a dynamic framework that describes what teachers need to know in order to design and implement curriculum instruction, while guiding their students' thinking and learning using digital technologies in a variety of subjects. The SAMR model of technology integration defines a spectrum from using technology to enhance or facilitate familiar tasks to, at the high end, redesigning educational approaches, using technology to enable activities that were not previously possible (Cambridge University Press, 2018). These definitions are adapted from Puentedura's model:

- **Substitution:** technology acts as a direct substitute for the tool, without functional change.
- **Augmentation:** technology acts as a direct substitute for the tool, with a functional improvement.
- **Modification:** technology enables a significant redesign of tasks.
- **Redefinition:** technology enables the creation of new tasks that were previously inconceivable.

Specifically, the SAMR framework enables teachers to assess the impact of technology on teaching and learning. Learning activities at the substitution and augmentation levels are intended to enhance learning, while activities at the modification and redefinition levels are meant to transform learning. These models aim thus to support the use of technology in the classroom. If we consider the TTS and Dys Vocal tools studied in this thesis, they are at the level of modification. Technology, in this case, allows the task or activity to be significantly redesigned.

2.3.2. TEACHING WITH TTS TOOLS

When early TTS tools were introduced, they did not attract much interest from language teachers because of their unnatural voice and low intelligibility (Moon, 2012). Teachers were worried that this new technology could not capture the full complexity

of human language, nor could it be used as a speech model for foreign language learners. Through time and technological advances, the quality of TTS speech has evolved. This has led some English teachers to consider integrating TTS tools into the classroom to provide spoken output to their students. Yet some other teachers are still hesitant about the integration of TTS tools into their teaching. According to them, some programmes can still lead to mispronunciation of words despite the improvement in voice quality, as TTS speech has limitations in terms of naturalness, pleasantness and expressiveness (Moon, 2012). More recent studies contradict this early view of the poor quality of TTS speech by claiming that with technological advances, the speech quality of TTS speech is close to "rivalling" human voices (Cambre, Colnago, Maddock, Tsai & Kaye, 2020, p. 1). Thanks to its outstanding speech quality, TTS technology has been proved to have a measurable positive impact on foreign language learning, for several purposes (Proença, Raboshchuk, Costa, Lopez-Otero, & Anguera, 2019; Golonka *et al.*, 2014; Cardoso, Smith, & Garcia Fuentes, 2015) and has been widely adopted through different forms. First of all, it is a fact that EFL learning often lacks native language input. Indeed, there are limited opportunities for exposure to the target language and interaction. This could be related to the insufficient number of native teachers available. In this view, one way to partially overcome this problem could be the use of TTS tools, which directly expose learners to the voice of 'native' speakers (Moon, 2012). Secondly, TTS has been proved to help learners improve their L2 pronunciation, particularly thanks to its high speech quality (Cardoso *et al.*, 2015; Moon, 2012; Kiliçkaya, 2009). Lastly, as will be further developed in section 2.3.3.1, there is strong evidence that read-aloud assistance can also facilitate text comprehension (Kořak-Babuder *et al.*, 2019; Crombie, 2000; Kormos interview, n.d.; Wood *et al.*, 2018; Schmitt, McCallum, Hawkins, Stephenson, & Vincencio 2019).

Some recommendations were listed by Moon (2012) for successful implementation of TTS in the FL classroom. Firstly, EFL teachers need to create an environment that allows learners to use TTS tools in a more personalised and

independent manner. In this way, learners can work individually by accessing auditory and visual data, while controlling the data at their own pace by adjusting or modifying certain features of the TTS as they wish, for example speed and synthetic voices. Then, teachers also need to guide learners in choosing a reliable TTS tool, as some programmes do not work properly.

2.3.3. RESEARCH ON ASSISTIVE TECHNOLOGIES: TWO TOOLS

As previously mentioned, a number of digital tools have become available in various fields over the last decade, also for educational purposes. Nowadays, technology has entered schools and settled into many classrooms (Kormos & Smith, 2012). The potential of new technologies is considerable, but too few teachers are currently exploiting it (Crombie, 2000). Not surprisingly, in a recent study (Van de Vyver & Meunier, 2015) to determine teachers' familiarity with Open Educational Resources (OERs), the vast majority of participants, being teachers, stated that the school(s) where they work did not encourage the use of mobile devices in their teaching. Moreover, almost all participants stated that they had not received training on how to use technology in their professional environment. This could explain the low incentive to use mobile devices within the institutions. This contrasts with the evidence that tools and technologies are increasingly designed for educational purposes (Liaw & English, 2017). In their research, Liaw and English (2017) also stress the fact that technologies are developed and applied for all levels of L2 learners to develop certain skills for effective L2 reading.

This research focuses on two complementary tools, namely Text-To-Speech technology and Dys Vocal software. Both tools are based on assistive technology (AT), which refers to "any item, piece of equipment, software program or product system used to increase, maintain or improve the functional abilities of individuals with disabilities" (Assistive Technology Industry Association, 2021). There are different types of ATs, but for the purpose of this research, we focus on ATs that help people with

reading difficulties, e.g. dyslexics. As a matter of fact, TTS and Dys Vocal devices aim at improving the learner's reading skills. The former by enabling learners to listen to a text while reading it simultaneously and the latter by allowing better integration of textual information through the adaptation of written information. Current knowledge regarding these tools is summarised in the following two subsections. For a detailed presentation and comparison of both tools, see section 4.

2.3.3.1. TEXT-TO-SPEECH DEVICES

By combining hearing and sight at the same time, TTS are consistent with the idea of making teaching multisensory for dyslexic people. In this sense, the use of TTS corresponds exactly to the earlier discussion of MSL. This method is thus suitable and recommended for dyslexic learners. Moreover, it should be also specified that the reading and listening processes can be complementary. Tunmer and Chapman (2012) argue that the processes of comprehending spoken (listening) and written (reading) texts overlap with each other. In fact, readers and listeners must perform the same tasks in order to understand a text: comprehend the structure of a text, make inferences and then check the overall comprehension. The major distinction in psycholinguistic processing between reading and listening is related to word-level decoding, which occurs through visual channels in reading and through auditory channels in listening. Apart from this difference, both processes occur in parallel and complement each other to facilitate the recognition of written words for people with learning disabilities (Kormos, Košak-Babuder & Pižorn, 2019).

This type of assistive technology was first developed in the 1980s and has grown rapidly since then (Wood *et al.*, 2018). Basically, TTS takes words from any digital device (computer, smartphone, tablets,...) and converts them into audio (Understood, 2020). Not all works agree on the categorisation of these tools. According to Harrison *et al.* (2013), TTS is considered an accommodation, while according to the IDA (2014), it is rather considered a modification. For this research, TTS is best classified as an

accommodation, as reading and listening to the text at the same time is not assumed to reduce students' performance expectations.

Several research studies have shown that read-aloud assistance would facilitate text comprehension (Kořak-Babuder *et al.*, 2019; Crombie, 2000; Kormos interview; Wood *et al.*, 2018; Schmitt, McCallum, Hawkins, Stephenson, & Vincencio 2019), which would be highly beneficial to dyslexic learners. In some cases, learners themselves (Chun, 2001) report that audio narration of a written text is generally considered to be a positive reinforcement of the textual presentation. The different features of TTS are also designed to improve reading comprehension and can have a significant influence on the effectiveness of the tool (Wood *et al.*, 2018). In fact, many TTS tools offer functionalities such as reading rate, dynamic highlighting, voice quality options, language choice with possibilities to choose particular (regional) accents, and many more. These features and the quality of TTS are constantly evolving since the 1980s and lots of free programs and apps are available worldwide (Wood *et al.*, 2018). The debate about the poor speech quality of these tools is no longer relevant as TTS speech is close to "rivalling" human voices (Cambre *et al.*, 2020, p. 1).

Particularly for dyslexics, TTS provides many benefits. Firstly, they give significant support for reading comprehension, as they compensate for ineffective basic reading skills (Schmitt *et al.*, 2019). Secondly, TTS enhance the students' autonomy (Kormos & Smith, 2012). Then, they emphasize phrase-level units, which in turn is likely to help students processing the meaning of larger semantic units (Kořak-Babuder *et al.*, 2019). In addition, the text being read and listened to is processed in the visual and auditory working memory, which helps to retain information and to build connections. Besides, TTS technology enhances student performance and participation by increasing engagement in L2 texts and motivation to learn L2 (Bottsford-Miller, Thurlow, Stout & Quenemoen, 2006). The sophistication (Moon, 2012) of TTS functionalities can also benefit dyslexic learners. Indeed, TTS tools that, for example,

offer reading rate training can help dyslexic learners increase their reading speed without noticing it. Tools that provide dynamic highlighting help learners to follow words on the screen while drawing their attention to new words (Huang, 2014; Moon, 2012). More globally, TTS technology compensates for the slow speed of word-level decoding of dyslexics, as well as freeing up working memory capacity and attentional resources for higher-level comprehension.

However, the advantages of read-aloud assistance for dyslexic students have been recently extensively debated, with the complexity of the texts at the heart of this debate. According to Košak-Babuder *et al.*'s publication (2019), TTS methods were actually found to increase the reading comprehension achievement of L2 dyslexic learners, but only when reading challenging texts, not with easy texts. Those methods enable dyslexic learners to reach the same level as their non-dyslexic peers as they relieve some of the processing burden of visual word decoding in L2. Košak-Babuder *et al.*' (2019) also added that since lexical representations in L2 are generally less well developed and lower-level reading processes are less automatic than in L1, the positive effects of TTS in more difficult texts may be more pronounced in young dyslexic L2 learners than in L1 readers.

These inconsistent results in the research may be due to the fact that the prevalence and quality of computer software with TTS features have also improved over the past 20 years (Wood *et al.*, 2018). TTS programs contain many options which can affect the user experience as well as the effectiveness of the tools such as reading speed, voice type and dynamic highlighting. Perhaps those subtle differences may affect the user experience and may thus play a role in the mixed results in the literature (Wood *et al.*, 2018).

2.3.3.2. **Dys VOCAL SOFTWARE**

Similar to TTS devices, the Dys Vocal resource enhances learners' reading comprehension but, in this case, by helping them to decipher the text visually. To this end, the software enables people to modify written information through visual adaptations. For example, by using larger fonts, coloured syllables, spaces between words, character spacing, line spacing, coloured text, and many others. This allows for better integration of the written material and makes it easier to scan the information. As a result, such software can alleviate fixation problems often encountered by dyslexic learners, i.e. lack of ability to scan the text without losing its place, and help them better concentrate on tasks of a higher cognitive level, such as reading comprehension (Gregor & Newell, 2000). In addition, a further objective of this kind of system is to make phonemes easier to distinguish by modifying the font type, size and colour to avoid confusing and/or reversing similar letters, which is also typical of dyslexics (Gregor & Newell, 2000; Appert & Truillet, 2016; Dyslogiciel, 2021).

As suggested in French *et al.* (2013), simplifying the visual display of material is always advantageous in order to reduce the learner's cognitive load and promote comfortable reading (Yu & Miller, 2010). Indeed, visual stress might cause concentration difficulties on too many elements at once (Cambridge University Press, 2020). Moreover, there is a common agreement in specific studies about dyslexia that text presentation has significant effect on dyslexic learners' readability (Appert & Truillet, 2016; Rello & Baeza-Yates, 2013; Rello & Baeza-Yates, 2015; Dyslogiciel, 2021). It has thus been suggested that making visual changes to the environment of dyslexic learners could be very beneficial. In practical terms, providing an easy-to-use interface that allows dyslexics to configure the screen to suit their individual preferences can ease reading comprehension (Gregor & Newell, 2000). It should also be noted that too many options on the user interface of the tool will reduce the user's intention to use it when reading web pages and will make reading understanding more challenging (Yu & Miller, 2010).

Overall, it has been shown that larger font sizes and larger character spacings result in learners reading faster, and in better reading accuracy while poor colour contrast, tiny fonts and illegible fonts impair reading comfort (Yu & Miller, 2010). It is also recommended not to use black text on white background as it can lead to swirling or word confusion since dyslexic learners are sensitive to brightness (Rollo & Baeza-Yates, 2015). In a study comparing different fonts, it was concluded that italic fonts should be avoided as they decrease reading performance, while Helvetica, Courier, Arial, Verdana and CMU fonts should be increasingly used (Rello & Baeza-Yates, 2013).

Furthermore, there has been recent controversy about the effectiveness of fonts designed for dyslexic people (Wery & Diliberto, 2017). These fonts were created with the aim of improving readability. They differ from more traditional fonts in that the letters have been designed to have thicker or heavier lines near the bottom of the letters, which should prevent letters from turning upside down and facilitate the distinction of individual letters for people with dyslexia, while reducing reading errors and the effort to read a text (Wery & Diliberto, 2017). However, teachers, parents and learners should be aware that no empirical evidence of the effectiveness of specialised fonts for people with dyslexia exists to date. The results of Rello and Baeza-Yates (2013) coincide with this finding: the so-called "OpenDys fonts" were not found to improve people's reading ability. In 2016, Marinus et al. also came to the conclusion that another special font called "Dyslexie" did not improve readability for learners. The only effective feature of the font they found was not the special font itself, but the spacing of characters, which has been extensively studied and considered significant for the ease of reading comprehension. Indeed, as indicated in Yu & Miller (2010) character, line and paragraph spacing features are really essential to learners. Without these features, readers may jump to the wrong line. With dense presentation of information, it is easy to miss the main idea when reading a long article. For non-native readers in particular, it is extremely difficult to read and understand long paragraphs, as they may have to

identify syntactic structures or mentally translate the content into their native language. 'Cascading' information would help readers recognise grammatical structure and improve reading comprehension (Yu & Miller, 2010).

