Dyslexia Friendly Reader

Prototype, Designs, and Exploratory Study

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Abstract*— *This paper describes results of an evaluation of a prototype of a dyslexia-friendly reader app developed based on analysis of readability research and a survey of existing technology. It consists of 1) mock up designs of a reader application based on research that identified shortcomings of existing reader apps as well as the best available research on reading by dyslexic readers, 2) a prototype reader implementing some significant features of this design, 3) results from an observational study of young readers identified as struggling with literacy. In addition, the papers offers an overview of the state of the art of research and provide a brief survey of existing reader applications on current mobile platforms.

The research and development described in this paper was conducted as part of the EU FP7 ICT project iLearnRW - Integrated Intelligent Learning Environment for Reading and Writing (318803).

Keywords*—*readability, text, reading, application interface, dyslexia, accessibility, design

Introduction

There is no substantive research literature on the design of reader application interfaces for people with dyslexia and similar reading difficulties. What research there is, focuses on the application and exploration of knowledge about fonts, colour schemes and text formatting. Some research has also identified benefits of using e-readers coming from the reduction of the amount of text displayed that accompanies the increase in size of text and there have been some preliminary suggestions that the timed display of text in small chunks (as small as individual words) presented in speed reading applications can be of benefit.

However, little to no attention has been paid to the reader interfaces nor other potential benefits of e-reading such as access to text structure, guidance about individual words, grammar, or alarmingly the possibility of easing the cognitive load of struggling readers through text-to-speech – either independently or through synchronised audio and text display. Yet, there is ample research that shows the benefits of text-to-speech as well as the significant role metacognitive control plays in reading whole texts. Thus alarmingly, the reader apps that claim being dyslexia-friendly aspire to that status purely through the use of dyslexia-friendly fonts and other text-formatting, some even lacking text-to-speech function, and all but ignoring simple design.

This paper will provide an alternative perspective by presenting a vision of an ideal reader that makes the overall process of reading whole texts more accessible backed up by preliminary qualitative results of using a prototype reader with 60 - 10-11 year old students in the UK.

Overview of Reader Research

All existing reader research has focused on font types [1] or on the effects of text-size [2]. Rello found relatively modest reading speed effects from font choice as well as some effects of other formatting preferences (these were implemented as the Dyslexia-friendly mode in IDEAL Group Reader [3], [4]). However, as Smythe [5] pointed out, the research on text formatting effects is surprisingly sparse and contradictory. However, using hardware e-readers and phones Schneps et al. [6], [7] found significant improvements from the amount of text presented and font size on certain types of dyslexia. We could find no research investigating effects of reader interface on the use of key accessibility features. However, research on text-to-speech should also be taken into account having reported significant gains from the earliest days [8], [9].

Overview of Existing Applications

During the development of the iLearnRW system, we conducted a review of existing readers used on tablets and phones. The research provided both an important overview of currently available software and common features but also revealed which features were missing.

Types of reader apps

The reader apps reviewed can be divided into three categories for ease of reference although they share many of the key functionality (see below)

1. Readers associated with well-known e-book shops (Amazon, Kobo, iBooks, Google Play Books)
2. Mainstream standalone readers not associated with a particular e-book repository (Aldiko Reader, Cool Reader, FB Reader, Moon+ Reader)
3. Alternative readers aimed at specific audiences or formats (Ideal Group Reader, AutoReader, SpeedReader, Repligo Reader, ezPDF Reader)

Typical features of reader apps

Although, readers in these different categories differ in the choices made by their creators, particularly with respect to the sources of books, there are a number of features that were present in all the readers surveyed:

- Basic features for navigating the text. This includes page turning and outline navigation. However, the

implementation of these features is not uniform across readers.

- All readers also allow the user some level of customization of text display. The level of customisation varies by reader as does the interface.
- Access to the basic copy of text (unless prevented by digital rights management).
- Management of books using a library and a file browser.
- Highlighting, notes and bookmarks.

