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Literature Survey on Interaction Design and Existing Software Applications for Dyslectic Users

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Abstract. The purpose of this study is a literature research on interaction design and existing software applications for dyslectic users. This literature research will contribute a future empirical study on how we could design a reading software application together with dyslectic users to enhance their reading skills. For the purpose of this research, we initially collected 175 studies, from which we selected, reviewed and made an overview table of 71 studies organized by areas of attention. The literature research on interaction design of systems for dyslectic users resulted in a presentation and comparison of interaction design (IxD) parameters. This process indicated common dimensions and elements among IxD parameters supporting users in improving their reading skills. Finally, reviewed studies on existing software applications resulted in a focus on improving dyslectics' reading performance. Our results showed that there is a trend on developing interaction designs focused on the reading conceptual area. We also discuss dyslectics users of existing software applications complaints, which resulted in a lack of existing software applications' design and system quality.

Keywords: dyslexia; causes of dyslexia; dyslexia teaching strategies; dyslexia treatments; dyslexia theories; dyslexia languages; dyslexia technology tools; mobile applications for dyslexia; IxD of SW apps for dyslexia; design guidelines for dyslexia;

1 INTRODUCTION

Dyslexia is a hidden learning disorder in reading, spelling and written language, and maybe in number work. It is a learning disability, which cannot be completely treated and has negative consequences for dyslectics' life by making it complicated [1]. Learning difficulties, caused by dyslexia, have often a negative impact on the way dyslectics are used to thinking, behaving and living. Statistics have shown that approximately 70-80% of people with reading problems are probably dyslectics, and one out of five students have a language-based learning disability [2]. Research have shown that dyslexia is a cognitive disorder, which affects deeply dyslectics' daily routine by isolating them often from the community. It is very usual for a dyslectic person to complain that (s)he is not able to be focused on a specific task, recall tasks, orders, messages, routes or even their daily schedule [3].

Furthermore, it is important to point out that research supports that there is a relation between dyslexia and the type of languages. A language can be either opaque (e.g. the English, Danish, French languages, etc.), or transparent (e.g. the Greek, Italian, Spanish languages, etc.), which difference affects the level of a language's complexity, and has an impact on dyslectics' reading and writing performance [4]. Studies have also proved that assistive technology contributes significantly the improvement of dyslectics' cognitive skills [5], [6], [7]. Technology is an alternative and modern way of helping people with dyslexia improve their skills on reading, writing, memory, organization or numeracy conceptual areas. Maybe technology is not able to treat dyslexia yet, but it is

able to facilitate dyslectics by enhancing the motivation for improvement [8], [9]. Especially Human-Computer Interaction (HCI) field can enhance this trial through designing systems for building a dyslexia friendly environment [10]

After a systematic literature research on interaction design of systems and existing software applications supporting dyslectic users, we realized that related studies to the field of dyslexia are very limited, even though dyslexia is a cognitive disorder with strong impacts to dyslectics' life. With this study, our goal is to contribute future research on developing designs for software applications addressing to dyslectic users.

2 RELATED WORK

In this section, two related works are presented regarding literature research on interaction design of systems for dyslectic users, and one related work on existing software applications that support dyslectic users to improve their cognitive skills.

2.1 Related Work on IxD Guidelines and Parameters

Otávio et al [11] investigated Web accessibility issues for users with dyslexia by involving in their study related literature studies on interaction design parameters. A number of related works on interaction design for dyslexia have been mentioned in their research. Some of them focused on functionality and some others on the user interface: From one hand, the studies of Freire et al [12] and Al-Wabil et al [13] focused on functionalities that could help dyslectic users improve their performance. In their studies, they refer to a number of 693 problems on accessibility and usability, which problems are related to difficulties in navigation, architecture of information, the form of texts, the organization of the content, the language and the amount of information that makes harder for dyslectics to scan a text. Because of the fact that such difficulties can be distracting for dyslectics, interaction design of systems for dyslexia has to be focused on fulfil these functionalities. On the other hand, the studies of Rello et al [14], [15], [16], Santana et al [17], Rello & Barbosa [18], and Rello & Baeza-Yates [19], [20] focused on user interface design-parameters. The recommended design-parameters allow users to highlight content of texts, adjust the size and type of fonts, the alignment of a text, the spacing of characters, the fore- and background colours, the length of texts, and its borders. Additionally, there are suggestions, which could improve dyslectics' reading skills: Rello & Baeza-Yates recommend Helvetica, Courier, Arial, Verdana and Computer Modern Unicode font types as the best font types for dyslectic users [19], [20]. Jacob McCarthy et al. [21], [22] included into their study a literature survey on interaction design for dyslectic users, which resulted in a number of parameters focused on the user interface as well. In this study, there have been mentioned features that allow dyslectic users to adjust the size of a text, and design parameters that refer to short sentences, use of pictures, dark background, and San Serif fonts of 12pt or larger. These recommendations are an overview of other researchers' studies [23], [24] , which McCarthy provides us.