Based on these previous studies, it is in the perspective of further development that new tools to modify text presentation have emerged. For example, the Mozilla Firefox Firefixia extension was released and provided readers with the ability to customise their reading preferences (Rello & Baeza-Yates, 2015). This customisation approach has been very well appreciated and has been adjusted according to studies and recommendations. The customisation settings¹ include font type, font size, colour, character spacing, line spacing and column width. Rello & Baeza-Yates (2015) emphasise the importance of opting for a customisable environment because there is no universal profile of dyslexic people in the world and, more importantly, because these tips for improving readability can also benefit non-dyslexic learners. This allows all learners, dyslexic or not, to adapt their preferences to suit their needs. Rello, Kanvinde & Baeza-Yates (2012, p. 1) summarise this idea very well in their article with the following statement: "good for dyslexics, useful for all". The use of dyslexia-friendly devices is indeed also advocated for other types of learners, as no two learners share the same individual characteristics and preferences.

In addition, this software addresses the specific needs of dyslexic students in two different ways. Firstly, the use of Dys Vocal enables to differentiate the supports' presentation of tasks and activities. As indicated in section 2.2, adapting the supports' presentation is part of the differentiation process, which is strongly recommended for dyslexic learners. This fits perfectly with the previously mentioned aim of differentiation, which is to give all students the opportunity to achieve common goals through different means. The task remains unchanged; it is only the presentation that is adapted. Secondly, thanks to its innovative functions, Dys Vocal also allows a MSL approach to

¹ For a detailed overview of dyslexia friendly style guide, see <https://www.bdadyslexia.org.uk/advice/employers/creating-a-dyslexia-friendly-workplace/dyslexia-friendly-style-guide>

language learning by enabling its users to listen to a written text simultaneously. Like with TTS tools, learners' auditory and visual channels are activated at the same time. This multisensory approach has a positive impact on individuals with dyslexia and facilitates the integration of new information into the foreign language (Consortium, 2021, article in progress). This software therefore fulfils the necessary conditions for differentiating and approaching language in a multisensory manner.

3. METHODOLOGY

3.1. PROJECT REORIENTATION

The initial project of this thesis was to go to a secondary school to test the effectiveness of these two technological tools with dyslexic students. The purpose was to practice the reading skills of these students and to compare the results of a reading comprehension exercise conducted with and without the devices and to get feedback from the students. Regrettably, in view of the Covid situation, the project has been reoriented as of March 2020. It was not possible to go to schools as agreed, but it was decided, in agreement with my supervisor, to create awareness-raising videos on the theme of my thesis, i.e. the relevance of using TTS and Dys Vocal tools to help dyslexic students in their reading comprehension of foreign languages. These videos therefore compensate for the initial project.

Due to this reorientation, there is no results section as there is no experimental project as such. Instead, there are different sections dedicated to the presentation and description of the tools, videos and a list of the top five TTS tools to guide teachers in using them in the classroom. For the same reason, and because of the hard work behind the creation of the videos, it was also agreed with the supervisor to reduce the amount of text that was originally planned.

3.2. RESEARCH QUESTIONS

Because of the reorientation of the project, the research questions have also been adapted. The first research question addresses how TTS and Dys Vocal tools affect the reading comprehension of L2 learners of English with dyslexia. The second research question is addressed to teachers and seeks to inform them about the top five TTS resources and their effectiveness in classroom settings.

(RQ1) HOW CAN TTS TOOLS AND DYS VOCAL SOFTWARE HELP L2 LEARNERS OF ENGLISH WITH DYSLEXIA IN THEIR READING COMPREHENSION?

(RQ2) WHICH TTS TOOLS ARE MOST EFFECTIVE FOR LANGUAGE TEACHERS IN THE CLASSROOM TO ENHANCE READING AND WHY?

3.3. HYPOTHESES

With regards to the impact of the tools, a favourable influence may be expected for RQ1 since the literature is very positive on the issue, especially for challenging texts. Besides, if we consider the fact that technological functionalities are constantly evolving, a beneficial impact on participants' reading comprehension is to be expected. These features can therefore potentially play a role in this positive impact. The effectiveness of the tools on dyslexic learners is likely to depend on the quality of the voice and the visual accommodations offered by them.

Regarding the effectiveness of TTS tools in RQ2, tools are more likely to be considered effective for educational purposes if they take into account the following criteria: ***user-friendliness, speech quality, speech language options, ESL strategies, dyslexia-friendly features, software compatibility*** and ***pricing***.

3.4. REALISATION OF THE LIST

3.4.1. CRITERIA SELECTION

In order to make a selection of TTS tools, it was necessary to establish criteria for assessing the usefulness of the tools for L2 learners of English who are dyslexic. The first step was thus to identify criteria that would fit the purpose of the list, namely to propose TTS tools to language teachers that could be useful to help their students in reading comprehension and be easily used in class. The eight criteria were selected on the basis of several aspects.

First of all, the selection of criteria was based on the literature. It is the case for the criterion **speech quality**, which was selected by looking at different studies that had already selected certain evaluation criteria and by adapting it to the specific context of this thesis. It was selected because the literature has considered it to be important both for the effectiveness of TTS tools and for teachers to take it into account in their teaching methods. The more natural the speech sounds, the more efficiently the tool will be evaluated, and the more likely teachers will consider using it.

The other criteria were selected on the basis of my personal teaching experience as a future secondary language teacher and are therefore subjective. They can be divided into three dimensions connected to RQ2. Firstly, as TTS tools are primarily technological, criteria related to technological tools have been selected. **User-friendliness, software compatibility** and **pricing** are three criteria that are important to know before considering using or buying any technological tool, and hence any TTS tool. Secondly, because the list is intended for language teachers, specific criteria related to L2, and especially ESL, were also included. **Speech language options** are crucial for language teachers. For example, tools that do not offer English voices should not be envisaged. In contrast, tools that provide regional accents may be interesting

for language teachers. This would allow users to hear different English accents, such as British, American, Australian and many others. Besides, tools with **ESL strategies** features that can facilitate the reading experience of its users can be advantageous. This may simply be the fact that the software is in English, which can train the user's English skills, or an option to translate a word or paragraph into the mother tongue directly in the interface, or to have its definition. Moreover, a criterion related to reading problems in dyslexic people were considered, especially as **dyslexia-friendly** features are likely to be beneficial to all readers. These include visual adaptations – font options (size, type, dyslexia font), text width, colour themes, character and line spacing, dynamic highlighting – and non-visual adaptations such as reading rate and OCR, among others. Because these adaptations can potentially help readers, TTS tools that contain these adaptations are likely to be favoured over others. The final criterion of value in this research is the **pedagogical potential** of the tool's use by language teachers in the classroom. Whether or not certain tools are easily adaptable to institutions is a crucial aspect for teachers to think about. If not, it is important to know it before considering the use of a certain tool.

These eight criteria form the basis for the evaluation of TTS tools and have a more or less progressive ranking of importance, as follows:

- 1) **Pedagogical potential**
- 2) **Dyslexia-friendly features**
- 3) **Speech quality**
- 4) **Speech language**
- 5) **User-friendliness**
- 6) **Software compatibility**
- 7) **Price**
- 8) **ESL strategies**

It should be noted that this ranking is purely subjective and has been made from the perspective of a future secondary school language teacher. Therefore, teachers are likely to favour certain criteria over others and modify the ranking. The fact that ESL strategies come last is because few TTS tools use them, and the few that do use them hardly use them at all.

3.4.2. TOOLS SELECTION

The selection of the TTS tools could subsequently be made based on the selection of the eight criteria. The first step was to compile a list of all the TTS tools mentioned in the literature and other tools I came into contact with during my master's courses. I have also included tools that I discovered on the Internet during my search. Then, the tools that did not offer a (limited) free trial version were directly excluded from the list, as I was not able to apply the criteria without paying. For the remaining dozen tools, I tested and compared them by examining the options offered on the basis of the criteria selection. Only the tools that showed a certain balance with regard to the different criteria were further selected, with the best of them making up my top five list. Consequently, there is a certain amount of subjectivity involved, although the selection is mostly based on the criteria.

3.5. VIDEOS

3.5.1. REALISATION

The first step before shooting the videos was to think about why to make them and decide how many to make and for whom. The main objective is to inform about the two tools presented in this thesis that seek to improve the reading skills of dyslexic students. In agreement with the supervisor, it was agreed to make three videos for three different types of audience: secondary schools and teachers, secondary school (dyslexic) students and future language teachers from the UCL. Once all this

information was obtained, the scripts for the videos had to be written and validated by the supervisor.

It was difficult to select what to include and not to include in the videos. I did not want to make explanatory videos that were too long, so I restricted myself to the essentials. Besides, I could not show how the tools work directly in the videos because it would have been too long to watch. I preferred to focus on the fundamental aspects and give my contact details if people would like more information about the tools.

The next step was to decide how to make the videos. In order to achieve professional quality, it was best to shoot them in a studio. I am very lucky to be acquainted with a computer graphics student at the Haute Ecole Albert Jacquard in Namur. The videos were therefore made in the studio of the school. After a few takes and several hours under the cameras and lights, the videos were ready to be edited. The editing was done in collaboration with this friend, who listened carefully and tried his best.

The final step is to distribute the videos to the target audiences. This will be done after the submission of this thesis, in June, through the supervisor's and UCL's contacts.

3.5.2. DESCRIPTION OF THE THREE VIDEOS

The videos are intended to inform about the existence of these tools and how they work. In this regard, it was decided to create three videos that target three different audiences.

The first video is in French and is aimed at secondary schools and teachers, especially language teachers. It is therefore a matter of informing institutions of these

possible accommodations and their effectiveness to help cope with dyslexia. This may encourage teachers to explore these tools and implement them in their lessons.

The second video is also in French and is addressed to secondary students, whether or not they are dyslexic. The aim here is to raise awareness of the existence of such tools. If interested, students could find out more about the tools and download them on their personal devices. As the use of these tools was found to be beneficial for all learners, not just dyslexics, it seemed obvious to address this video to all students, and not just dyslexic learners.

The third video is in English and is intended for students of the Master in Germanic languages following didactics at the UCL. Having completed the programme myself, I believe it is essential for future secondary school teachers to be aware of SpLDs and their influence on language learning, as they are likely to encounter them in the classroom. It is also important for them to know how to deal with them and to develop strategies that will be useful to their future students. SpLDs is a topic that is hardly covered in this programme. Therefore, I would be pleased to bring my contribution with this video.

After submitting this thesis, the videos will be sent to the different target audiences. The first video will be sent to as many secondary schools as possible, which may or may not use it and forward it to teachers. The second one will be sent to the same schools and teachers who may share it with their students if they wish. The last video will be directly sent to Fanny Meunier, supervisor of this thesis and professor at the UCL, who is in charge of the agrégation courses in English.

3.5.3. *SCRIPTS OF THE VIDEOS*

In this section are included the scripts of the three videos that were produced. The videos differ only partially from each other, for a few sentences. The first two are in French and the last one is in English. They can be viewed by clicking on the link below the title of each video.

Video 1: for secondary schools and teachers

<https://www.dropbox.com/s/3lqmfejdgk0i55h/Video%201%20for%20schools%20and%20teachers.mp4?dl=0>.

Bonjour, je m'appelle Laurie et je suis étudiante en dernière année en langues germaniques finalité didactique. Cette année je rédige mon mémoire sur un thème qui me tient particulièrement à cœur, à savoir les outils numériques qui permettent d'aider les élèves dyslexiques dans la compétence de la lecture. Compte tenu de la situation sanitaire du moment, je n'ai pas pu tester ces outils dans des écoles. J'ai donc décidé de réaliser cette vidéo pour vous informer, chères écoles, chères enseignantes et chers enseignants, de l'existence de ces outils et de la manière de les utiliser efficacement au sein de la classe.

Comme vous le savez probablement, la dyslexie est un trouble de l'apprentissage basé sur le langage qui peut compromettre la réussite scolaire des élèves. Elle se caractérise par des symptômes entraînant des difficultés dans certaines aptitudes linguistiques, notamment la lecture. Ces difficultés sont susceptibles de s'intensifier dans une langue étrangère. Concrètement, ces troubles ont pour effets que les élèves dyslexiques lisent plus lentement et ont plus de difficultés à comprendre le sens des textes lorsqu'ils lisent dans leur langue maternelle et parfois encore plus dans le cas d'une langue additionnelle. Afin d'aider à remédier à ces difficultés, j'ai décidé d'analyser 2 outils : Text-To-Speech & Dys Vocal. Ces outils sont assez complémentaires mais possèdent chacun leurs propres spécificités.

Les logiciels de type Text-To-Speech transforment des textes et documents écrits en audio à partir de n'importe quel appareil numérique (ordinateur, smartphone, tablettes, etc.). Cela permet à l'élève d'entendre le texte tout en le lisant simultanément. En combinant la lecture et l'écoute, les élèves dyslexiques améliorent leurs performances en lecture. Les différentes fonctionnalités de l'outil contribuent également à cette amélioration. En effet, il est possible de modifier la vitesse de lecture, de surligner les mots au fur et à mesure qu'ils sont lus à haute voix, choisir le type de voix (homme, femme, parfois enfant), la qualité de la voix et même choisir l'accent (par exemple pour l'anglais : américain, britannique, australien, etc. ; pour le néerlandais : néerlandais des

Pays-bas et néerlandais de Belgique ; etc....). Ces options personnalisent donc l'expérience des utilisateurs.