Some features were present in many but not all readers:

- Accessing the text by Text to Speech. The quality of implementation of this feature varies across readers and only some (Moon+ Reader Pro, VoiceDream Reader, and ezPDF Reader) can be said to implement all the necessary features for successful text-to-speech interaction. In some (FB Reader, Cool Reader) the features are present but the implementation has bugs that reduce usability.
- Retrieval of books from online book repositories. Some readers such as the Kindle, Google Play Books and iBooks are only associated with one e-bookstore but others have implemented a variety of APIs to alternative sources of e-books (both free and commercial).
- Some readers also provide support for multiple formats while others only support one format. The most common format is ePub which is supported by all readers except the Kindle. There are a number of legacy formats such as .lit that are only supported by select readers.

Some features are only implemented by very few readers.

- Accessing the digitally protected documents loaned by some UK libraries using Adobe ID. This feature is available for free in the Overdrive Reader but only as part of the paid version of Aldiko and several other apps.
- Some readers (FB Reader and Cool Reader) are open to plugins that provide additional functionality.
- Two readers AutoReader and Speed Reader, were specifically designed to promote speed reading. While research on dyslexia and speed reading is lacking, both of these readers were found to use techniques that promote fluency, such as displaying only small chunks of text at a time to reduce distraction and offering autoscroll.

Many of the most commonly used readers have a very limited feature set and features that are present are frequently only partially implemented. For instance, many readers (including Google Play Books) contain text-to-speech but no easy way to navigate back and forward during playback. There were also frequent bugs in the implementation, such as navigation and highlighting going out of sync with the voice. Also, many readers (most notably all three associated with major e-book stores) do not allow full control of text display, such as the choice of font, font size or text/background colour combination.

Another finding was that the interface for accessing features and changing settings is also inconsistent across readers and often only presented in long text-based lists difficult to navigate for users with hard to comprehend categories. This makes a focus on usability essential. Settings should be presented in logical sections with graphical illustrations. Bluefire Reader and VoiceDream Reader are one of the few demonstrating good practice although even here, we can see over reliance on text.

Several readers implement an autoscroll feature with various blinds. However, all of these implementations simply roll a bar across text in a way that would be very confusing to a reader with cognitive control issues.

The review also identified two very popular Open Source projects (FB Reader and Cool Reader) developing free reader apps for the Android platform. Both of these apps are the most feature-complete of the whole set. However, they both lack interface polish and focus on features over usability. At least two other readers focused on the special needs community (GoReader and IDEAL Group Reader) are based on code from these Open Source projects. However, even these suffer from quite basic usability and accessibility issues.

Reader apps reviewed

The majority of readers reviewed were designed for the Android platform. However, for comparison, the review included 2 readers from iOS.

	Platform	Notes
Aldiko Reader	Android	Most popular alternative reader
AutoReader	Android	Speed reading app
Bluefire Reader	iOS	
Cool Reader	Android	Open Source reader
ezPDF Reader	Android/iOS	PDF reader
FB Reader	Android	Open Source reader
GoRead	Android	Aimed at readers with visual difficulties produced by BookShare.org based on FB Reader
iBooks	iOS	
IDEAL Group reader	Android	Aimed at dyslexic readers based on FB Reader
Kindle for iPad and Android	Android/iOS	
Moon+ Pro reader	Android	Pro version best for dyslexic readers.
OverDrive	Android/iOS	Aimed at e-books loaned from libraries
Repligo	Android	PDF reader (discontinued)
Speed Reader	Android	Speed reading app
VoiceDream Reader	iOS	Clear focus on speech and usability

Table 1 Reader apps reviewed

Recommendations based on review of Reader apps

Based on the reader app review, a list of recommendations to developers of reader apps was drawn up. The recommendations were based on the evaluation of features from the perspective of a dyslexic reader. This took

into account what is known about readers with cognitive impairments such as dyslexia as well as readability research referenced above. The recommendations are:

1. Focus on usability and clean interface will set a reader app apart in a very crowded field of existing applications which often prefer a long feature list to usability.
2. A reader app should balance feature completeness with the accessibility of key features. In particular, it should combine sensible presets with full customisation options for advanced users.
3. The reader settings interface should make use of icons over text and all slider bars should be accompanied by step control.
4. Text-to-speech is essential to accessibility of a wide range of users and has the potential to bring reluctant or struggling readers to an application. However, it needs to be implemented reliably and provide basic navigation features.
5. A reader app should also provide a means of controlling the amount of text displayed on screen. Ideally this should be accompanied by an autoscroll feature with some visual guidance such as a rolling blind. However, this visual guidance must not confuse users.