2.2 Related Work on Existing Software Applications

A literature survey on existing software applications for dyslectic users led us to the CALL Research and Development center of Scotland, which provides two 'App Wheels' that present a number of 180 different types of existing Android and iPad software applications categorized into five conceptual areas of Reading, Writing, Numeracy, Organization and Memory. A thorough research on the 'AppWheels' showed that there is a trend on the majority of the existing software applications for dyslectic users towards the reading conceptual area. [25], [26]

3 METHOD

As we mentioned earlier, our literature research focused on interaction design of software applications for dyslectic users. We divided our literature research into four phases of the Review Focus, the Filtering, Categorization, and in-depth Analysis (Reading) of the literature. For reviewing the literature, we based on a combination of the Müller-Bloch and Kranz's literature review framework [21], and the Wolfswinkel's et al [22]. Below we explain each research phase individually.

3.1 Phase 1: The Review Focus

For the research purpose, Google Scholar, Scopus and IEEE literature databases have been used, since they cover a variety of research fields. We did not limit our research on specific conferences, since the sources regarding dyslexia and interaction design are very limited. We included, for instance, in our research conferences such as ICCHP, ACM, WCE, ITiCSE, etc. Additionally we included published reports and books related to our focus area. Before starting, the literature research 6 keywords/key-phrases selected as leaders: dyslexia, causes of dyslexia, dyslexia theories, IxD of SW applications for dyslexia, dyslexia technology tools, mobile applications for dyslexia. Initially, the review of the literature was concerned with the keyword 'dyslexia'. This keyword led the survey to a large number literatures have been conducted with a more theoretical focus, which provided us general information on dyslexia. Therefore, the survey's focus particularized on 'dyslexia theories', and 'causes of dyslexia', which key-phrases enhanced our knowledge on dyslexia. Papers with a high focus on medical models of dyslexia were excluded. Moving on, the review concerned with the 'IxD of SW applications for dyslexia'. This key-phrase excluded papers suggesting methodologies of interaction design for developing software applications for users without dyslexia. Afterwards, the key-phrase of 'dyslexia technology tools' provided us various technological tools being used addressing to dyslectics, but due to the fact that our literature survey focus area was on IxD for mobile applications, we added the sub-keyword of 'mobile applications for dyslexia'. This sub-keyword excluded a number of literature works related to other types of assistive technologies, e.g. for desktops, developed for using by dyslectics.

3.2 Phase 2: Filtering studies

In the filtering process, we should decide if the preselected literature should be included to the final selection. For the final selection of the studies, we added four questions as rules for the final selection of a study: "Is the study related to dyslexia?", "Is the study related to theories on dyslexia?", "Is the study related to mobile applications for dyslexia?", "Is the study related to interaction design for mobile technology?" If the answer on the question was 'Yes', the study was accepted, if the answer on the question was 'No', the study was rejected. The phase 1 resulted to a number of 175 studies before filtering: 63 about dyslexia, 33 about causes of dyslexia, 34 about dyslexia theories, 8 about IxD of SW apps for dyslexia, 17 about dyslexia technology tools, 20 about mobile applications for dyslexia.

Afterwards, we re-evaluated the found studies to be sure that they corresponded to our research. The final number of selected studies after filtering was 71 with 22 studies about dyslexia, 16 about causes of dyslexia, 18 about dyslexia theories, 9 about IxD of SW apps for dyslexia, 5 about dyslexia technology tools, and 1 about mobile applications for dyslexia. As we can see, the total number of studies was decreased significantly by reaching approximately the half number of the initially selected studies. Furthermore, in some cases the numbers reached only just one literature, e.g. on 'mobile applications for dyslexia', since the majority of literature was conducted either in a very

theoretical background or it was referred very generally to the usefulness of the technology for dyslectic people.