Dys Vocal, quant à lui, est un logiciel qui permet à l'élève de déchiffrer un texte ou un document en utilisant et intégrant des modalités visuelles (polices de caractères plus grandes, syllabes colorées, espaces entre les caractères et/ou les mots, interlignes, textes colorés, intégration d'images, etc.). Cela permet une meilleure intégration multimodale du matériel écrit et facilite la lecture des informations. Grâce à ces aides, l'élève peut mieux se concentrer sur une tâche d'un niveau cognitif plus élevé, comme la compréhension de la lecture. Dans l'ensemble, il a été démontré que ces adaptations visuelles permettent à l'élève de lire plus rapidement et avec une meilleure précision. Une option de synthèse vocale est également disponible sur ce logiciel.

Ce mélange entre le côté auditif du Text-To-Speech et le côté visuel de Dys Vocal rend donc ces 2 outils complémentaires et optimise ainsi la capacité de lecture des élèves dyslexiques. Ces outils favorisent par ailleurs une approche différentielle et multisensorielle/multimodale grâce à leurs caractéristiques, ce qui est vivement conseillé pour les apprenants avec des troubles de l'apprentissage.

D'un point de vue pratique, adopter ces outils au sein d'une classe n'est pas très compliqué. Il vous faut une connexion Internet, un équipement électronique tel qu'un ordinateur, un smartphone ou une tablette et un casque ou des écouteurs. Toutefois, il existe plusieurs types d'outils Text-To-Speech et Dys Vocal sur Internet. Je recommande les liens suivants pour télécharger les logiciels qui sont gratuits pour une version limitée et payants après un certain nombre d'utilisations.

Je souhaiterais conclure par une phrase en anglais " good for dyslexics, useful for all ". En effet, ces outils ne sont pas seulement bénéfiques pour les élèves dyslexiques, mais pour tous les élèves, quel que soit leur profil. Cela peut concerner les élèves qui ont une mémoire plus visuelle et/ou auditive. Il ne faut donc pas hésiter à faire découvrir ces outils à l'ensemble de vos élèves.

Si vous avez des questions ou si vous souhaitez obtenir des informations complémentaires, n'hésitez pas à me contacter, je vous laisse mes coordonnées.

Video 2: for secondary school students (dyslexic and non-dyslexic)

<https://www.dropbox.com/s/modjeuygrclyfw/Video%202%20for%20students.mp4?dl=0>.

Bonjour, je m'appelle Laurie et je suis étudiante en dernière année en langues germaniques finalité didactique. Cette année je rédige mon mémoire sur un thème qui me tient particulièrement à cœur, à savoir les outils numériques qui permettent d'aider

les élèves dyslexiques dans la compétence de la lecture. Compte tenu de la situation sanitaire du moment, je n'ai pas pu tester ces outils dans des écoles. J'ai donc décidé de réaliser cette vidéo pour vous informer, élèves du secondaire, de l'existence de ces outils et de la manière de les utiliser.

Comme certains le savent probablement, la dyslexie est un trouble de l'apprentissage basé sur le langage qui peut compromettre la réussite scolaire des élèves. Elle se caractérise par des symptômes entraînant des difficultés dans certaines aptitudes linguistiques, notamment la lecture. Ces difficultés sont susceptibles de s'intensifier dans une langue étrangère. Concrètement, ces troubles ont pour effets que les élèves dyslexiques lisent plus lentement et ont plus de difficultés à comprendre le sens des textes lorsqu'ils lisent dans leur langue maternelle et parfois encore plus dans le cas d'une langue additionnelle. Afin d'aider à remédier à ces difficultés, j'ai décidé d'analyser 2 outils: Text-To-Speech & Dys Vocal. Ces outils sont assez complémentaires mais possèdent chacun leurs propres spécificités.

Les logiciels de type Text-To-Speech transforment des textes et documents écrits en audio à partir de n'importe quel appareil numérique (ordinateur, smartphone, tablettes, etc.). Cela permet d'entendre le texte tout en le lisant simultanément. En combinant la lecture et l'écoute, les élèves dyslexiques améliorent leurs performances en lecture. Les différentes fonctionnalités de l'outil contribuent également à cette amélioration. En effet, il est possible de modifier la vitesse de lecture en l'augmentant ou en la ralentissant. On peut aussi surligner les mots au fur et à mesure qu'ils sont lus à haute voix, choisir le type de voix (homme, femme, parfois enfant), la qualité de la voix et même choisir l'accent (par exemple pour l'anglais : américain, britannique, australien, etc. ; pour le néerlandais : néerlandais des Pays-bas et néerlandais de Belgique ; etc....). Ces options personnalisent donc l'expérience des utilisateurs.

Dys Vocal, quant à lui, est un logiciel qui permet de déchiffrer un texte ou un document en utilisant et intégrant des modalités visuelles (polices de caractères plus grandes, syllabes colorées, espaces entre les caractères et/ou les mots, interlignes, textes colorés, intégration d'images, etc). Cela permet une meilleure intégration multimodale du matériel écrit et facilite la lecture des informations. Grâce à ces aides, l'élève peut mieux se concentrer sur une tâche complexe, comme la compréhension de la lecture. Dans l'ensemble, il a été démontré que ces adaptations visuelles permettent de lire plus rapidement avec une meilleure précision. Une option de synthèse vocale est également disponible sur ce logiciel.

Ce mélange entre le côté auditif du Text-To-Speech et le côté visuel de Dys Vocal rend donc ces 2 outils complémentaires et optimise ainsi la capacité de lecture des élèves dyslexiques. Toutefois, il existe plusieurs types d'outils Text-To-Speech et Dys Vocal sur Internet. Je recommande les liens suivants pour télécharger les logiciels qui sont gratuits pour une version limitée et payants après un certain nombre d'utilisations.

Je souhaiterais conclure par une phrase en anglais "good for dyslexics, useful for all". En effet, ces outils ne sont pas seulement bénéfiques pour les élèves dyslexiques, mais pour tous les élèves, quel que soit leur profil. Cela peut concerner les élèves qui ont une mémoire plus visuelle et/ou auditive. Il ne faut donc pas hésiter à télécharger les outils et à les utiliser pour les tester et voir si ils peuvent vous être utiles.

Si vous avez des questions ou si vous souhaitez obtenir des informations complémentaires, n'hésitez pas à me contacter, je vous laisse mes coordonnées.

Video 3: for Fanny Meunier (and future students UCL)

<https://www.dropbox.com/s/dwotdhqp11jczao/Video%203%20for%20UCL.mp4?dl=0>.

Hello, my name is Laurie and I am in the last year of my master's degree in Germanic languages with a specialisation in didactics. This year I am writing my thesis on a topic that is very special to me, that is digital tools that help dyslexic students in their reading skills. Due to the current Covid situation, I have not been able to experiment with these tools in school settings. Therefore, I decided to make this video to inform you, future secondary school teachers, about the existence of these tools and on how to use them effectively within the classroom.

As some of you may know, dyslexia is a language learning disability/difficulty that can compromise students' academic success. It is characterised by symptoms leading to difficulties in certain language skills, including reading. These difficulties, experienced in the L1, are likely to be intensified when learning a foreign language. In practice, this learning difficulty impacts dyslexic students as they tend to read more slowly and have more difficulty understanding the meaning of texts when they read in their first language but also in a language other than their mother tongue. In order to help address these difficulties, I decided to analyse 2 tools: Text-To-Speech & Dys Vocal. These tools are quite complementary, but each has its own specificities.

Text-To-Speech software converts written texts and documents into audio files from any digital device (computer, smartphone, tablets, etc.). This allows the student to hear the text while simultaneously reading it. By combining reading and listening, dyslexic students can improve their reading performance. The different features of the tool also contribute to this improvement. It is indeed possible to choose the voice type (male, female, sometimes even children), to modify the reading speed, to highlight words as they are being read aloud, to choose a particular voice quality and even to choose a particular accent (for instance American, British, or Australian English, Dutch Dutch or Belgian Dutch, etc.). These options therefore help customise the user experience.

Dys Vocal is a software that allows students to decipher a text or document visually by using larger fonts, coloured syllables, spaces between characters and/or words, line spacing, coloured text, insertion of images, etc. This facilitates the multimodal integration of written material and makes it easier to read visual information. Thanks to those adaptations, students can focus their attention to higher cognitive level tasks, such as the actual comprehension of what they are reading. Consequently, these visual adaptations have been shown to enable students to read more quickly and accurately. A text-to-speech option is also available in the software.

This mix between the auditory aspect of Text-To-Speech and the visual aspect of Dys Vocal makes both tools complementary and thus optimises the reading performance of dyslexic students. These tools also favour a differentiated and multisensory/multimodal approach thanks to their characteristics, which is highly recommended for learners with learning disabilities.

From a practical point of view, adopting these tools in the classroom is not very complicated. You need an internet connection, electronic equipment such as a computer, smartphone or tablet and headphones or earphones. However, there are several types of Text-To-Speech and Dys Vocal tools available on the Internet. I recommend the following links to download the software which is free for a limited version and payable after a certain number of uses.

I would like to conclude with the following statement "good for dyslexics, useful for all". Indeed, these tools are not only beneficial for dyslexics, but for all students, regardless of their profile. This may include students with a more visual and/or auditory memory. It is therefore useful to introduce these tools to all students.

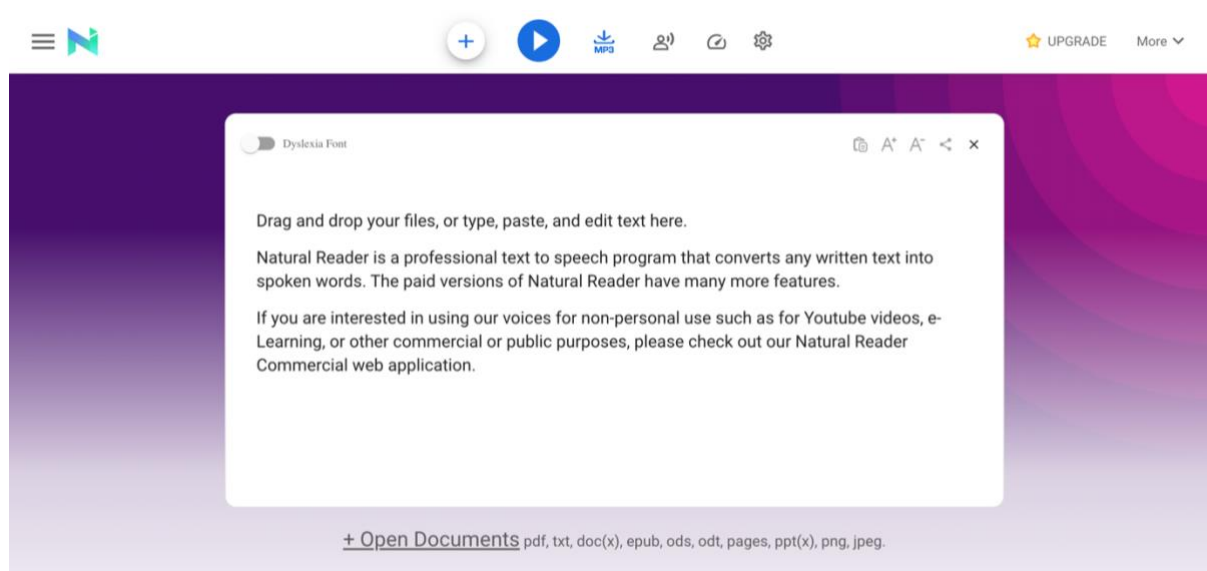
If you have any questions or would like further information, please do not hesitate to contact me, here are my contact details.

4. TOOLS PRESENTATION

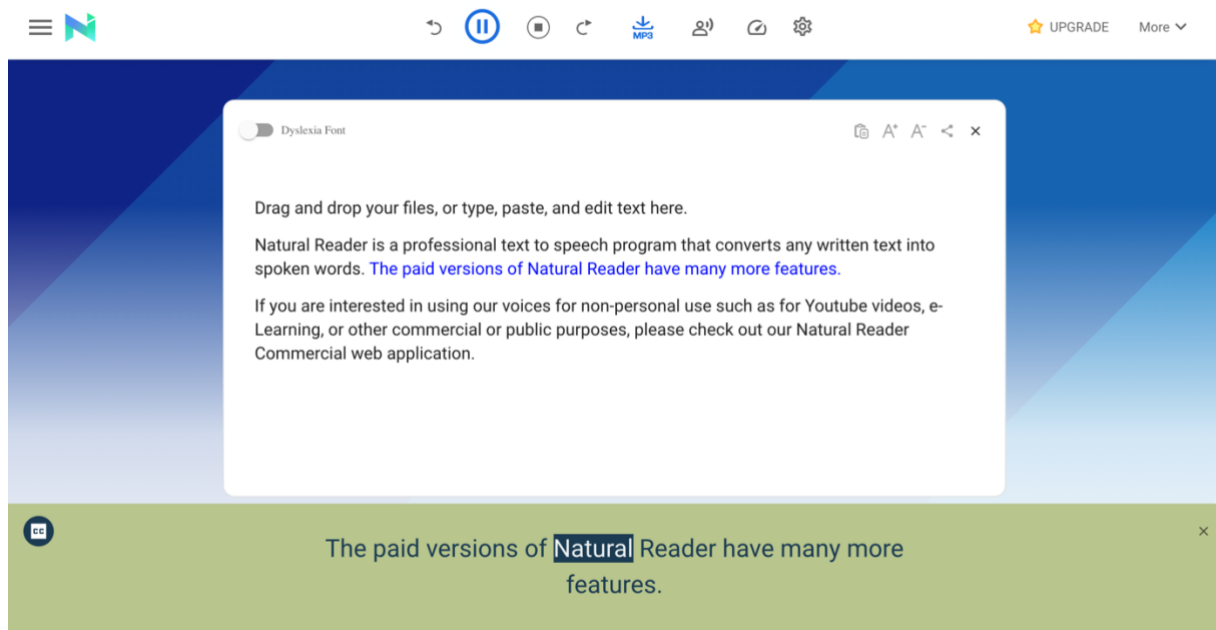
Before detailing each type of tool, it is important to note that there are a large number of Text-To-Speech websites, applications and Google extensions available on the Internet. However, only a few such comprehensive Dys Vocal programs are available (for free). The following two subsections provide a complete description of each tool and how they work.

