

Proposed user interface design criteria for children with dyslexia

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Abstract

Children with dyslexia have difficulties with accurate word recognition, poor spelling and inability to differentiate certain phoneme and colours. Writing is another issue that is faced by most kids with dyslexia. There are many font families, text colour contrast and input methods for interface designing such as word selection, dropdown list and typing from a keyboard. There is a need to investigate, what font family, input method, and colour can ease children with dyslexia. Therefore, this study aims to explore and propose a suitable font, colour and input method for children with dyslexia. For this purpose, we have designed a mobile application having several user interfaces to test with a group of children with dyslexia. Comparison results was further concluded to be a set of recommendations for future interface design for them.

Keywords: Dyslexia; Font Family; Font Color; Human Computer Interface; User Interface.

1. Introduction

According to The International Dyslexia Association, dyslexia is a type of learning disability that is believed to be a neurological disorder that causes linguistic difficulties, related to reading, and other abilities such as orthography, writing and pronunciation. Usually, the effect of dyslexia varies from one person to another. Dyslexia is a disorder in which a child cannot develop the skill of reading, writing and spelling expected according to their age and intellectual performance though with regular schooling. According to American Psychiatric Association [1], people with dyslexia have difficulties to understand written words and sentences and this interferes with accomplishments of task that involves reading. According to the neuropsychological approach, the difficulties are understood as a consequence of one or more dysfunctional brain systems involved in learning [2].

Children with dyslexia have difficulties to understand written words and this could interrupt Dyslexics performance. There are very few experiments done to measure the impact of font type on reading performance. A study done by Gregor and Newell [3], show that text presentations is an important factor affecting reading performance of people with dyslexia. There are few guidelines published by Dyslexia Association of Ireland and British Dyslexia Association [4] on the appropriate font type that are good for people with Dyslexia. However, the website does not have any proof or evidence on where and how these recommendations are made.

Colour can affect readability among children with dyslexia. According to McCarthy & Swierenga [5], poor coloured text is one of the main problems encountered by people with dyslexia. According to the dyslexia association of Ireland and British Dyslexia Association [4], it is better to use a coloured background than white because white can appear dazzling to some children with dyslexia. According to the association, colour like cream, off white and pastel colour can ease reading. However, some Dyslexics may have their own preference of colour such as yellow or blue. There

are not many studies done that takes into account the effect of colour on reading performance among Dyslexics.

Writing is another issue that is faced by most people with dyslexia. There are some technologies that are currently used to support writing such as spellcheckers and word prediction software but these tools do not contribute to improvements of spelling skill of a person with dyslexia. There are many writing methods in interface such as selecting letter or word from a list and typing from a keyboard. Technology can play a role to ease writing for Dyslexics. It is important that a person with dyslexia gets a proper intervention method in order to cope with their daily activities. Since Information and Communicative Technologies are blooming rapidly, this medium can be used as a tool to aid learning process among children with dyslexia. Many mobile applications with different functions are currently available and can be easily accessed by anyone anywhere. Applications in smartphones are a powerful tool that can help children with dyslexia to motivate and facilitate them. A specifically designed application for children with such disabilities can help to stimulate student's interest and help them to fit into and progress in school [6].

Therefore, this study explored and proposed a suitable font type, suitable colour and writing method that can ease dyslexics. For this purpose, we have designed a mobile application having several user interfaces to test by the dyslexics. We gave the application to the dyslexics and recorded their times and errors. After analyzing the time and number of errors we proposed a user interface for dyslexics.