3.3 Categorization of the studies

In this phase, we categorized the selected studies based on their content. Specifically, we made a table consisting of four main areas of attention of 'Dyslexia Understanding' included dyslexia and causes of dyslexia keywords, 'Theories on Dyslexia' included dyslexia theories keyword, 'Technology on Dyslexia' included dyslexia technology tools and mobile applications for dyslexia keywords, and 'IxD and Dyslexia' included IxD of SW apps for dyslexia keyword. In these main categories (areas of attention), we classified the selected papers based on keywords/key-phrases. Categorization of papers facilitated us to the next phase of 'Reading of Literature', since it was easier for us to know beforehand, which papers –based on the related keywords/key-phrases- belong to which category (area of attention).

3.4 Reading of Literature

Through reading the selected studies, we found new pieces of information related to the mentioned areas of attention. After translating the new pieces of information into keywords/key-phrases, four keywords/key-phrases were added: dyslexia teaching strategies, dyslexia treatments (Dyslexia Understanding), dyslexia languages (Theories on Dyslexia), and design guidelines for dyslexia (IxD and Dyslexia). Finally, we had 10 keywords/key-phrases instead of 6. New keywords/key-phrases were added into three out of four areas of attention, which contributed highly our literature research, especially in the area of 'IxD and Dyslexia' attention.

4 FINDINGS

This section presents the results we received from the literature review. Initially, an overview table illustrates the studies' number organized by areas of attention. Then interaction design guidelines and parameters are shown and compered with each other. The section ends looking at the existing software applications that support dyslectic users.

Table 1. Literature References Organized by Areas of Attention

Areas of Attention	Keywords/ Key-phrases	Literature Reference Number
Dyslexia Understanding	Dyslexia	1, 2, 3, 4, , 9, 11, 12, 22, 25, 28, 30, 50, 51, 57, 63, 67, 69
	Dyslexia causes	31, 32, 33, 34, 36, 37, 39, 41, 42
	Dyslexia teaching strategies	5, 6, 8, 29
	Dyslexia treatments	7
Theories on Dyslexia	Dyslexia theories	5, 10, 12, 13, 14, 23, 35, 36, 38, 40, 56
	Dyslexia languages	14, 15, 16, 18, 24, 52, 53, 11
Technology for Dyslexia	Dyslexia technology tools	20, 21, 26, 27
	Dyslexia mobile applications	17, 29, 47, 48
IxD Design and Dyslexia	IxD dyslexia	19, 49, 65
	Design guidelines dyslexia	43, 44, 45, 46

At this point, there is an explanation of each area of attention. Additionally, we explain what kind of information each area of attention provided us:

Dyslexia Understanding: Studies of this area of attention provided us pieces of information enough to equip us with the necessary knowledge regarding dyslexia, its aspects, teaching strategies have been used until now and trials of treatment. Based on

this area of attention studies, we managed to learn that dyslexia is a learning disability that belongs to cognitive disorders; dyslexia can be caused by phonological, magnocellular, cerebellar, auditory and visual deficits; it is cognitive impairment that cannot be treated yet, but by using sophisticated teaching strategies, dyslectics' learning skills can be improved.

Theories on Dyslexia: Studies on this area of attention provided us pieces of information regarding theories related to the causes of dyslexia and the impact of the type of languages to the level of dyslexia. Five causal theories of dyslexia relate the difficulties facing dyslectic people to their causes. The phonological deficit theory relates dyslectics' difficulties in matching sounds to letters to phonological deficits. The magnocellular deficit theory relates dyslectics' visual, auditory and tactile difficulties to magnocellular deficits. The cerebellar deficit theory relates dyslectics' difficulties in automizing learn tasks to cerebellar deficits. The auditory deficit theory relates dyslectics' difficulties in perceiving rapid changes of sounds to auditory deficits. The visual deficit theory relates dyslectics' difficulties in reading to visual deficits.

Technology and Dyslexia: Studies on this area of attention provided us pieces of information regarding the contribution of technology to the improvement of dyslectics' performance. Assistive technology can be a useful tool for dyslectics. Especially mobile applications can help dyslectics improve their reading and writing skills and performance. In this area, there is also one study, which provided us an overview of a number of 180 existing software applications for dyslectic users. Based on this study the largest number of existing software applications aims at improving dyslectics' reading skills.