4.1. NATURAL READER

As stated in previous sections, the key principle of TTS tools is to provide a synchronised visual and auditory presentation of text (Bone & Bouck, 2016). Thus, the electronic text on any digital device is converted into spoken words, in an audio file format. Basically, all forms of text files can be read aloud, which is why this type of technology is often called “read aloud”. Besides the speech synthesis option, many features contribute to the efficiency of the tool. The *Natural Reader* website will be used as an example for this description, as it is user-friendly and contains many built-in features. This is the main page you find when you go to the website:



The first step is to type, copy-paste a text, or drop an electronic file in the white rectangle. Then you can click on the play button to listen the text while reading it simultaneously. Automatically, the written text (as it is spoken) scrolls on the screen with the dynamic highlighting feature. These options are the most basic and are common to all existing TTS tools:



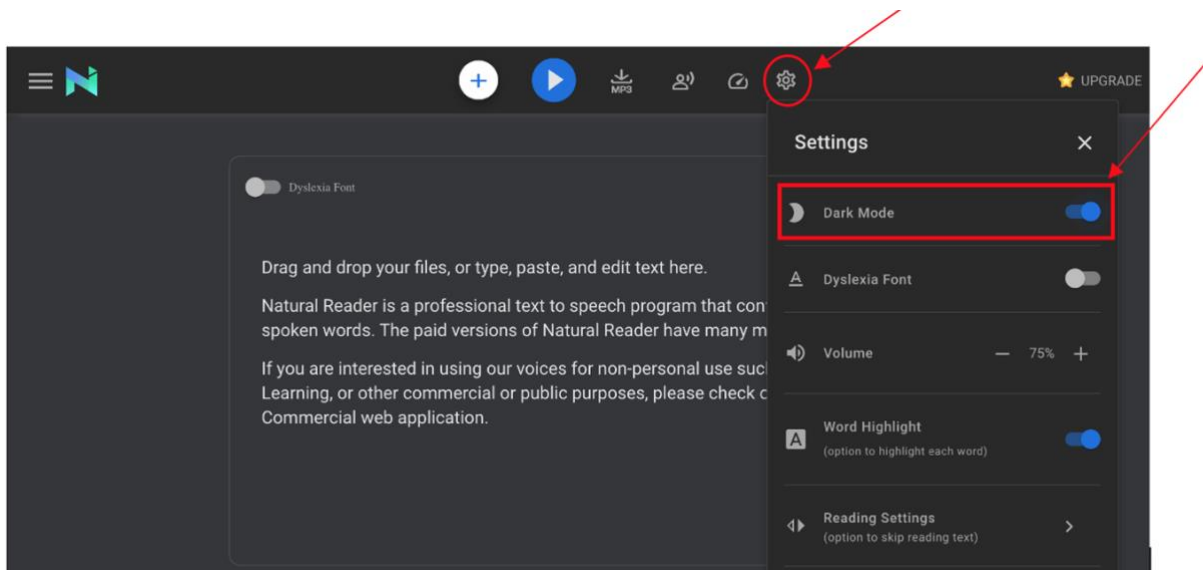
Then, users can customise their experience with the numerous features proposed by the website: reading rate, font size, dyslexia font, accent's choice, dark mode, volume settings, and more. These features differ from one TTS tool to another. It is important to take them into account when selecting a particular TTS tool. In the case of *Natural Reader*, you can increase or decrease the reading rate by clicking on the speed button.



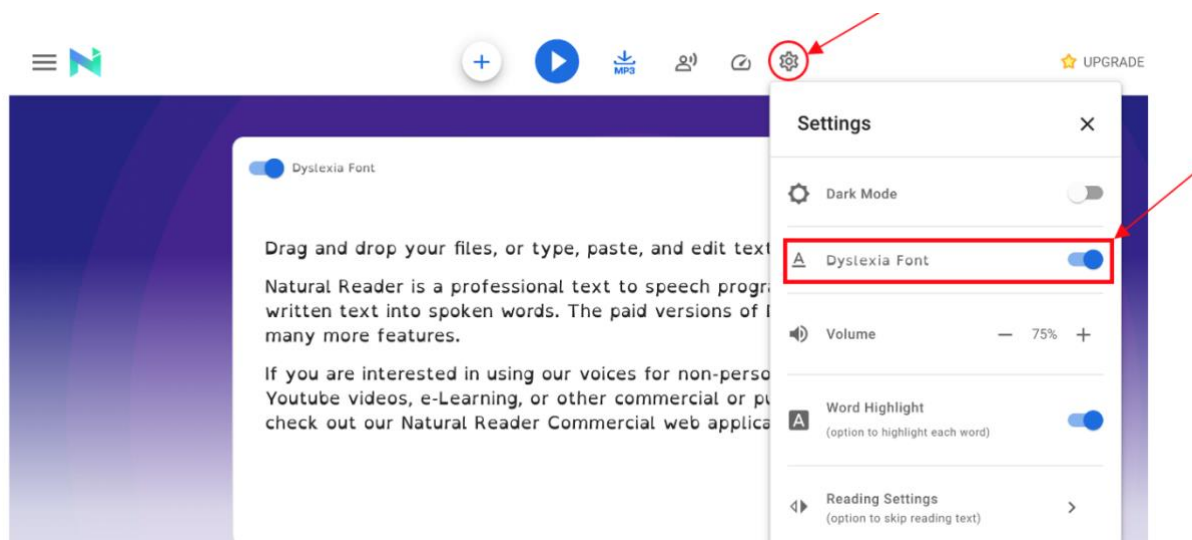
The following feature is the choice of accent. Depending on the language in which the text is written, there are several accents and even several speakers per accent. This allows the users to choose the accent and/or speaker that is most relevant to them. For example, in the case of English, it is possible to choose between a British, American or Australian accent. You can find female, male and even children's voices.



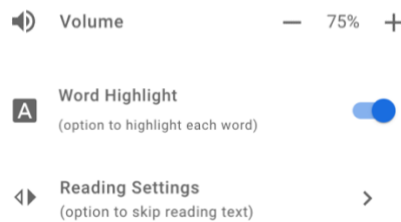
For those who are sensitive to light settings, a dark mode is also available. The use of a dark background with light print makes the text stand out:



The following feature is the possibility to use a “dyslexia font”. It is therefore specially designed for dyslexic users:

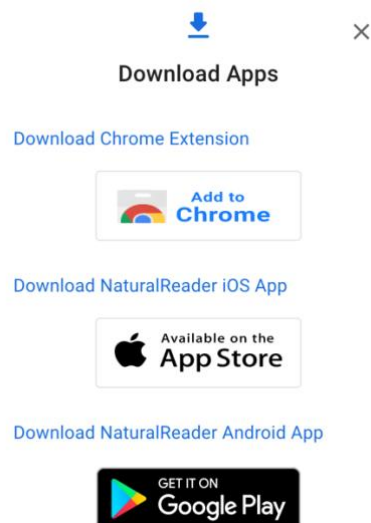


In the settings option, there are three more features. Users can also adjust the volume of spoken text as they wish, disable dynamic word highlighting (which is automatically activated), and skip reading aloud the text in brackets and the URLs.



All these subtle features contribute to the individualised user experience and the effectiveness of this particular website.

Natural Reader is available in different formats. You can use the regular website by clicking on <https://www.naturalreaders.com/online/>, or you can download the Chrome Extension or iOS and Android Applications. The user experience will be the same whether you use a smartphone, a computer or a tablet.



As far as the software package is concerned, there is a free version and two paid versions (Premium Plan and Plus Plan) at \$60 and \$110 per year respectively (also possible to pay monthly). All the features that have previously been presented are available in the free version for unlimited use. If you subscribe to the Premium Plan

version, you will benefit from several additional features, namely unlimited use of Premium voices, the ability to read from images and scanned PDF files, MP3 conversion, a Chrome extension with an unlimited number of Premium voices and a pronunciation editor. The Plus Plan offers all the features of the Premium plan, together with unlimited use of Plus voices, and the use of the most intelligent, accurate and reliable Plus voices on the market.

For an overview of the top five TTS tools, see section 5.

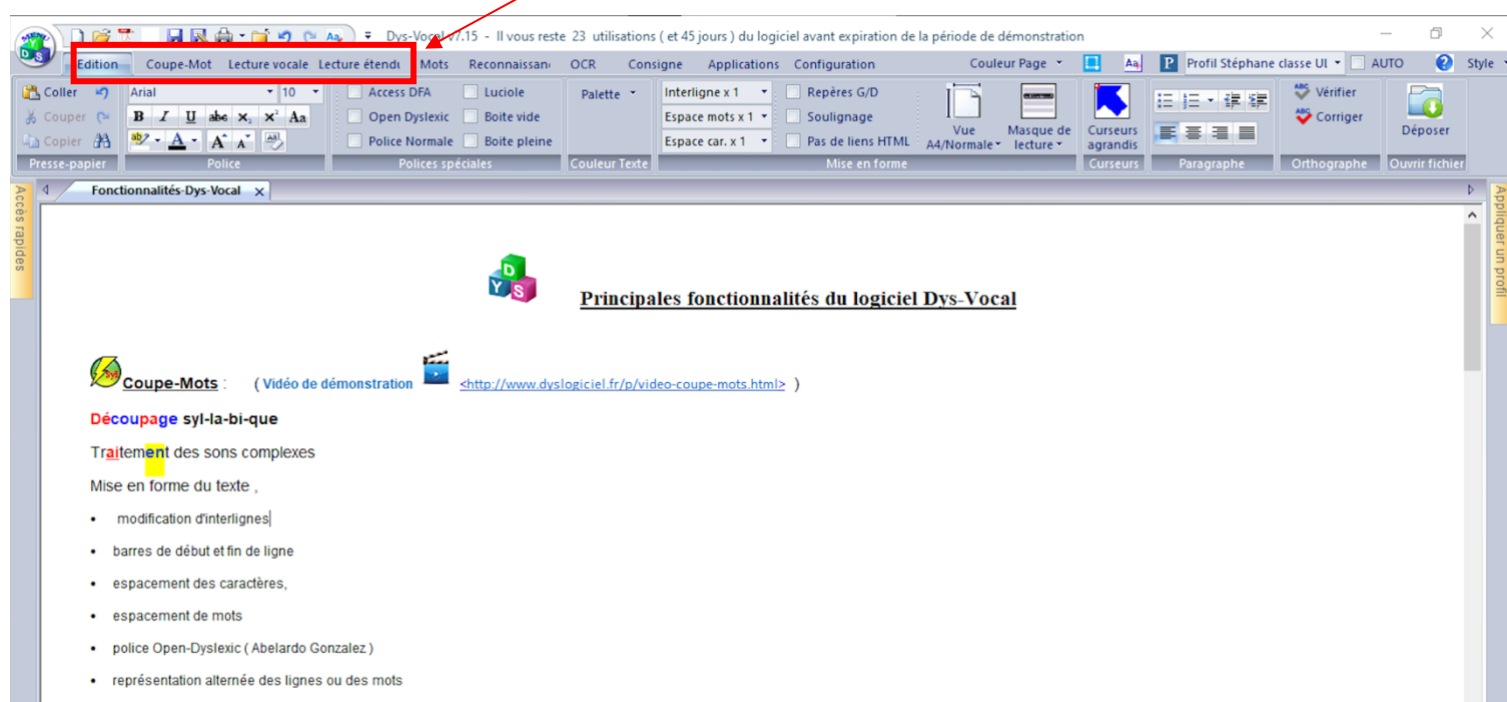
4.2. *DYS VOCAL SOFTWARE*

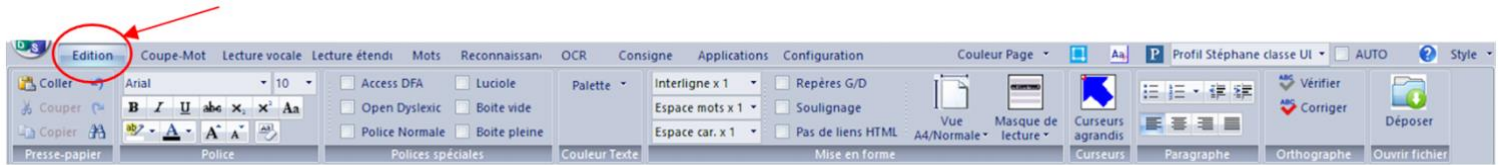
This software aims to decipher texts visually by offering visual adaptations of the written information. In this sense, plenty of visual options are included. The idea is to make the text visually accessible to users who require adjustments. The software is in French and contains 3 distinct but complementary modules: **Coupe-Mots** and **SDVocal**, which have been merged, and **the ScribeDico** module:

- **Coupe-Mots**: module that allows visual text formatting to facilitate readability (syllabic cutting of words, spacing between words and characters, highlighting of complex sounds).
- **SDVocal**: module that allows the synchronised reading aloud of a written text. There is also a voice recognition function that allows the dictation of text that will be directly transcribed on the screen.
- **ScribeDico**: module which supports the lexicon and allows words to be completed from the first characters entered on the keyboard.



It is the ***Coupe-Mots*** and ***SDVocal*** modules that are used for the treatment of reading comprehension. After opening the software and clicking on the first module, you should find the following display on the screen. There is a lot of information on the page but as you get used to it, it becomes easier and more automatic to use the software. The options in the red frame will be detailed in the next few pages. These are the basic tabs containing features that contribute to the improvement of the user's reading experience.