2. Literature review

2.1. Effects of fonts on people with dyslexia

The type of fonts used in any devices is an important aspect that significantly affects the reading process of children with dyslexia. A number of guidelines had been recommended to ease reading process among people with dyslexia. Based on the study done by Rello and Baeza-Yates [7] that uses eye tracking method to study the effect of font type on reading speed using 48 people with dyslexia to read 12 different type fonts shows that good fonts for people with dyslexia are Helvetica, Courier, Arial, Verdana and Computer Modern Unicode. The study also mentioned that the font family that increase reading performance of Dyslexics are Sans Serif, roman and mono space font type. British Dyslexia Association [4] has also created guidelines for dyslexia friendly text. The aim of these guidelines is to ensure that written material takes into account the visual stress experienced by some dyslexic people, and to facilitate ease of reading. Some of the recommendations are to use a plain, evenly spaced sans serif font such as Arial and Comic Sans. Alternatives include Verdana, Tahoma, Century Gothic and Trebuchet. The guidelines suggested that the font size is 12 – 14 points though some dyslexic readers may request larger fonts. The dyslexia association of Ireland [8] published the same guidelines for fonts as the British Dyslexia Association [4]. They also recommended the usage of lower-case letters and to avoid unnecessary use of capitals, the usage of all capitals can make it harder to read.

2.2. Effects of colour on people with dyslexia

Previous studies [2, 3] have shown that specific text colour and background colour such as brown on muddy green could increase readability and could be beneficial in reading process among people with dyslexia. British Dyslexia Association [4] stated that people with Dyslexia normally prefer lower brightness and colour differences among text and background compared to the average reader. Based on the recommendation in Web accessibility by Bradford [9], the colour off-black and off-white are recommended by this guideline. However, previous experiment done by Gregor and Newell [10], the pair brown and dark green and blue & yellow were chosen by people with dyslexia. Other suggestions include black and crème as suggested by British Dyslexia Association and were used in their websites into considerations when developing an interface. Evett & Brown (2005) [11, 12], suggested Black on Yellow background and Black on Cream background.

2.3. Effects of text input style on people with dyslexia

A research by Page [13] had explored design and ergonomic considerations underpinning the use of six commonly used smartphone text input methods in order to determine and compare their usability. McHale and Cermak [14] found that almost 90% of children with dyslexia have handwriting problem as handwriting requires fine motor skill. Therefore, technology is very important in assisting children with dyslexia to write. Since most the task needs them to input data to achieve something, it is important that text entry method is suitable and easy for them to use. Since letter in keyboard is small and requires fine motor skills to operate it, it is very likely that children with dyslexia have problem to input data or text. There is many other texts input style (such as selection from a list, checkboxes or tapping on buttons) that can be used to assist these children to input data when using any devices.

2.4. Sound and dyslexia

Hearing aid can be very helpful for people with dyslexia. A text accompanied with sound output which requires less effort to read can help people with Dyslexia to learn faster. However, very few research had been worked on this area to find to what extend sound

can help people with Dyslexia to learn. Many mobile applications that are currently in the market do not have a sound output and many developers do not consider the sound factor when developing their mobile application.

A mobile application with a sound aid is powerful tool in helping people with dyslexia to cope with their disabilities. According to Kazakou et al. [15], through the information that are presented via visual and auditory will reinforce bimodal presentation and information is faster and mnemonic recall will be much easier. Temple [16] stated that people with dyslexia usually have a hard time to distinguish rhyming sound, pronounce novel word and count the syllables of words because they have less phonological awareness. Therefore, it is important that a mobile application have sound feature in it to aid them.

2.5. Dyslexia and mobile applications

Mobile application provides an individualized teaching and learning environment, and may help to improve memory, visual perception, auditory ability, language, reasoning, and time orientation. Ball and McCormack [17] argue that developments in computer and other assistive technologies significantly help students with dyslexia. Some of the research on mobile application for children with dyslexia includes EasyLexia, Graphogame, and Dysegxia [18-20].