These recommendations are illustrated in our suggestions for an ideal reader app with a focus on readers with cognitive impairments such as dyslexia.

Towards an Ideal Reader App for Readers with Cognitive Impairments

Reader Design Principles

An ideal reader should implement the following main features:

- Text-to-speech interface with navigation and voice controls
- Accessible text style settings with sensible presets
- Outline-based navigation
- Bookmarking, highlighting and annotations
- Chunking interface to display the text in smaller segments, including autoscroll
- Additional advanced reader settings not mixed with basic settings
- Library and access to online repositories of texts

A reader focused on learners and reluctant readers should also offer text guidance to assist with difficulties contained in the text. At the minimum, this means an integration with a dictionary. However, this must be done in a way that enables a novice reader to take advantage of the information.

Reader modes

One way to present the key user interface in a reader is through modes. The modes suggested below are complementary and should be combined to respond to the needs of a user. We suggest three modes: 1) Listen mode, 2) Chunking mode, and 3) Guidance mode.

Listen mode

The possibility to access any text through text-to-speech should be enabled in all instances. Students should always be able to listen while reading or listen without reading. The listen mode should highlight sections being read and allow for an easy navigation of the audio. The suggested interface is presented in figures below:

Figure 1 Minimal listen toolbar

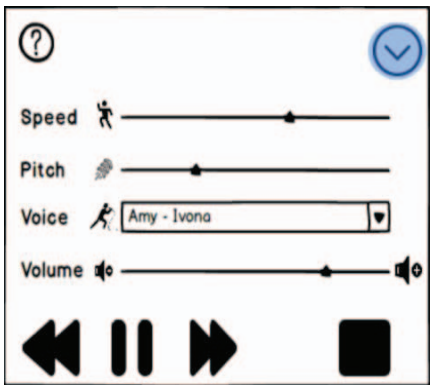

Figure 2 Full listen toolbar

This interface should be accompanied by settings of the amount of text highlighted and amount of text to jump by on Rewind and Fast Forward.

Similar design can be found in several readers but none combines both accessibility, ease of use and access to key features.

Chunking mode and autoscroll

Research has shown that controlling the amount of text displayed on screen at once can have great benefits for dyslexic readers. This can be achieved as a side effect of increasing font size but on tablets with larger viewports, this can be infelicitous.

The key features of this mode are illustrated below in Figure 4 and Figure 3. Readers can choose to enable automatic scroll with control of speed. This can be combined with listening to the text.

Figure 3 Chunking mode minimised toolbar

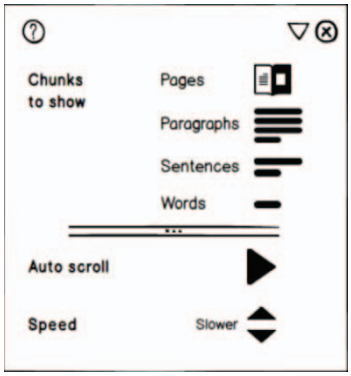

Figure 4 Chunking mode full toolbar

Chunking, although long a feature of reading instruction, has not been implemented in any general purpose reader. It can be found in some speed reading apps. Some readers implement a type of autoscroll, however, the existing implementations are more likely to confuse struggling readers than help them.

Guidance mode

We suggest three possible types of guidance.