Firstly, there is the editing tab. This tab contains settings for editing written text (whether copied and pasted, downloaded from an electronic file, or written directly into the software). If we take a closer look at the settings, we observe that it is in this tab that the user can visually format the text as desired. The user can increase or decrease the font size, choose a font type (normal font or dyslexia font), choose the general colour of the text, and adapt the text formatting (line spacing, word/character spacing) and the paragraph structure.

The next tab *Coupe-Mot* is used to visually cut the text using colour codes. It is possible to cut text into syllables, words, sounds, lines and letters (consonants and vowels, choice of letters).



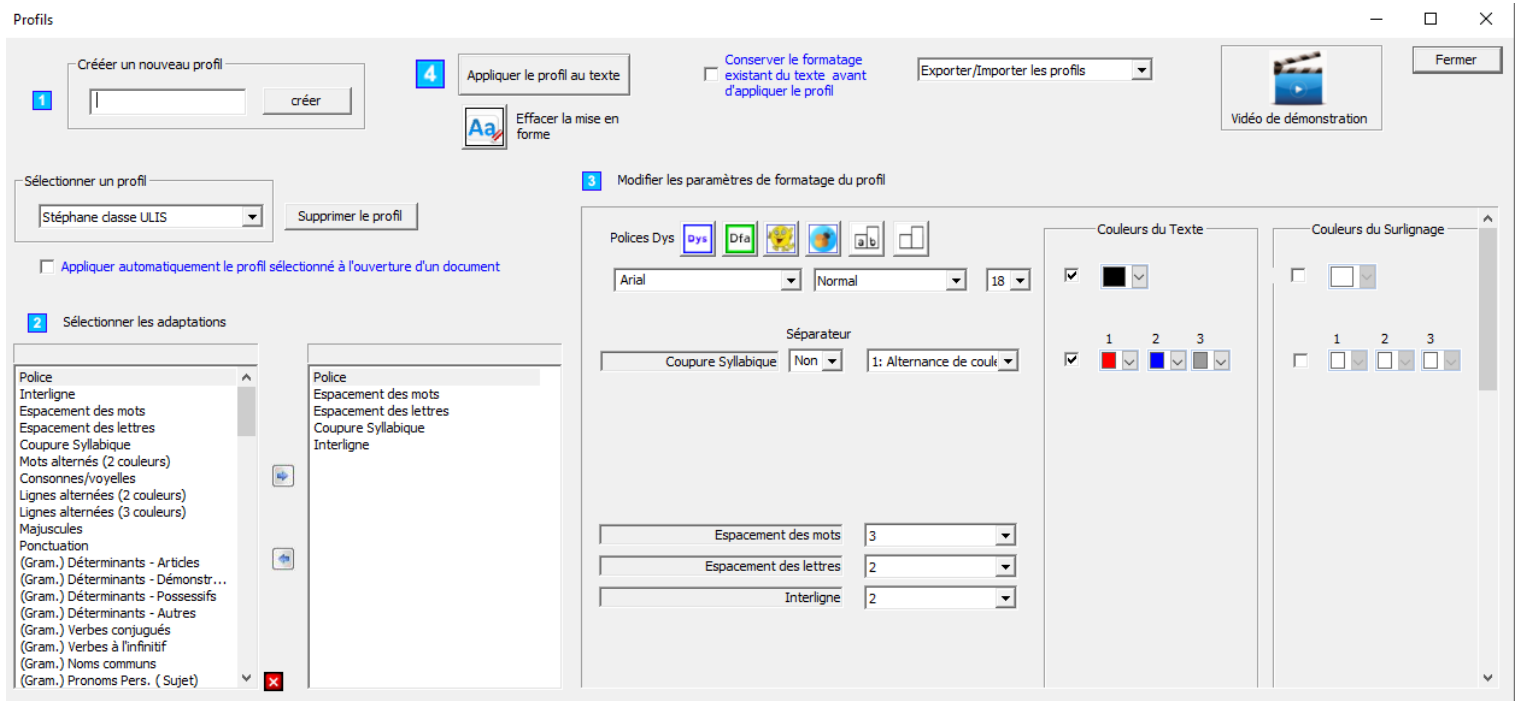
Here is a visual overview of what it looks like in the software, with the six options framed in red. The user can configure the colour code with lots of colour options. S.he can also select the difficult sounds to emphasise in example 3 and the letters in example 6.

1. Syllable cutting Traitement des sons complexes Mise en forme du texte , - modification d'interlignes - barres de début et fin de ligne	2. Word cutting Traitement des sons complexes Mise en forme du texte , - modification d'interlignes - barres de début et fin de ligne	3. Sound cutting Traitement des sons complexes Mise en forme du texte , - modification d'interlignes - barres de début et fin de ligne
4. Line cutting Traitement des sons complexes Mise en forme du texte , - modification d'interlignes - barres de début et fin de ligne	4. Consonant/ vowel cutting Traitement des sons complexes Mise en forme du texte , - modification d'interlignes - barres de début et fin de ligne	6. Letter cutting Traitement des sons complexes Mise en forme du texte , - modification d'interlignes - barres de début et fin de ligne

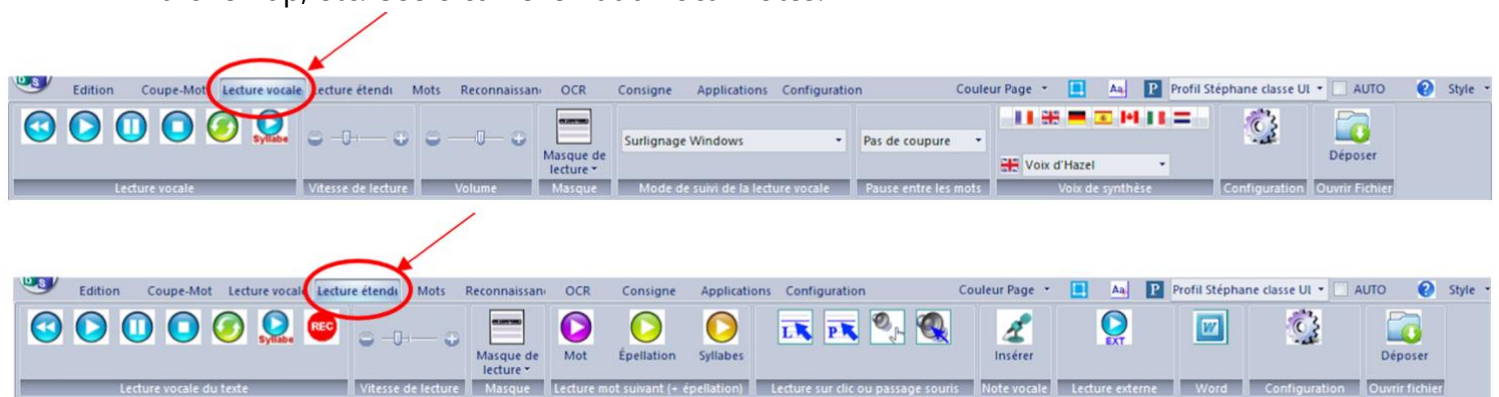
In this tab, it is also easy to select special fonts for dyslexic users if it had not been done in the editing tab. In addition, there is a very interesting function to create one or more student profiles. It allows user preferences to be saved so that they do not have to re-apply the options each time they use the software. Similarly, it allows teachers who use the software, for example to give instructions or texts to their students, to create profiles for their students who need these adaptations and to save their preferences. You can find the profile option in the tab bar, in the *Coupe-Mot* tab and as you will see in the *Lecture vocale* tab too.



If you click on it, you can create a new profile or modify an existing profile. In order to create a new profile, you first need to create it by adding the user's or student's name in the box. Then, you select the adaptations that need to be adjusted (font, line/character spacing, syllable cutting, etc.). You are now able to adjust them in the formatting section according to preferences. The last step is to click on apply profile to text. When you need to change your profile, simply click on "student profiles" and choose the appropriate profile.



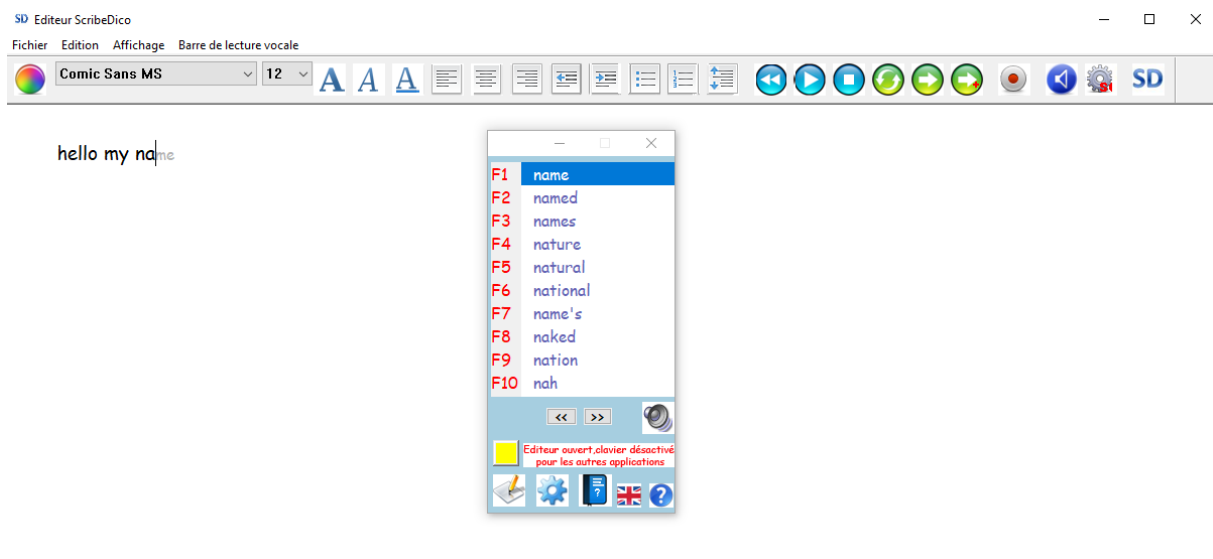
The next two tabs concern the speech synthesis mode of the software. This option offers users the possibility to configure the many TTS settings that are included in the software after typing, copying and pasting or uploading the text. They can adjust the reading rate, volume, choose the dynamic highlighting mode, choose the reading language (1 voice per language, choice between French, English, Dutch, Italian, German, Spanish and French Canadian). There are also more advanced options. Instead of listening to the text all at once, it is possible to add pauses between words, to have one word read orally, to have a word spelled out, to have a word read out with each syllable broken up, etc. Users can even add vocal notes.



In brief reference to the other tabs, the *Words* tab is used to perform in-depth searches on selected words in the text. It includes Internet searching and there is the possibility to have direct access to the definition of the selected word and its synonyms. The next tab is a speech recognition module with which it is possible to dictate text into the interface and add the desired adaptations to it. Text, punctuation and adaptations can be dictated. In the *OCR* tab, the content of documents scanned from a paper document can be easily extracted. Optical Character Recognition (OCR) is the electronic conversion of printed text into machine-encoded text, such as a scanned document or image, in a format that allows some TTS tools to extract and read aloud the text from that image. This feature is thus very useful for listening to physical written documents, such as books. Then, in the *Consigne* tab, it is possible to define the instruction that will be read out vocally. In the *Applications* tab, you will find a variety of applications that can also be useful for all purposes, such as a teleprompter, a virtual keyboard, a talking

calculator and a PDF reader, among others. If you want to easily configure certain settings, you can click directly on the *Configuration* tab and customise syllable cutting, complex sounds, text-to-speech mode, speech recognition, external magnifier and character recognition. You can also customise the menus if necessary.

The **ScribeDico** module is an auto-completion module that speeds up and facilitates typing. It is not linked to reading understanding but rather to writing skills. Users simply need to type the first few letters of a word and a list of possible word suggestions appears, then the user selects the right word, and the word is automatically entered into the editor. This module works in French, English, German, Spanish, Italian and Portuguese.



It is worth mentioning that Dys Vocal software is downloadable to Windows-compatible computers and tablets. In order to run it under Macintosh it is necessary to install a Windows emulator. The installation of the software is free, but its use is limited. There are 24 free trials possible over a period of 45 days and then it becomes payable, with a license of 42 euros for one computer. Most importantly, the use of this software requires prior preparation of the teaching material (reformatting and annotation) and prior training to understand its overall functioning.

5. Top five TTS tools list

Although the number of TTS tools is multiplying over time in various forms: application, website, software, Google extension, and more, they do not all offer the same features. From the most basic to the most elaborate, the choice is vast on the internet. It should be noted that the proliferation of these tools has had an impact on their quality and, as a result, total free access is increasingly rare, especially for TTS tools providing multiple features. The main question is how to choose the right tools and according to which criteria? In the specific framework of this thesis, the aim is to find tools that can be used by teachers in the classroom and subsequently by students. It is therefore necessary to take into account several criteria that are relevant to the tools' evaluation. Based on previous studies looking at TTS evaluation criteria (Sobkowiak, 2003; Cardoso et al, 2015) and my personal teaching experience as a future secondary language teacher, the following criteria have been selected: (1) ***user-friendliness***, (2) ***speech quality***, (3) ***speech language options***, (4) ***ESL strategies*** (facilitating reading fluency), (5) ***dyslexia-friendly features***, (6) ***pedagogical potential***, (7) ***software compatibility*** (across different operating systems) and (8) ***pricing***. Taking these criteria into account, I have created a list of the top five TTS tools by describing each tool as best as possible according to each criterion. This list is ranked in descending order, with tool number five being considered the least well evaluated and number one being considered the best for educational use. This evaluation is obviously subjective and is based on master's degree training and on my teaching experience, as well as on my personal experience with the different tools and software presented that I have tested. I believe that this list can be an interesting educational resource for language teachers to use in their classrooms with their students (dyslexic or not).