Ojanen, Ronimus et al. [19] developed a game called Graphogame for supporting children with reading difficulties such as dyslexia. It was developed in the University of Jyväskylä with Niilo Mäki Institute in Finland. This game application use algorithm that analyzes child's performance and it will constantly adjust and update the content so that the challenge matches the wide range of learner's ability. Rello et al. [20] developed a mobile game called Dysegxia for improving spelling skill among children with dyslexia. Dickinson et al. [3] run a pilot study on visual environment individually configured using the SeeWord software to study reading accuracy and reading comfort. This study focusing on the software not on font types and colours suitable for dyslexics. Easylexia on the other hand is in English and operates in windows operating system developed in the University of the Aegean, Greece. Such assistive technology is an important to support people with learning disabilities. Williams et al. [6] stated that Dyslexia is the main group among people with special needs that could possibly gain many benefits from technologies. Mobile applications are favored these days compared to traditional classroom because mobile application has a wide range of styles, features and material presented in more engaging manner. Mobile application specifically designed for children with dyslexia can reduce stress, frustration and confusion and making learning process much easier for them.

3. Methodology

In this study, we have designed mobile interface prototypes with different fonts types, colours, and input styles. The study was conducted with 6 children with dyslexia from the association in Kuching, Sarawak, Malaysia. We decided to choose four most common font types suggested by previous researchers which are Arial, Verdana, Comic Sans MS, and Times New Roman. After exploring many studies, we decided to choose four colours for the interface which are Black on Cream background, Black on Yellow Background. Blue on Yellow background and Dark Blue on light Blue because these four colours are among the most frequent colours suggested by the previous researchers. We decided to use other input methods which are drop down list, check list, keyboards and select buttons for our interface.

Based on literature, many researchers have proposed different combination of font styles and font and background colours [4, 5, 10]. Therefore, we filtered and selected the most frequently proposed fonts types, colours, and text input styles for Malaysia context for practical verification. The study was conducted using

smart phone; however, results should be similar for other devices in term of font family, colour contrast and input methods. The participant's ages range from seven to twelve years old and consist of both female and male. Participant's involvement in this study is purely volunteer basis. Parent's permissions are granted to carry out this research with their consents. The three main focus of this research is font types, colours, and input styles. Three tests were created, and the interfaces used in these tests are different using different font, colour and input style. The font type tests consist of sentences of five to six words. We test four fonts which are Arial, Verdana, Comic Sans MS and Times New Roman. For each font types, there are two different sentences. Participants asked to read out the sentences and the time taken by the participants to complete is recorded. The error made during the reading also recorded. The language used is Malay. The interfaces are show in the Figures 1, 2 and 3.