1. Lexical support

Dictionary integration is a common feature of reader apps and should be considered the minimal guidance available. However, as implemented, this feature is mostly focused on fluent readers who may be unfamiliar with rare words or non-native speakers who are looking for word equivalents. However, dyslexic readers often find this type of information hard to access. They also need other information about the phonic and morphological structure of the word. Furthermore, they need audio feedback. Figure 5 below illustrates some features that struggling readers could benefit from, including integration with pre-reading activities (see below).

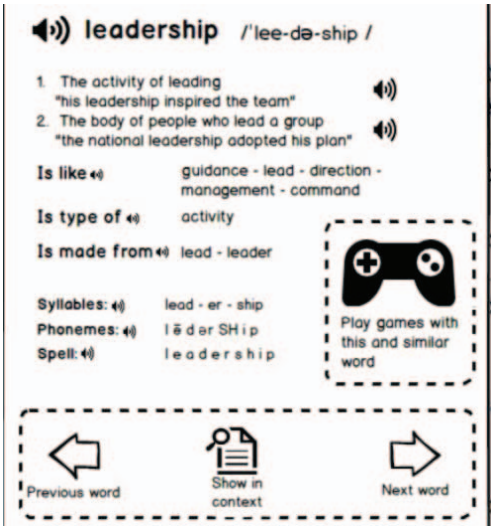

Figure 5 Lexical support interface

2. Text highlighting

Dyslexic readers often struggle with segmenting words into their components. To assist them with accessing complex words, highlighting of elements like affixes or syllables is suggested. This would most often be used by teachers helping students acquire metacognitive control over words rather than assist with everyday fluent reading. The functionality illustrated in the figures below depends on the implementation of the Phonics Engine presented in Lukes and Litsas [10].

Jane really likes reading books on her tablet. She sits by the window every afternoon and reads a story. One afternoon her brother John fell over their cat. He ran into Jane's chair and she dropped her tablet.

Figure 6 Example of text with highlighted suffixes

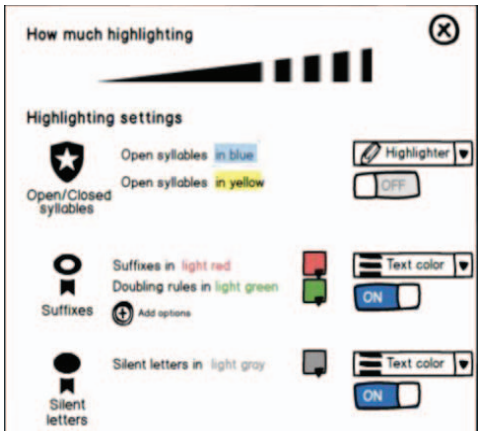

Figure 7 Highlighting interface

3. Instructional support

Reading is not simply a matter of decoding text. It requires planning, contextualised prediction, reviewing and forecasting. Accuracy also needs to be accompanied by fluency. Practice of these activities and their associated skills such as skimming and scanning is part of the process reading instruction.

We propose some way through which these aims could be achieved. These would be unlikely to find a place in a general purpose reader but would take centre place in a reader app aimed at learners and struggling readers.

Pre-reading activities

Based on the analysis of text and optionally the students individual needs, an interface would be presented to the reader highlighting potentially difficult words, common words or words containing difficult patterns before starting a text. The reader-student would be given the option to review the words and optionally play games using these and similar words, to increase their facility and familiarity. This would result in the reader approaching text both with greater levels of confidence but also potentially with a sense of what the text is about. The integration with games was one of the possible features of the iLearnRW project.

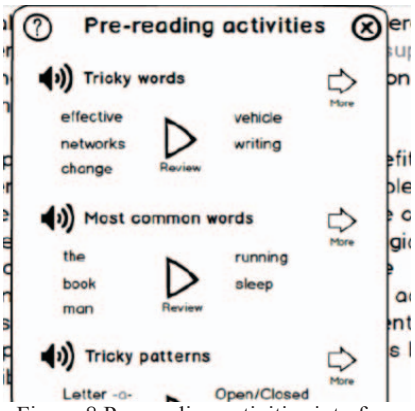

Figure 8 Pre-reading activities interface

Fluency and accuracy check

As part of planning their reading, dyslexic readers can benefit from estimating reading time of text. However, since their individual reading speed is often impaired, it is important that the actual reading speed is measured. This can serve in developing additional fluency. However, fluency measures are only useful if they are also accompanied by an

accuracy check. This is usually done by comprehension checking. However, this is not possible to achieve automatically without significant manual intervention. As a substitute (of as yet unverified reliability) we suggest an interface that checks mere the memory of a presence of randomly selected words. See Figure 9 below.