5) Newscaster Vocalizer

The very recent launch of *Newscaster Vocalizer* in 2019 brings greater improvements to (2) **speech quality** by increasing the naturalness of the speech through new neural technology. The emphasis of the software is clearly on the high degree of naturalness, which is a key factor contributing to the creation of a realistic speech, closer than ever to the human voice. To achieve this, the software provides three types of voices: standard, newscaster and neural. Neural voices differ from standard ones in the measure that they overcome the inevitable variations in speech and the techniques used to segment waveforms that limit speech quality. In other words, neural technology produces the most natural and human-like TTS voices possible. You will find unique intonation characteristics such as pitch, emphasis, whisper, breath, and others that emphasise human-like speech. It is almost impossible to know whether the voices belong to humans or are generated by the software. Moreover, the interface is very (1) **user-friendly** as users only have to copy-paste the text, adjust the settings to their preferences and listen to the audio file (which can be downloaded). As far as (3) **speech language options** are concerned, it is possible to choose from over twenty spoken languages with different accents for some of the languages. In the case of English, you can choose between American, Australian, British, Welsh, and Indian English. In addition, an (4) **ESL strategy** for translating written text directly into the software is available. Users and ESL learners who struggle to understand English text can easily translate it into their native language. Unfortunately, the software does not offer many (5) **dyslexia-friendly features**. With the exception of reading speed, you will not find features that improve the reading skills of dyslexic learners, such as dynamic highlighting or visual adaptations to the text, such as font size or character and line spacing. In my opinion, this is because the main purpose of the software is not primary educational, but rather business-related, which is why the (6) **pedagogical potential** is very low. This tool is apparently widely used by companies to create videos using the voices supplied, rather than to explore the ability of TTS to improve reading

comprehension. It would be potentially interesting to exploit the tool for pedagogical purposes because, as explained in section 2.3.3., voice quality is the most influential factor for language teachers when it comes to integrating TTS technology. Regarding (7) **software compatibility**, the software can be downloaded to both Mac and Windows computers. There are different (8) **pricing** plans, the two most popular being a monthly subscription to the software for \$9.95 or an annual price of \$69 with five free months included.

4) Dys Vocal

Dys Vocal software has already been presented in section 4.2. As it contains a speech synthesis mode, it can also be considered as a TTS tool in its own right. First and foremost, many (5) **dyslexia-friendly** features are implemented in the interface. These include common adaptations for dyslexia, such as the dynamic highlighting of text, the adjustment of reading speed and the possibility of using dyslexia-friendly fonts (although the effectiveness of dyslexia fonts has not yet been proven). More sophisticated visual adaptations are also available, such as OCR, coloured syllables and letters, character spacing, line spacing, coloured text (depending on the lines), and many others, which make it easier to explore the document and therefore concentrate on higher-level tasks such as reading comprehension. With all these features, the visual text can be fully customised; even more easily with the customised profile option that allows users to save their visual preferences. This enables teachers using *Dys Vocal* to create different profiles for different types of students and easily reuse them. However, the interface contains so many elements that it is not very (1) **user-friendly**. The overload of options makes it difficult to use the software properly, so it requires some practice to get the maximum benefit. There are also options associated with (4) **ESL strategies**. In the Words tab, users can click on a word they want to have spelled or have it read syllable by syllable. They can also do a classic Google search of the selected word or do a Google image search. By clicking on the word, it is also easy to get the

word definition as well as synonyms. Among the (3) **speech language options**, only seven languages are offered, with one voice for each language. There is no possibility to opt for regional accents. Nevertheless, there is apparently the possibility to download more voices. Also, the (2) **speech quality** is not as developed as in other TTS tools. Indeed, the voices sound more robotic than natural, with no possibility to have premium voices. In terms of (7) **software compatibility**, *Dys Vocal* is only compatible with Windows on computers and tablets, which is an obstacle for people who use MacOS or iPadOS. To access the software, there are different (8) **pricing plans**. A license for personal use costs 34€. For an institutional license, the price is 144€ for five computers and 399€ for fifteen computers. It is also important to mention that this programme has a strong (6) **pedagogical potential** as it is used in national education and by health professionals working on SpLDs. The fact that it provides institutional licenses reinforces this idea. The cost of a license for personal use is relatively cheap, but the price of an institutional license for five and fifteen computers is quite high compared to other institutional license prices.

3) Speechify

Speechify is a personal "reading assistant", powered by artificial intelligence and deep learning, that is consciously designed for students. It was actually founded by a dyslexic student, Cliff Weitzman, who sought to improve his reading comprehension and thereby help other people suffering from dyslexia or other text-based learning problems. This is particularly interesting because the software itself has been created considering the difficulties faced by dyslexics and has incorporated features to assist them. The (5) **dyslexia-friendly dimension** is prominent in this respect. *Speechify's* aim is to "read less and comprehend more". Features such as font size and type, dynamic highlighting, reading speed, lighting mode and OCR are likely to help dyslexic learners extract meaning from text. *Speechify's* automatic speed ramping algorithm, for instance, helps users to train themselves over time to listen at twice the speed that most people

read without noticing it. The OCR function is very useful as dyslexic learners can scan any text from their textbooks and have the content read to them instantly. With regard to (4) **ESL strategies**, it is interesting to know that users can have a text written in one language, and have it read aloud in another language. They can therefore listen to texts in English that are not necessarily written in English. In addition, *Speechify* provides users with natural (2) **speech quality** HD voices that make the listening experience easier, more pleasant and more enjoyable than with traditional robotic voices. There is a wide choice of voices and (3) **speech language options** available. Indeed, users can choose between more than thirty different spoken languages with different accents for some languages such as English. As regards (7) **software compatibility**, *Speechify* syncs with all devices in real-time: smartphone (Android and Apple), tablets and computers. You can even add the *Speechify* extension to Google and click on it if you want your emails, homework, favourite eBooks, newspaper articles, websites, etc. to be read aloud. You can even save for later anything you want to be read aloud in the application itself. The (1) **user-friendly** nature of *Speechify* is excellent; everything is simple and clear. You can find numerous tutorials created by the founder on every aspect of the tool on YouTube. The only disadvantage of the tool is its high (8) **price**, although this is not entirely clear to find. No information is given regarding pricing offers is given on the official website. When searching on the internet, a monthly subscription package of \$7.99 is given after a seven-day free trial. But if you download the current application onto your smartphone, you will almost directly come across the pricing plans. Users can actually get three days of premium access and then pay 149.99€ for a year or 12.50€ per month for premium service. This high price includes: HD natural voices, unlimited voices of quality, advance documents' framing, choice of any speed, text editing and study tools. Lastly, *Speechify* does not show strong (6) **pedagogical potential** so far. There is no offer (yet) for the implementation of this tool in schools, nor the possibility to use an institutional account for users to date.

2) Natural Reader

The website Natural Reader, previously described in section 4.1, provides its users with more than a hundred different voices from twenty (3) **languages**. The examples include a wide range of accent options for several languages. The number of voices per accent vary according to the user's pricing plan (free, Premium or Plus). If we look at the case of English, there are five English voices available in the free plan (four for American and one for British English). In the Premium plan, you find twenty English voices (ten for American, eight for British and two for Australian English). In the Plus plan, seventeen English voices are offered (eight for American, four for British, two for Australian, two for Indian and one for Welsh English). Premium and Plus access are available through subscription only with both yearly and monthly plans. Regarding (8) **pricing**, a monthly Premium subscription costs \$9.99 USD per month or \$59.88 USD per year. The Plus subscription costs \$19 USD per month or \$110 USD per year. Premium subscribers have unlimited access to both the Free voices and Premium voices. No access to Plus Voices is included. It is also important to mention that free users can also use Premium voices for twenty minutes per day and Plus voices for five minutes per day. In addition, the (2) **speech quality** of the different voices evolves through the plan offers. The voices from the Plus plan sound outstandingly natural compared to the free voices available. Because *Natural Reader* is a web-based application, there is nothing to download. Users simply need to login through the website from their browser. Its (7) **software compatibility** works with Windows, Mac, Android, iOS and as a Google Chrome extension. It appears that the website pays special attention to dyslexic users, adopting (5) **dyslexia-friendly** functionalities. Among these are the option to use a dyslexia font, the ability to change font sizes, the dynamic highlighting, OCR and dark mode option. However, one should be cautious about the use of dyslexia fonts. As explained in section 2.3.3.2, the literature has shown that such fonts do not improve reading comprehension in dyslexic learners. As the use of black text on a white background has been shown to be inadvisable for dyslexic learners, the use of *Natural Reader's* dark

mode is likely to compensate for word confusion. In addition, the site is very (1) **user-friendly** as it is easy and pleasant to use. All information is organised on one page and can be accessed very quickly with a few clicks. Except for the fact that the website is in English, no (4) **ESL strategy** to ease reading fluency has been found. Furthermore, Natural Reader has a special institutional package for institutions called "NaturalReader EDU" at an affordable price, for which institutions and/or teachers can apply. Its (6) **pedagogical potential** is therefore very interesting. Teachers who wish to try it out can take advantage of a free one-year trial including access to all premium features, multi-device access and a home-use license. There are also group licenses, the price of which depends on the number of users. For example, a group license must include at least five members and costs \$199 per year, while a group license with fifty members costs \$599. A site license can also be purchased with the minimum of a hundred and fifty users.

1) Capti Voice

Capti Voice is one the simplest and most convenient TTS tool to use. Its interface is very clear and (1) **user-friendly**. This software is (7) **compatible** with all sorts of operating systems: Mac and Windows, smartphones, iPads and there is even a Google Chrome extension. You can use the regular website if you do not want to download it. The choice of (3) **speech languages** is vast, there are twenty-six in total, with different regional accents available, including six regional accents for English: British, American, Australian, Indian, Irish and South African. To have access to all accents, you need to choose the Premium plan. The basic plan (free) does not offer all these possibilities. In addition, the (2) **speech quality** of the default voices in the basic plan is dire. The voices do not sound natural at all, but rather very robotic. The Premium voices, on the other hand, offer an incredible, natural voice quality that is very close to human speech. In terms of (5) **dyslexia-friendly features**, the software includes a large number of them, making reading more accessible to dyslexic users. Users can set various features

according to their personal preferences, such as reading speed, font options (size, colour, dyslexia font), text width, colour themes (dark or light modes), line spacing and dynamic highlighting. These features have been specifically designed to be useful for dyslexic and visually impaired users. As far as (4) **ESL strategies** facilitating reading comprehension are concerned, the software itself is in English, which means that users, or ESL students, must focus on English throughout the entire TTS experience. However, for ease of understanding, there is an option to define and translate words and paragraphs, in the users' mother tongue if necessary. *Capti* also has a high (6) **pedagogical potential** as it is particularly easy to use in educational settings, due to the fact that there is a special organisational account function to manage students, share content with them, monitor their activity, etc. The program is as convenient to use for teachers as for students, and is already implemented in education in the USA. This aspect could therefore extend its action and penetrate new school contexts. Concerning (8) **pricing plans**, *Capti* is free for personal use, but full access to all features is not included. The Premium plan includes better quality voices, more document types, document editing and language translations. It costs \$1.99 per month or \$19.99 annually. It should also be noted that Premium voices are charged separately, and each Premium voice costs \$5.99 per month or \$29.99 for the year. In total, Premium access to *Capti* with one Premium voice costs about \$50 per year.

6. Conclusion

Turning to the first research question focusing on how TTS and Dys Vocal software can improve the reading comprehension of L2 English learners with dyslexia, there are different aspects that the literature strongly suggests should be taken into account if the tools are to be beneficial.

Regarding TTS tools, it has been shown that the multisensory experience of combining hearing and sight at the same time can be advantageous, especially for dyslexic learners. The ability to hear what we read positively reinforces the textual presentation. In fact, presenting reading material orally in addition to presenting it in a traditional written format removes the need to decode reading material and therefore has the potential to better facilitate comprehensions of the texts. More importantly, the various features included in TTS tools can have a considerable influence on the effectiveness of the tool. On the one hand, it has been reported that certain non-visual features such as the ability to adjust the reading rate, the voice quality, different voice options with regional accents, etc. are very likely to play a role in improving reading comprehension. On the other hand, it was also claimed that visual options related to font (size and colour), text width, colour themes (dark and light modes), character and line spacing and dynamic text highlighting are also crucial for improving reading performance. However, the premade dyslexia fonts should not be included as an important feature as they do not (yet) seem to promote reading. It is the interplay between visual and non-visual features that forms the perfect combination for a TTS tool to be most effective, depending on the degree of quality of the different features. The more a tool offers these latter features to its users, the more likely it is to improve the reading comprehension of dyslexic L2 learners. Nevertheless, it is also essential for dyslexics that the tool is user-friendly, with a clear layout and an easy-to-use interface. Furthermore, in addition to being dyslexia-friendly, if a tool includes features that enhance ESL strategies, it is also worth considering the tool as the research focuses on

L2 learners of English. Since reading in a L2 can constitute a barrier for dyslexics, these features can further facilitate the reading process. By ESL strategies, it refers to features that allow, for example, users to click on a word or a paragraph and get an immediate translation in the mother tongue or a definition of it.

In the end, all the relevant features found in most TTS tools are also present to some extent in the Dys Vocal software. Both tools have many features in common, so it is a matter of perception: TTS tools focus primarily on the oral aspect of reading aloud assistance and provide many visual features, whereas Dys Vocal software focuses principally on the visual features of text with TTS options. These tools are therefore complementary and have their own specificities at the same time, in addition to their common characteristics. The vocal options are more sophisticated in TTS tools while the visual options are more developed in the Dys Vocal software.