IxD and Dyslexia: Studies on this area of attention provided us pieces of information regarding the recommended interaction design guidelines and parameters focused on functionality and user interface. Based on studies of this area of attention, we learned that specific font size, colors and layouts facilitates dyslectics to improve their reading performance. Based on this area of attention studies, IxD guidelines and parameters focus on helping dyslectics improve their reading skills.

4.1 Interaction Design guidelines and parameters

Research on interaction design guidelines resulted in one design guideline with an emphasis on three design dimensions -Form, Content and Behavior- mentioned of high importance for software applications' design addressing to dyslectic users. To be more precise the interaction design guideline supports that these dimensions and their elements facilitate users, who address visual (the form dimension), or phonological deficits (the content and behavior dimensions) due to dyslexia [27], [28], [29], [30]. Simple and clear layouts with font sizes from 12 to 14 and Sans Serif fonts, as well as features that allow dyslectic users to adjust the font size, the style, and colors, or specific combinations on colors and contrasts by avoiding bright colors, have been recommended as supportive to dyslectic users and able to improve their reading performance. Additionally, features that provide explanations, enrichment of texts with pictures and audio elements make reading tasks more accessible for users with dyslexia.

Moving forward, our literature analysis led us to Rello and Barbosa study on IxD parameters of software applications for dyslectic users. These interaction design parameters focus on the Form dimension, as visual deficits affect deeply dyslectic users' reading performance. This study recommends a number of layout-design parameters as appropriate to help dyslectic users improve their reading performance [31]. Specifically, *Font Types /Sizes:* Arial, Comic Sans Verdana, Century, Gothic, Trebuchet, Dan Sassoon Primary, Times New Roman, Courier, Dyslexie/12 or 14, and extra-large letter spacing, *Brightness-Colors:* Low Brightness & color differences among text and background, and Light grey as font color, *Space/Lines/Columns:* Lines of 60-70 /Characters Clear Spacing between letter combinations/Line spacing: 1.3, 1.4, 1.5, 1.5-2/ Narrow columns should be avoided. [18]

Explaining the Rello and Barbosa text layout parameters, Sans Serif fonts of a size between 12 and 14, low brightness and light contrasts between background and fonts' colors have been recommended by their study. Furthermore, suggestions for lines of 60 to 70 characters maximum and clear spacing between letter combinations, as well as line spacing from 1.3 to 2, and avoidance of narrow columns have been recommended as supportive to dyslectic users and able to improve their reading performance [18]. Based on comparisons among the IxD guidelines/parameters there are many similarities on (i) the font type and size, (ii) the recommendations about avoiding bright colors and narrow columns, and (iii) the suggesting number of characters and line spacing (see table 2).

Table 2. Comparisons among IxD guidelines/parameters

Design Guidelines' Synopsis (Table 4)			Rello and Barbosa's text layout parameters (Table 5)		
Fonts	Colour	Layout	Fonts	Colour	Layout
Font Type /Size	Brightness/ Colours	Space/Lines/ Columns	Font Type /Size	Brightness/ Colours	Space/Lines/ Columns
Font Type: Arial, Comic Sans Verdana, Century, Gothic, Trebuchet, Dan Sassoon **Font Size:** from **12 to 14** points or larger	Avoid bright green and red colours & **Suggested pale colour-codes:** #A4D5A6 #CCE685 #A8E685 #DED8E4 #87AA74 #9E9E7C #F19D3B	Lines of no more than 70 **characters** Line **spacing:** 1.5 **Avoidance** of **narrow columns**	**Font Type:** Arial, Comic Sans Verdana, Century, Gothic, Trebuchet, Dan Sassoon **Font Size: 12 or 14** extra-large letter spacing	**Low Brightness** & colour differences among text and background Light grey as **font colour**	Lines of 60-70 **characters** **Line spacing:** 1.3 1.4 **1.5** 1.5-2 **Narrow columns** should be **avoided**

Similarities on examined IxD guidelines/parameters indicate that there is an agreement within the literature in interaction design guidelines for systems to support dyslectic users. (See table 3)

Table 3. Suggested IxD generated by Comparisons

Suggested IxD		
Fonts	Colour	Layout
Font Type /Size	Brightness/ Colours	Space/Lines/ Columns
Font Type: Arial, Comic Sans Verdana, Century, Gothic, Trebuchet, Dan Sassoon **Font Size:** 12 - 14	Pale colours e.g. #A4D5A6 #CCE685 #A8E685 #DED8E4 #87AA74 #9E9E7C #F19D3B Avoidance of brightness	Lines of maximum 70 **characters** **Line spacing:** 1.5 Narrow **columns** should be avoided

As we can see on the table (See Table 3), design elements, such as Sans Serif fonts of 12 to 14 size, pale background colors, avoidance of brightness and narrow columns, and lines of maximum 70 characters with a line spacing of 1.5 have been recommended as the most appropriate for designs addressing to dyslectic users.