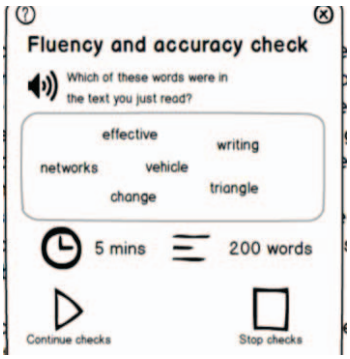

Figure 9 Fluency and accuracy check interface

Other features

Text structure navigation and manipulation

Accessing the structure of even relatively short text is essential for impaired readers for both navigation and managing their reading. Basic chapter navigation and bookmarking are present in all readers but this may not be granular or customisable enough. An interface that would encourage active reading and engagement with longer text might look similar to what is presented in Figure 10.

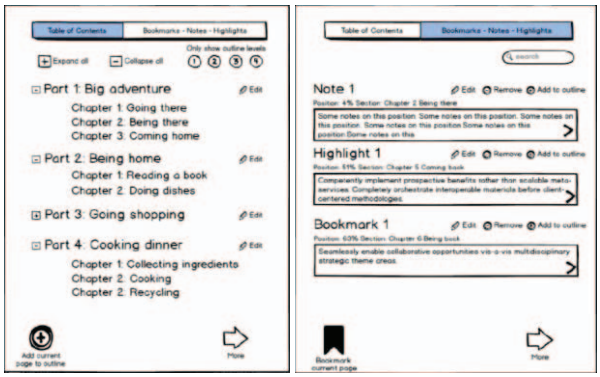

Figure 10 Text structure navigation interface

Display control and presets

Our ideal reader designs also included suggestions for control of text and paragraph formatting. They are omitted here for reasons of space but will be available online on the iLearnRW project website.

Reader Prototype

Based on this research and work done in previous projects, a simple reader prototype was developed as part of the iLearnRW project. The project resources were quite limited and therefore the prototype only implemented text-highlighting, linguistic guidance, text-to-speech control and text formatting presets. Due to technical reasons the prototype can only process short texts in plain text format. It was bundled with short texts from Dyslexia Action supplemented by short extracts from Aesop's Fables. The overall interface is presented in Figure 11 and its standout features are its simplicity and the key interface elements being always available rather than disappearing as with most other reader apps.

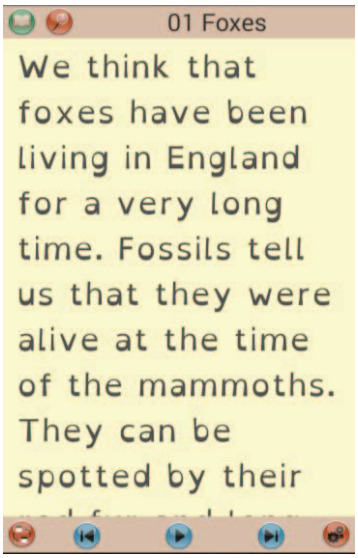

Figure 11 iLearnRW Reader prototype interface

The lexical guidance interface in Figure 12 was implemented without the semantic features proposed.

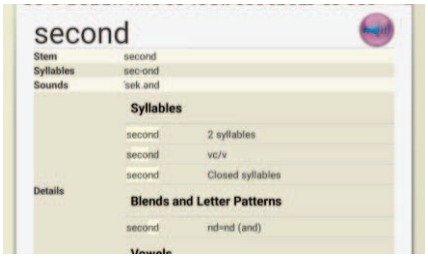

Figure 12 Word guidance from Phonics Engine

The reader prototype was preset with default dyslexia-friendly text formatting but allowed users to change this either from presets or complete customisation. This required significant testing since certain options clash with each other. See an example of colour presets in Figure 13.