In conclusion to RQ1, TTS and Dys Vocal tools, each in their own manner, can improve the reading ability of L2 learners of English with dyslexia through the interaction of their visual and non-visual features, together with the degree of quality of these features. This finding is consistent with the hypothesis presented in 3.3., that both tools were likely to be beneficial depending on their technological characteristics, which evolve over time. This suggests that the more the technological functions evolve, the more the tools will have a positive impact on reading comprehension. In addition, it is interesting to note that the fact that both tools favour a customisable environment thanks to their numerous features is a crucial factor in their effectiveness.

Lastly, there are two additional remarks to address. Firstly, the fact that a recent study reported that TTS tools were more beneficial with challenging texts, showing no positive effects with easy texts, is an aspect that could not be addressed in this research. This is because no experimental research was conducted due to Covid's situation and the fact that no other publications mention this issue. Secondly, it should also be noted

that all these features that are useful for dyslexic learners are also useful for other students, regardless of their profile. Indeed, this observation is frequently repeated in the literature. The differentiation approaches, including the MSL one, that are associated with the TTS and Dys Vocal tools are valuable for everyone: "good for dyslexics, useful for all".

With respect to RQ2, namely which of the available TTS tools are most effective for use by language teachers in the classroom to enhance reading comprehension, a list of the top five tools has been created based on various criteria, my master's degree in modern Germanic languages with a specialisation in didactics, my teaching experience, as well as my personal experience with the various tools and software that I have tested. This list aims to inform language teachers about the tools and their functionalities while guiding them in their choice of a particular TTS tool over others. The more positive elements a tool has in relation to the eight criteria, the more likely it is to be ranked among the best tools, bearing in mind that the criteria themselves have also been ranked according to their importance.

The TTS tool that comes in fifth position is the *Newscaster Vocalizer* programme. It features many positive aspects: the interface is very user-friendly, there are up to twenty different speech languages with regional variations, the software is compatible with Mac and Windows and costs less than \$10 per month, some ESL strategies are also integrated, but the most valuable feature is the quality of the speech. Thanks to the neural technology, the naturalness of the speech is very high. Usually, TTS tools can produce very realistic human voices, but cannot fully reproduce intonation and stress. However, it is possible to obtain the emotions of the speech with this programme because it is very recent and can therefore provide the most sophisticated intonation features. Unfortunately, the two main criteria are not met. Firstly, the tool's pedagogical potential is very low. Indeed, this tool was not designed to be used for educational purposes, but rather for commercial purposes, as the tool is reportedly largely used by

companies to create videos using the voices provided so that people no longer have to record themselves speaking. It might be interesting to exploit the programme for pedagogical purposes, as many interesting criteria can be identified in it. As a result, it would be worthwhile to rethink the visual and non-visual aspects that can ease the reading process of dyslexic students.

Link to software: <http://newscastervocalizer.com/fe/>

In fourth position, we find the *Dys Vocal* tool that has been studied in the context of this research and presented in section 4.2. The opinion on this tool is rather mixed, as it contains some less important criteria that are not fulfilled (enough) and other more important criteria that are promising. The high pedagogical potential of the software is attractive: although it can only be implemented on Windows devices, the tool is already used in national education and by health professionals. It could therefore easily be implemented in institutions equipped with computers or tablets because it even offers institutional licenses. Furthermore, the dyslexia-friendly features are innumerable. To put it simply, none of the other tools on the list provides as many dyslexia-friendly options as this one. By comprising both visual and non-visual features, everything is gathered to maximise the reading skills of users, including dyslexics. The possibility of creating different personalised profiles so that users can save their personal preferences and reuse them is an undeniable asset. Besides, the software even provides enhanced ESL strategies' options. In contrast, there are criteria that are not so clear-cut, such as the price and speech language options. That said, the speech language options are not particularly great, offering only seven voices with only one per language. There is no option to choose regional accents, although voices can apparently be added, but there is little documentation on how to do this and on the voice quality and languages available. Downloading newer voices could be an improvement of *Dys Vocal*, especially as the speech quality is not as developed as in other TTS tools. The voices in the programme are very robotic and have no intonation.

On top of that, the overload of options results in a very user-unfriendly interface with too much information on the screen. It is a pity because it is not so simple to grasp the software directly; it requires some preparation beforehand to be able to use it correctly.

Link to software: <https://www.dyslogiciel.fr/>

Speechify comes in third place with a rather mixed but generally positive opinion. Apart from its very high price for premium access (150€) and the fact that the educational potential of the tool has not (yet) been exploited, many criteria are positively met. What could be better for dyslexic users than a tool designed by a dyslexic student himself? The dyslexia-friendly dimension of the tool is very promising, at all levels. Lots of visual and non-visual adaptation options are combined for a more effective and enjoyable reading experience. The application even includes an automatic speed ramping algorithm that enables users to train their reading speed without noticing it. Concretely, it allows people to listen to a text more quickly than actually reading it. The founder of *Speechify* is convinced that people's brain adjusts to faster speeds with training. To achieve this, the algorithm increases the listening speed by three words per minute every thousand words. With practice, the listening speed increases without the users even realising it. *Speechify*'s main goal is to "read less and comprehend more". Moreover, the tool works easily with all devices, regardless of the type. The Google Chrome extension allows users to have the *Speechify* button in the Google tab, and consequently have anything read aloud anywhere and anytime. Also, it is difficult to find a more user-friendly tool than this one, given its simplicity and convenience. Regarding speech quality, there is a wide choice of voices and they are remarkably natural. More than thirty different spoken languages are included, with additional choices for regional accents. It is also useful to know that a text written in a language can be read aloud in another language. Users can therefore listen to texts that are not necessarily written in the same language.

Link to software: <https://speechify.com/>

Then, the second place goes to Natural Reader, a website that has already been discussed in section 4.1. The fact that one criterion is not covered at all by this site and that some other criteria are more or less well satisfied earns it this second position. Unfortunately, this programme does not offer any ESL strategies and the speech quality and language options are too strongly associated with its price. Indeed, the quality of speech evolves positively with the pricing plans, from default voices that are 'normal' to natural voices that are very close to human speech. The higher the price, the better the quality. There are in total three price options: free, Premium, or Plus. Prices are reasonable: to get full access to the best features, the subscription costs \$19 USD per month or \$110 USD per year. A Premium monthly subscription costs \$9.99 USD per month or \$59.88 USD per year and provides already high-quality voices. The number of voices per accent also vary according to the price. The more you pay, the more you will find new voices with regional accents. Apart from this price-related criteria, the two main criteria are satisfied. *Natural Reader* comprises some valuable visual and non-visual dyslexia-friendly features to compensate for poor word recognition. Besides, its educational potential is very high. Institutional group licenses are cost-effective, offering a full access to all premium features to between five and a hundred fifty members, costing \$199 and \$599 respectively. Interestingly, teachers who are interested in trying Natural Reader can benefit from a free one-year trial period during which they will have full access to all premium features. In addition, the program is compatible with any device and provides a handy Google Chrome extension, all of this on a very user-friendly, easy and pleasant site that holds all the necessary information in the main interface.

Link to software: <https://www.naturalreaders.com/online/>

In the top position, it is the *Capti Voice* software that has been selected. This tool matches all eight criteria, with only a single small disadvantage. From the most

important to the least valuable criteria, everything is designed to improve users' reading skills, starting with a very user-friendly and convenient interface that is simple and clear to the reader. *Capti* is already being used in educational settings in the United States and holds promise for development elsewhere as well, while offering functionalities that are different for students' accounts and for teachers' accounts. It also includes a large number of visual and non-visual dyslexia-friendly options, making reading much more accessible to dyslexic users. These have been specifically designed to suit dyslexic and visually impaired users and are consequently very valuable. Additionally, *Capti* is compatible with all devices and works with all operating systems. There is no need to download it as the web version offers the same assets as the software. In terms of speech options, there are twenty-six different spoken languages available, together with some regional accents. However, the speech quality is the only downside due to its default (free) voices that are disastrous and robotic. One should not restrict oneself to a limited free version of the tool, as the premium voices sound incredibly natural, close to human speech. Opting for the premium version is therefore the best decision to make and it is very affordable. It costs \$19.99 per year, which is very reasonable. On top of this, users must add the price of one or more premium voices, depending on their voice preferences. Finally, *Capti* also includes ESL strategies' options to easily define and translate words and paragraphs into the users' native language. In conclusion, the whole tool is designed to ensure the best possible reader experience, both for the general public and for L2 English learners with dyslexia.

7. Discussion

The objectives of this thesis were firstly to present a theoretical overview of the benefits of TTS and Dys Vocal technological tools on the reading comprehension of L2 learners with dyslexia and secondly to provide a useful resource for L2 teachers of TTS tools that can be utilised in the classroom class.

The literature has shown that dyslexia is a very complex phenomenon with different labels depending on the domains. In an educational context, it is considered a specific learning difficulty (SpLD) that impacts on several language skills, especially reading. Dyslexia causes particular difficulties in the initial reading process necessary for effective reading comprehension, i.e. efficient word recognition. This research focuses on L2 learners with dyslexia, which implies that the L2 is an important factor to consider. It has also been demonstrated that the language itself in which a dyslexic person reads is an additional barrier to effective reading comprehension. In fact, the language orthographies and the influence of the mother tongue can either alleviate or aggravate the reading problems of dyslexic learners. More opaque languages such as English and French seem to pose a much greater challenge to readers than German and Spanish, which are more transparent. In addition, the relationship between the mother tongue and the L2 is also relevant. Mother tongue reading skills are an essential basis for L2 reading comprehension. It has been observed that since dyslexia already involves reading problems in the mother tongue, these difficulties are likely to be intensified in a L2.

In order to compensate for these shortcomings, various components are involved. Firstly, educational institutions are legally obliged to accommodate the needs of all students, including those with SpLDs. To achieve this, a series of 'reasonable' accommodations can be implemented depending on the specific needs of the students. Different categories of classroom accommodations were identified, namely of

presentation, response, time/scheduling and setting. Secondly, the application of such accommodations relates to a general educational concept, i.e., differentiation, that is strongly recommended, especially for dyslexic students. The primary goal of differentiation is to ensure that all students achieve common objectives through different means. Institutions and teachers must provide suitable accommodations for students by informing themselves and building on existing models, such as Luyer-Tanet's model illustrated in the literature. Still in the context of differentiation, another teaching method is also advisable for dyslexic learners, namely the MSL approach. In multisensory learning, different sensory channels (visual, auditory and kinesthetic-tactile) are activated simultaneously, which can enhance the development of individuals' reading skills.

Drawing on all these findings, two technological tools were examined to determine whether they could help improve the comprehension of L2 students with dyslexia and how this is achieved. Indeed, both tools were found to be beneficial in this respect through the interplay between the visual and non-visual functionalities that they respectively provide to their users. Furthermore, a list of the top five TTS tools was compiled on the basis of eight criteria. The top list is: 1) Capti Voice, 2) Natural Reader, 3) Speechify, 4) Natural Reader and 5) Newscaster Vocalizer.

It is also important to reiterate that the list is intended to be a valuable resource for language teachers, especially as they are not usually trained in differentiating SpLDs. However, it is particularly relevant to point out that teaching languages to students with SpLDs does not require radically different methods and techniques from those used in mainstream language classes. Rather, the aim is to improve the quality of teaching and make it appropriate and accessible to all, by adopting different methods and techniques. As a teacher, the aim is not to adapt one's teaching to each student, but rather to adapt one's teaching to as many students as possible. In other words, it is about lots of small details that include all students and put them on an equal footing.

Although the benefits of TTS and Dys Vocal tools on the reading comprehension of L2 learners of English with dyslexia were emphasised and a top five list of TTS tools was drawn up, there are still limitations to this research. Obviously, the conclusions are only based on theoretical background, as they could not be tested in real educational contexts due to the Covid situation. Additional research is needed to confirm the benefits that have been identified, both with dyslexic students and specifically in the field of SLA, as no research to date has focused on the use of TTS with EFL teachers, including the aspect of dyslexia. This might occur in a near future as there is a general growing interest among teachers to be informed and trained in the use of TTS tools in their lessons. Another limitation is the degree of subjectivity involved in the choice of the criteria and the selection of the five best TTS tools. This is clearly due to a lack of evaluation criteria in the literature for specific purposes. However, these choices are not so trivial as they are based on my personal experience as a future language teacher; my training being very valuable for this research. As it has been reported in different studies, I too can affirm the lack of awareness-raising in training on SpLDs, having completed my master's degree courses. Another suggestion for future research is to consider evaluation criteria for TTS tools for specific purposes that involves FL teachers' perception. A final limitation concerns the quality of the tools' features, which can have an impact on the overall effectiveness of the tools. It should be borne in mind that these features evolve over time and become more and more sophisticated. Therefore, further research on new or recently updated TTS tools will also be valuable, as the benefits of the tools and their effectiveness may differ.

8. Bibliography

- **Journals and books**

Appert, D. & Truillet, P. (2016). *Impact of Word Presentation for Dyslexia*. Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility, 265-266.

Bachmann, C., & Mengheri, L. (2018). Dyslexia and Fonts: Is a Specific Font Useful? *Brain Sciences*, 8(5), 1-12.

Bone, E., & Bouck, E. (2016). Accessible text-to-speech options for students who struggle with reading. *Preventing School Failure: Alternative Education for Children and Youth*, 61(1), 48-55.

Bowers, P., & Swanson, L. (2001). Naming Speed Deficits in Reading Disability: Multiple Measures of a Singular Process. *Journal of Experimental Child Psychology*, 51, 195-219.