4.2 Existing SW applications supporting dyslectic users

As we mentioned earlier, the CALL study that we found on 'IxD and Dyslexia' area of attention provided us two 'AppWheels' presenting a number of 180 different types of Android and iPad software applications for dyslectic users, categorized into five conceptual areas of reading, writing, numeracy, memory and organization [25], [26] (See Figure 1). Finally based on the 'AppWheels', we made an overview table presenting the total number and types of the existing software applications categorized by conceptual areas of reading, writing, numeracy, organization and memory. This table helped us learn that the majority of the existing software applications for dyslectic users focus mainly on improving the Reading conceptual area, even though there is no any clear and reliable scientific evidence on the reflection of those numbers (See Table 4).

As we can see on the table below, the majority of the existing software applications (70 out of 180) have been developed to help dyslectic users improve their performance on reading. A number of 64 software applications have been developed to help dyslectics improve their writing performance, and only a small total number of 41 applications

have been developed to improve dyslectics' skills and these applications belong to the numeracy, organization and memory conceptual areas.

Fig. 1. Android and iPad Apps for Learners with Dyslexia [25],[26]

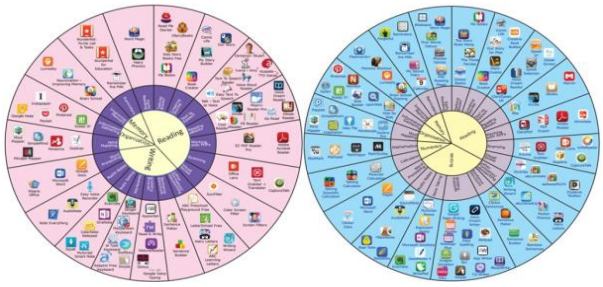

Table 4. Overview of Existing SW applications [25],[26]

	Categories				
Software Applications	**Reading**	**Writing**	**Numeracy**	**Organisation**	**Memory**
Early Reading	7				
Taking Books	8				
Creating Stories	9				
Text to Speech	12				
Reading eBooks	12				
Working with PDFs	6				
Scanning	9				
Visual Stress	7				
Letter Formation/Handwriting		9			
Sentence Structure		6			
Writing Support		18			
Keyboards		6			
Note Taking		11			
Audio Notes		8			
Word Processing		6			
Calculator			3		
Mathematics			4		
Mind Mapping				12	
Information Gathering				12	
Improving Memory					7
Reminders					8
Total	**70**	**64**	**7**	**24**	**15**

Unfortunately, there is not any clear and reliable scientific evidence of why the numbers are higher on the reading conceptual area. If we take into consideration the principle of dyslexia "Dyslexia is a hidden disorder in reading, spelling and written language" [32], these numbers may reflect that the reading one is this conceptual area, where dyslectics face the majority of their difficulties in comparison to the other four areas. Alternatively, the numbers of the existing software applications in this area are too high because this may be the conceptual area of developers' interest. Based on the overview table of the existing software applications (See Table 4), we divided the software applications into Android and iPad software applications, and made a with the purpose of finding, if the high numbers on the reading conceptual area are based on an increase of one OS's numbers, or if the numbers are high on both OS. The results indicate a trend on the software applications' development focused on improving dyslectic users' reading skills and performance. Because of the fact that there was not any clear scientific evidence to excuse the previously mentioned trend on the reading conceptual area, we decided to investigate it. For this purpose, we visited the Google Play Store [33] and collected dyslectic users' comments on the 29 first reading software applications addressing to dyslectic users. The total number of dyslectic users' complaints on reading software applications makes us clear that the main problem of users refers to applications' design and systems' quality, which make an application useless in the end, as they claim. This was partially surprising for us, since both related work and reviewed literature focused mainly on design, and there was not any suggestion focused on the

systems' quality. Below we can see a sample of dyslectic users' complaints with the higher total numbers:

NOT WORKING

"*It just doesn't work I speak into it and it comes out as a scramble of words.*"