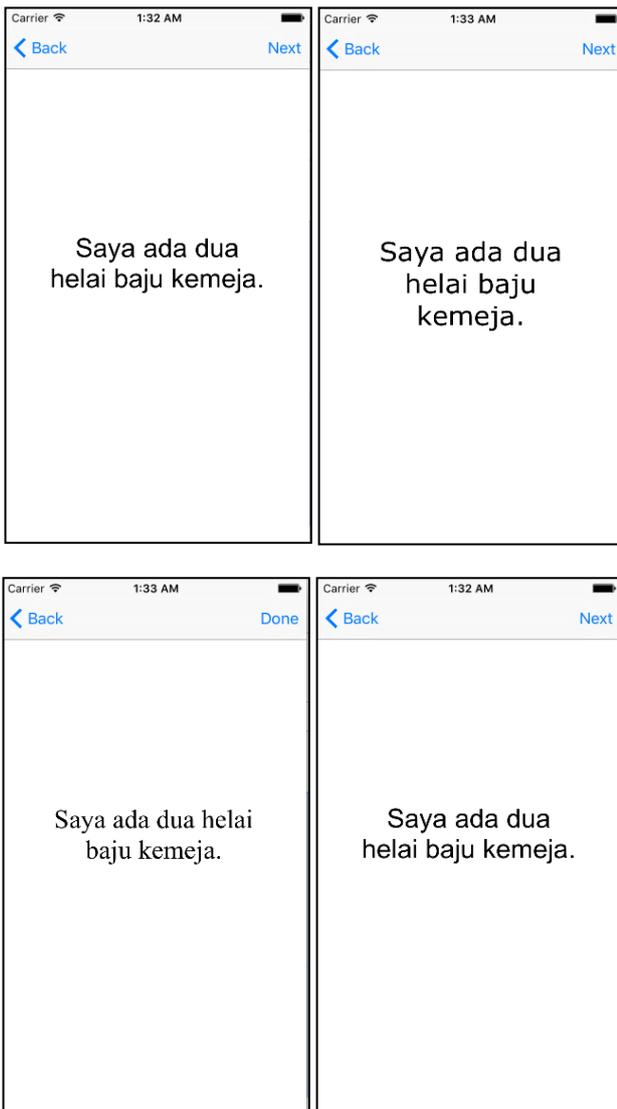


Fig. 1: Interface For Arial, Verdana, Comic sans M and Times New Roman.

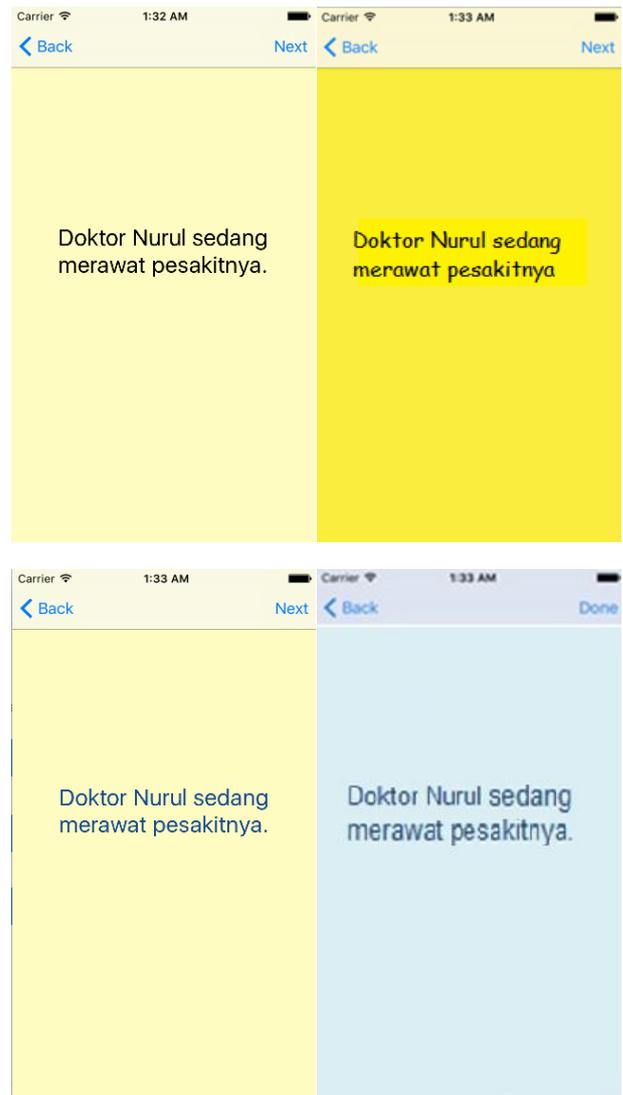
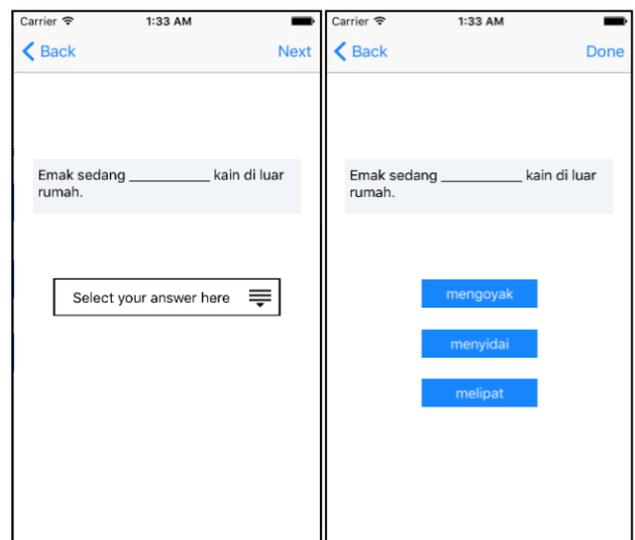


Fig. 2: Interface for Font Colour and Background Colour Test.