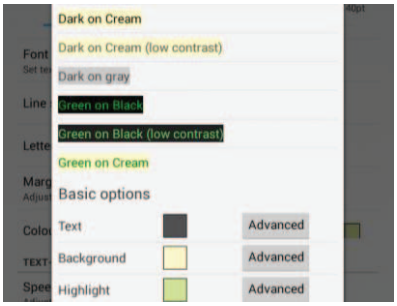

Figure 13 Colour options presets

Phonic features and a pacing mode are omitted due to space and lack of evaluation data (see below).

Preliminary Evaluation Results

The prototype reader was installed on over 60 tablets which were given to students aged 9-11 in 4 English schools. The students were selected by the schools as needing assistance with literacy. This was part of a larger iLearnRW evaluation which focused on an integrated serious game system which was also installed. Students were shown the functionality of the reader in a dedicated session and were

given headsets when working in groups. Students were observed in all school sessions and interviewed twice about their home use pattern. Their home use is ongoing and at the end of the process we will be able to supplement our knowledge about their reading patterns and preferences with server logs.

The reactions of the vast majority of students were overwhelmingly positive. The simplicity of the reader interface due in part to design but also lack of development resources proved to be a huge success and will cause us to reconsider methods of surfacing additional features in any future developments. The fact that the playback functionality is front and centre of the reader interface encouraged even students who normally have very negative attitude to reading to access the texts regularly. These are key observations available from the evaluation so far.

- During interviews, most students claimed to have used the reader at home, some regularly. This is an increase over their regular reading patterns.
- During sessions, students were able to answer questions about the text they read, some volunteering more information.
- Students varied in the mode they preferred to access text. Most used text-to-speech at least part of the time. Some before or after reading without it. Several only read without sound. Since the aim of the app is to provide increased access to texts, any pattern of use leading to more text exposure is to be welcomed.
- During sessions, sometimes students would switch from playing games to using the reader. Several calling it the 'reading game'.
- Several students admitted to listening to the texts in bed, one to falling asleep to them.
- One student described taking the tablet when visiting family members and listening while they watched "boring shows".
- Several students attributed their reading improvements to using the reader.
- Many students appreciated the factual nature of the texts included but some asked for fiction.
- One student admitted that even though he preferred Audible, he still listened to the texts. This same student previously claimed that the only thing he liked in school was PE (Physical Education).
- Several students asked for more texts having read all those provided (the reader came bundled with about 80 texts of 300-500 words). When asked, students in one school generated a list of over twenty books they would like included with the reader.

Conclusions and Future Directions

Despite a large number of reader apps available, none of them offer a friendly and inviting reading experience to struggling and reluctant readers. Review of the existing apps and readability research has identified gaps and led to practical suggestions towards features and interfaces. User feedback and preliminary evaluation of the prototype confirmed that the direction outlined is the right one. In particular, a simple interface focused on immediate results through text-to-speech has proved very popular with young struggling readers. In light of this, the lack of text-to-speech or gaps in its implementation in many high profile reader apps must be seen as a major accessibility omission in the industry. Students also appreciated the ability to customise the way the text is displayed but this did not result in the same increases in the access to text.

Much still needs to be done to determine the ideal feature set of an accessible reader. Future steps include:

1. Implement and evaluate additional features, particularly chunking and guidance modes. Project proposals are ongoing.
2. Use reading on tablets with larger curriculum texts. Dyslexia Action has launched pilots in two schools using texts from the Load2Learn repository and the Moon+ Pro reader.
3. Work with app developers to implement some of the feature and design suggestions.

Clearly more research and development is necessary in this area but our work demonstrates that this is a fruitful area of inquiry and outlines some of the directions future work should take.

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