Cambre, J., Colnago, J., Maddock, J., Tsai, J., & Kaye, J. (2020). Choice of voices: A large-scale evaluation of text-to-speech voice quality for long-form content. *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*, 1-13.

Cardoso, W., Smith, G., & Garcia Fuentes, C. (2015). Evaluating text-to-speech synthesizers. *Critical CALL—Proceedings of the 2015 EUROCALL Conference, Padova, Italy*, 108-113.

Chuang, H., Joshi, R. & Dixon, L. (2012). Cross-language transfer of reading ability: evidence from Taiwanese Ninth- grade adolescents. *Journal of Literacy Research*, 44 (1), 97–119.

Chun, D. (2001). L2 reading on the web: Strategies for accessing information in hypermedia. *Computer Assisted Language Learning*, 14(5), 367-403.

Chun, D., & Plass, J. (1997). Research on text comprehension in multimedia environments. *Language Learning & Technology*, 1(1), 60-81.

Crombie, M. (2000). Dyslexia and the Learning of a Foreign Language in School: Where Are We Going? *Dyslexia*, 6, 112-123.

Diemand-Yauman, C., Oppenheimer, D., & Vaughan, E. (2011). Fortune favors the bold (and italicised): Effects of disfluency on educational outcomes. *Cognition*, 118, 111–115.

French M., Blood A., Bright N. D., Futak D.; Grohmann M. J., Hasthorpe A., Heritage J., Poland R., Reece S., & Tabor, J. (2013). Changing Font in Education: How the benefits vary with ability and dyslexia. *The Journal of Educational Research*, 106(4), 301-304.

Frith, U. (1999). Paradoxes in the Definition of Dyslexia. *Dyslexia*, 5, 192-214.

Golonka, E., Bowles, A., Frank, V., Richardson, D., & Freynik, S. (2014). Technologies for foreign language learning: A review of technology types and their effectiveness. *Computer assisted language learning*, 27(1), 70-105.

Gregor, P., & Newell, A. (2000). An empirical investigation of ways in which some of the problems encountered by some dyslexics may be alleviated using computer techniques. *Assets '00*, 85-91.

Guardiola, J. (2001). The evolution of research on dyslexia. *Anuario de Psicología*, 32(1), 3-30.

Harrison, J., Bunford, N., Evans, S., & Owens, J. (2013). Educational Accommodations for Students With Behavioral Challenges: A Systematic Review of the Literature. *Review of Educational Research*, 83(4), 551-597.

Hengeveld, K., & Leufkens, S. (2018). Transparent and non-transparent languages. *Folia Linguistica*, 52(1), 139-175.

Huang, H. (2014). Online versus paper-based instruction: Comparing two strategy training modules for improving reading comprehension. *RELC journal*, 45(2), 165-180.

Jeon, E., & Yamashita, J. (2014). L2 reading comprehension and its correlates: A meta-analysis. *Language Learning*, 64(1), 160-212.

Kamala, R. (2014). Multisensory Approach to Reading Skills of Dyslexic Students. *Journal Of Humanities And Social Science*, 19(5), 32-34.

Kılıçkaya, F. (2009). The effect of a computer-assisted language learning course on pre-service English teachers' practice teaching. *Educational Studies*, 35(4), 437-448.

Kormos, J. (2017). The Effects of Specific Learning Difficulties on Processes of Multilingual Language Development. *Annual Review of Applied Linguistics*, 1-15.

Kormos, J., & Smith, A. M. (2012). *Teaching languages to learners with specific learning difficulties*. Clevedon: Multilingual Matters.

Kormos, J., Kořak-Babuder, M., & Piřorn, K. (2019). The Role of Low-level First Language Skills in Second Language Reading, Reading-While-Listening and Listening Performance: A Study of Young Dyslexic and Non-dyslexic Language Learners. *Applied Linguistics*, 40(5), 834-858.

Kořak-Babuder, M., & Jazbec, S. (2019). Exploring Pre-service and In-service teachers' perceptions about Early Foreign Language Learning and Dyslexia. *Porta Linguarum*, 32, 87-102.

Kořak-Babuder, M., Kormos, J., Ratajczak, M., & Piřorn, K. (2019). The effect of read-aloud assistance on the text comprehension of dyslexic and non-dyslexic English language learners. *Language Testing*, 36(1), 51-75.

Liaw, M., & English, K. (2017). Technologies for Teaching and Learning L2 Reading. *The handbook of technology and second language teaching and learning*, 62-76.

Meihami, H., & Hussein, F. (2014). Bringing TTS software into the classroom: the effect of using text to speech software in teaching reading features. *Teaching English with Technology*, 14(1), 23-34.

Meunier, F., & Paquot, M. (2019-2020). English Linguistics: Second Language Acquisition. Louvain-La-Neuve: Université Catholique de Louvain-La-Neuve.

Miles, E. (2000). Dyslexia May Show a Different Face in Different Languages. *Dyslexia*, 6, 193-201.

Miller-Guron, L., & Lundberg, I. (2000). Dyslexia and second language reading: A second bite at the apple? *Reading and Writing: An Interdisciplinary Journal*, 12, 41-61.

Niess, M. (2011). Investigating TPACK: Knowledge growth in teaching with technology. *Journal of educational computing research*, 44(3), 299-317.

Nijakowska, J. (2014). Dyslexia in the European EFL teacher training context. *Essential topics in applied linguistics and multilingualism*, 129-154.

Pfenninger, S. (2015). MSL in the digital age: Effects and effectiveness of computer-mediated intervention for FL learners with dyslexia. *Studies in Second Language Learning and Teaching*, 5(1), 109-133.

Proenęa, J., Raboshchuk, G., Costa, Â., Lopez-Otero, P., & Anguera, X. (2019). Teaching American English pronunciation using a TTS service. *SLaTE (conference)*, 59-63.

Rello, L., & Baeza-Yates, R. (2015). How to present more readable text for people with dyslexia. *Universal Access in the Information Society*, 16, 29-49.

Rello, L., & Baeza-Yates, R. (2013). Good fonts for dyslexia. *Proceedings of the 15th international ACM SIGACCESS conference on computers and accessibility*, 1-8.

Rello, L., Kanvinde, G., & Baeza-Yates, R. (2012). Layout guidelines for web text and a web service to improve accessibility for dyslexics. *Proceedings of the international cross-disciplinary conference on web accessibility*, 1-9.

Schmitt, A., Hale, A., McCallum, E., & Mauck, B. (2011). Accommodating remedial readers in the general education setting: Is listening-while-reading sufficient to improve factual and inferential comprehension? *Psychology in the Schools*, 48(1), 37-45.

Schmitt, A., McCallum, E., Hawkins, R., Stephenson, E., & Vincencio, K. (2019). The effects of two assistive technologies on reading comprehension accuracy and rate. *Assistive Technology*, 31(4), 220-230.

Schneider, E., & Evers, T. (2009). Linguistic Intervention Techniques for At-Risk English Language Learners. *Foreign Language Annals*, 42(1), 55-76.

Shanahan, T., Callison, K., Carriere, C., Duke, N., Pearson, P., Schatschneider, C., & Torgesen, J. (2010). *Improving reading comprehension in kindergarten through 3rd grade: A practice guide*. Washington, DC: National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, US Department of Education.

Tunjera, N., & Chigona, A. (2020). Teacher Educators' appropriation of TPACK-SAMR models for 21st century pre-service teacher preparation. *International Journal of Information and Communication Technology Education (IJICTE)*, 16(3), 126-140.

Tunmer, W., & Chapman, J. (2012). The Simple View of Reading Redux: Vocabulary Knowledge and the Independent Components Hypothesis. *Journal of Learning Disabilities*, 45(5), 453-466.

Vellutino, F., Fletcher, J., Snowling, M., & Scanlon, D. (2004). Specific reading disability (dyslexia): what have we learned in the past four decades? *Journal of Child Psychology and Psychiatry*, 45(1), 2-40.

Villacañas de Castro, L. (2016). The pedagogical turn in the research on cross-language transfer: Re-thinking the Language Interdependence and the Language Threshold Hypotheses. *Tejuelo*, 23, 201-227.

Wery, J., & Diliberto, J. (2017). The effect of a specialized dyslexia font, OpenDyslexic, on reading rate and accuracy. *Annals of dyslexia*, 67(2), 114-127.

Wood, S., Moxley, J., Tighe, E., & Wagner, R. (2018). Does use of Text-to-Speech and related read-aloud tools improve reading comprehension for students with reading disabilities? A meta-analysis. *Journal of Learning Disabilities*, 51(1), 73-84.

Yu, C., & Miller, R. (2010). Enhancing web page readability for non-native readers. In *Proceedings of the SIGCHI conference on human factors in computing systems*, 2523-2532.

Zafar, S., & K., Meenakshi. (2012). Individual Learner Differences and Second Language Acquisition: A Review. *Journal of Language Teaching and Research*, 3(4), 639-646.

- **Internet**

American Psychological Association. (2012). *Reasonable Accommodations Explained*. Retrieved December 9, 2020, from <https://www.apa.org/pi/disability/dart/toolkit-three>

Assistive Technology Industry Association. (2021). *What is AT?* Retrieved March 30, 2021, from <https://www.atia.org/home/at-resources/what-is-at/>

Bottsford-Miller, N., Thurlow, M.L., Stout, K.E., & Quenemoen, R.F. (2006). *A comparison of IEP/504 accommodations under classroom and standardized testing conditions: A preliminary report on SEELS Data*. Retrieved December 5, 2020, from <https://files.eric.ed.gov/fulltext/ED495884.pdf>

Cambridge University Press. (2020). *Specific Learning Difficulties in ELT*. Retrieved March 28, 2021, from https://www.cambridge.org/gb/files/2415/7856/0079/CambridgePapersInELT_SpLDs_2020_ONLINE.pdf

Cambridge University Press. (2018). *Using mobile devices in the language classroom*. Retrieved May 13, 2021, from <https://www.cambridge.org/elt/blog/wp-content/uploads/2018/03/Whitepaper-mobiles-in-class.pdf>

Crombie, M. (2017) *Foreign Language Learning and Dyslexia*. Retrieved April 2020, from <https://languageswol.files.wordpress.com/2017/01/dxa1.pdf>

Dyslogiciel. (2021). Logiciel d'aide à la lecture et écriture pour dyslexie et dyspraxie. Retrieved April 12, 2021, from <https://www.dyslogiciel.fr/logiciel-de-compensation-des-troubles-dys-dyslexie-dyspraxie/>

Fédération Wallonie-Bruxelles. (2018). *La différenciation pédagogique*. Retrieved March 30, 2021, from <http://enseignement.be/index.php?page=27910>

International Dyslexia Association. (2002). *Definition of Dyslexia*. Retrieved April 28, 2020, from <https://dyslexiaida.org/definition-of-dyslexia/>

International Dyslexia Association. (2009). *Multisensory Structured Language Teaching Fact Sheet*. Retrieved April 28, 2020, from <https://dyslexiaida.org/multisensory-structured-language-teaching-fact-sheet/>

International Dyslexia Association. (2017). *Dyslexia basics*. Retrieved April 28, 2020, from <https://dyslexiaida.org/dyslexia-basics-2/>

International Dyslexia Association. (2020). *Accommodations for Students with Dyslexia*. Retrieved December 4, 2020, from <https://dyslexiaida.org/accommodations-for-students-with-dyslexia/>

International Dyslexia Association. (2014). *Multisensory Structured Language Teaching Fact Sheet*. Retrieved December 6, 2020, from <https://dyslexiaida.org/multisensory-structured-language-teaching-fact-sheet/>

Luyer-Tanet, S. (2020). *Différencier, en temps "normal" et en période de confinement - Volet 1/3*. Retrieved April 3, 2021, from <http://ww2.ac-poitiers.fr/anglais/spip.php?article305#nb1>

Non-word. (2021). Collins dictionary. Retrieved April 29, 2021, from <https://www.collinsdictionary.com/dictionary/english/nonword>.

Understood. (2020). *Text-to-Speech Technology: What It Is and How It Works*. Retrieved February 19, 2020, from <https://www.understood.org/en/school-learning/assistive-technology/assistive-technologies-basics/text-to-speech-technology-what-it-is-and-how-it-works>

SpLD Assessment Standards Committee. (2005). SpLD Working Group DfES Guidelines. Retrieved December 5, 2020, from [https://sasc.org.uk/SASCDocuments/SpLD Working Group 2005-DfES Guidelines.pdf](https://sasc.org.uk/SASCDocuments/SpLD%20Working%20Group%202005-DfES%20Guidelines.pdf)

SOAS University of London. (2021). *Specific Learning Differences*. Retrieved December 7, 2020, from <https://www.soas.ac.uk/studentadviceandwellbeing/information-for-staff/disabledstudents/learningdifficulties/#:~:text=The%20most%20common%20SpLDs%20are,to%20moderate%20through%20to%20severe>.

Van de Vyver, J. & F. Meunier. (2015). *A survey of existing OER resources in the field of language processing and their uptake: Belgium*. Retrieved April 10, 2021 from <http://www.tellop.eu/survey-report-belgium/>

- **Interviews from Lancaster university's course on 'Dyslexia and Foreign Language Teaching'**

Kormos, J. (n.d.). Effect of Dyslexia on Foreign Language Learning. [online interview]. Retrieved April 20, 2020, from <https://www.futurelearn.com/courses/dyslexia/6/steps/679444>

Smith, A. M. (n.d.). Dyslexic Learners in the EFL classroom. [online interview]. Retrieved March 29, 2021, from <https://www.futurelearn.com/courses/dyslexia/6/steps/679444>

- **Article in progress**

Consortium. (2021). *Dys-Vocal*. Article in redaction. Retrieved April 3, from a Word document.