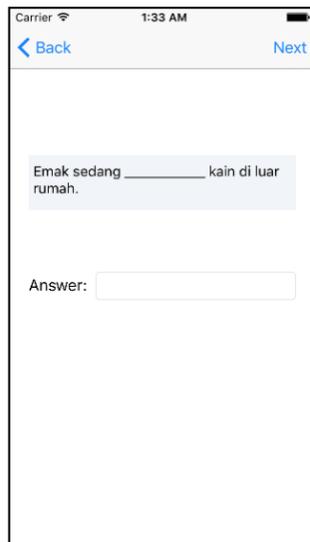


Fig. 3: Interface for Text Input Methods.

Before conducting the study, formal permissions from the head of dyslexia association Kuching and the parents of dyslexics were achieved. Then the procedure of data collection and testing the interfaces was planned as in the figure 4.

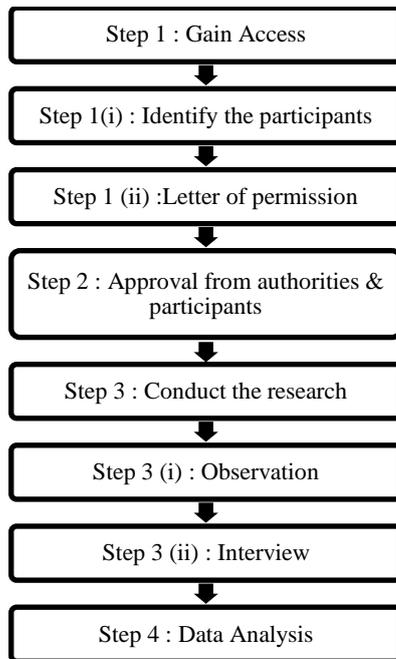


Fig. 4: Data Collection Procedure.

4. Results and discussions

There are total of six Dyslexic students of Dyslexia Center Kuching who participated in this study. Each student has different level of reading ability. Some are at intermediate level and some shows poor reading skill. The student’s particulars are in the Table 1 below.

Table 1: Participants Particulars

| Participants | Gender | Age | Years of dyslexic rehabilitation |
|---------------|--------|-----|----------------------------------|
| Participant 1 | Male | 12 | 3 |
| Participant 2 | Male | 12 | 1 |
| Participant 3 | Male | 9 | 2 |
| Participant 4 | Male | 10 | 2 |
| Participant 5 | Female | 9 | 2 |
| Participant 6 | Female | 11 | 1 |

4.1. Font test

Based on the observation Comic Sans MS font type has less average time and less average errors as shown in the Table 2 below.

Table 2: Average Time and Average Errors

| Participants | Average Duration for font type test | | | |
|---------------|-------------------------------------|---------------|---------|-------|
| | Arial | Comic Sans MS | Verdana | TNR |
| Participant 1 | 2.5s | 3s | 3.5s | 3.5s |
| Participant 2 | 42s | 52s | 59s | 74s |
| Participant 3 | 23s | 19s | 25s | 31s |
| Participant 4 | 36s | 33s | 39s | 40.5s |
| Participant 5 | 16s | 10s | 9s | 15s |
| Participant 6 | 12s | 13s | 21s | 20s |
| Average time | 21.9s | 21.6s | 26.08s | 30.6s |
| Average Error | 0.66 | 0.5 | 1.5 | 1.6 |

The results showed on average, children with dyslexia performed better in using the San Serif font type of Arial and Comic Sans. It complied with the recommendations from previous study to prioritise the usage of San Serif font type, preferably Arial and Comic Sans followed by Verdana, but lastly Serif font type like Times New Roman [4, 7]. It is a standard guideline also that San Serif font type is easier for screen reading as compared to Serif font type.

4.2. Colour test

Colour test was conducted and results were recorded in the Table 3 below. The results show that kids performed well in black colour text on yellow background.

Table 3: Average Duration for Colour Test

| Participants | Average Duration for colour test | | | |
|---------------|----------------------------------|-----------------|---------------|-------------------------|
| | Black on Cream | Black on Yellow | Blue on Cream | Dark Blue on Light Blue |
| Participant 1 | 4s | 3s | 3s | 3.5s |
| Participant 2 | 21s | 20.5s | 19s | 24.5s |
| Participant 3 | 18s | 13.5s | 14s | 16s |
| Participant 4 | 19.5s | 15.5s | 20.5s | 25s |
| Participant 5 | 26.5s | 10.5s | 10.5s | 11s |
| Participant 6 | 17.5s | 15s | 18s | 21s |
| Average Time | 17.75s | 13s | 14.16s | 16.83s |
| Average Error | .66 | 0.5 | 0.5 | 1.5 |

Based on the results, the children with dyslexia read faster with the screen of black text with yellow background. According to British Dyslexia Association [4], people with dyslexia prefer lower brightness, in fact, in this study, black text with yellow background and blue text with cream background have lower brightness and lower contrast as well.

4.3. Input methods test

Writing or inserting input is a difficult task for Dyslexics. We tested 4 different ways input i.e. Drop-down List, Check List, Keyboards and Buttons. The results show that Buttons are more suitable for getting input from dyslexics, as shown in Table 4 and 5.

Table 4: Average Duration for Text Input Style Test

| Participants | Average Duration for text input style test | | | |
|---------------|--|------------|-----------|---------|
| | Drop down List | Check List | Keyboards | Buttons |
| Participant 1 | 30s | 6s | 10.5s | 3s |
| Participant 2 | 74s | 71.5s | 99s | 47.5s |
| Participant 3 | 19s | 16.5s | 25s | 14.5s |
| Participant 4 | 31s | 25.5s | 29.5s | 21s |
| Participant 5 | 45.5s | 15s | 47.5 | 11s |
| Participant 6 | 15s | 12.5s | 15.5s | 11s |
| Average Time | 35.75s | 24.5s | 37.8s | 18 |

Table 5: Average Error Made for Text Input Style Test

| Participants | Average error made for text input style test | | | |
|----------------|--|------------|-----------|---------|
| | Drop down List | Check List | Keyboards | Buttons |
| Participant 1 | 1 | 0 | 1 | 0 |
| Participant 2 | 4 | 3 | 4 | 2 |
| Participant 3 | 1 | 0 | 1 | 0 |
| Participant 4 | 1 | 1 | 2 | 0 |
| Participant 5 | 1 | 0 | 2 | 0 |
| Participant 6 | 0 | 0 | 1 | 0 |
| Average Errors | 1.3 | .66 | 1.8 | .3 |

Results showed input type that allow children with dyslexia to have direct access and select will be easier for them, e.g. button and selection list. The drop-down list needed another steps and is hidden. It required them to scroll and select, so, it would be slower. According to McHale and Cermak (1992), 90% of children with dyslexia have handwriting issue due to the need of fine motor skills. The typing input type also will create more problem to them as they need to properly type and spell the word, which is the most difficult task for them.

5. Conclusion

In this research we found that Dyslexics are facing problems in recognising or differentiate some characters like lower case p and q or m and w et cetera. Similarly, background colour also effects the reading of Dyslexics. People with dyslexia also facing problems in interacting with devices. User interface defines the way how to use the software. Therefore, play a very important role to ease the usability of ICT devices.

The study we found that a text written in Comic Sans MS font family over a yellow background is the most suitable combination for dyslexics. Similarly, during interaction Dyslexics preferred button click over drop down, lists or check boxes and typing.

Therefore, some recommendations were concluded in Table 6 to ease the reading and interacting with smart phones.

Table 6: Proposed User Interface Components

| User interface element | Proposed type |
|------------------------|---|
| Font family | San Serif font type (Preferably Comic Sans MS and Arial) |
| Font case | Lower case for ease reading |
| Font size | 14pt to 16pt (depends on smart phone size) |
| Font colour | Dark colour text, especially black |
| Background colour | The background should not be too bright and create high contrast. Suggested here off-Yellow |
| Input style | Tapping of buttons for selection to avoid many steps and fine motor movement for fingers. |

References

- [1] American Psychiatric Association, Diagnostic and statistical manual of mental disorders (5th ed.). 2013, America: American Psychiatric Publishing.
- [2] Rello, L., G. Kanvinde, and R. Baeza-Yates. Layout guidelines for web text and a web service to improve accessibility for

- dyslexics. in Proceedings of the international cross-disciplinary conference on web accessibility. 2012. ACM.
- [3] Dickinson, A., P. Gregor, and A.F. Newell. Ongoing investigation of the ways in which some of the problems encountered by some dyslexics can be alleviated using computer techniques. in Proceedings of the fifth international ACM conference on Assistive technologies. 2002. ACM.
- [4] British Dyslexia Association, Dyslexia style guide. 2012.
- [5] McCarthy, J.E. and S. Swierenga, What we know about dyslexia and web accessibility: a research review. Universal Access in the Information Society, 2010. 9(2): p. 147-152.
- [6] Williams, P., H.R. Jamali, and D. Nicholas. Using ICT with people with special education needs: what the literature tells us. in Aslib Proceedings. 2006. Emerald Group Publishing Limited.
- [7] Rello, L. and R. Baeza-Yates. Good fonts for dyslexia. in Proceedings of the 15th international ACM SIGACCESS conference on computers and accessibility. 2013. ACM.
- [8] McPhillips, T., et al., Dyslexia in Ireland, North and South: Perspectives on developments since publication of the Dyslexia Reports (2002). 2015, Armagh: SCOTENS.
- [9] Bradford, J., Designing web pages for dyslexic readers. 2011.
- [10] Gregor, P. and A.F. Newell. An empirical investigation of ways in which some of the problems encountered by some dyslexics may be alleviated using computer techniques. in Proceedings of the fourth international ACM conference on Assistive technologies. 2000. ACM.
- [11] Böttger, H., et al., Contrast and font affect reading speeds of adolescents with and without a need for language-based learning support. 2017. 1(4): p. 45.
- [12] Evett, L. and D.J.I.w.c. Brown, Text formats and web design for visually impaired and dyslexic readers—Clear Text for All. 2005. 17(4): p. 453-472.
- [13] Page, T., Usability of text input interfaces in smartphones. Journal of Design Research, 2013. 11(1): p. 39-56.
- [14] McHale, K. and S. Cermak, Fine motor activities in elementary school: Preliminary findings and provisional implications for children with fine motor problems. American Journal of Occupational Therapy, 1992. 46(10): p. 898-903.
- [15] Kazakou, M., et al., Phonological Awareness Software for Dyslexic Children. themes in science and technology education, 2011. 4(1): p. 33-51.
- [16] Temple, E., Dyslexia and the Brain: Research Shows that Reading Ability Can be Improved. 2008.
- [17] McCormack, J. Aesthetics, art, evolution. in International Conference on Evolutionary and Biologically Inspired Music and Art. 2013. Springer.
- [18] Skiada, R., et al., EasyLexia: A mobile application for children with learning difficulties. Procedia Computer Science, 2014. 27: p. 218-228.
- [19] Ojanen, E., et al., GraphoGame—a catalyst for multi-level promotion of literacy in diverse contexts. Frontiers in Psychology, 2015. 6: p. 671.
- [20] Rello, L., C. Bayarri, and A. Gorriz. What is wrong with this word? Dysegxia: a game for children with dyslexia. in Proceedings of the 14th international ACM SIGACCESS conference on Computers and accessibility. 2012. ACM.