"*Amazing idea but failed to work. I am myself severely dyslexic and found the idea of this program amazing but sadly it fails to work every time. If the bugs can be worked out I would be very happy to re evaluate. Please do not abandon the attempt to get this program to work as I can see the potential in the idea.*"

"*Does not work. All it keeps saying is that it could not extract text from image…even though very clear picture.*"

USELESS

"*Without the option for font size, the app is useless if don't have a device it was made for. This font is too big and it's unreadable. Can't understand why there isn't an option for changing font size.*"

"*Cool idea but doesn't give any controls to go back a few sentences or to navigate a table of contents. In the end, not quite usable. I look forward to future improvements.*"

BUGS/ BAD DESIGN

"*Interface is also poor-need to keep pressing the record button for long text and keyboard editing capability (e.g. to correct errors) us very clunky.*"

"…the PDF to text translator doesn't seem to be able to handle the formatting. PDF documents written in LaTeX also fail. I'll keep it installed for the time being in hopes that this can be remedied. Thanks!"

The first indication generated by the above comments is that there is a need for developing system and design of high quality for software applications, especially because they address to users with dyslexia. Complaints like, "Interface is also poor", "It just doesn't work I speak into it and it comes out as a scramble of words", or "…I found the idea of this program amazing but sadly it fails to work every time", or "the PDF to text translator doesn't seem to be able to handle the formatting." , validate this indication. Dyslectic users can be patient or even contribute the improvement of promising software applications, if there are possibilities for future improvement. Comments, like "If the bugs can be worked out I would be very happy to re-evaluate.", or "I look forward to future improvements.", or "I'll keep it installed for the time being in hopes that this can be remedied.", validate this indication.

5 DISCUSSION

In this section, we compare the findings to related work, in regards to the literature research on interaction design and existing software applications for dyslectic users. Specifically, we discuss the interaction design guidelines and parameters shown in the study and their relation to the related work. We also discuss possible reasons for the focus of the existing software applications' focus on the reading conceptual area. Finally, we discuss if there is any relation between the users' complaints on the existing software applications on Google Play Store and the results of the literature.

5.1 Interaction Design guidelines and parameters

Regarding the interaction design guidelines and parameters shown in the study, and their relation to the design parameters of the related works, there is a clear agreement among them. Both IxD guidelines/parameters of literature research and related work

focused on user interface and functionalities that help dyslectic users improve their reading performance. In both related works and literature research's IxD guidelines, design parameters have been proposed for developing designs for software applications addressing to dyslectic users. Their aim? To facilitate and help dyslectic users improve their reading skills and performance.

5.2 Existing SW applications supporting dyslectic users

As for the existing software applications supporting dyslectic users and based on literature, the largest number of them have been developed with a focus on improving dyslectic users' reading skills and performance. Even though there is not any clear and reliable scientific evidence regarding this trend on the reading conceptual area, we assume that this trend may be based on three main factors: (i)The poor reading-performance is the first sign that a person has a cognitive disorder, like dyslexia [34]. (ii)As the IxD guidelines/parameters focus mainly on the reading conceptual area, it is reasonable for the developers to focus their work on this conceptual area. (iii)Developers may focus their interest on the reading conceptual area, as the better reading performance of dyslectic persons is, the better their daily routine becomes, since reading is a daily requirement for everybody either dyslectic or not.

5.3 Users' complaints on quality and literature

Based on findings about users' complaints on reading software applications, the main problem was related to the designs and systems' quality of the existing software applications for dyslectic users. That was partially surprising for us. The elated work, the reviewed literature and the users comments have mentioned a focus on design parameters and guidelines for systems addressing to dyslectic users. On the contrary, there is not any mention on the quality of the systems.

5.4 Implications

Given the trend of developing reading software applications for dyslectic users and the users' comments about a need for improving the designs of applications for dyslectic users, the current research indicates a further investigation for appropriate designs to improve dyslectic users' reading performance. This indication may imply the involvement of dyslectic people to the developing process in order for the designs (but also the systems) to correspond to dyslectic users' expectations.

6 CONCLUSION

In this paper, we presented the results of a literature review on studies about interaction design of systems for dyslectic users. The studies have been selected without any limitation on specific conferences, since the sources regarding dyslexia and interaction design were very limited. The literature review resulted in a number of 71 studies related to interaction design and dyslexia. Each study was categorized by areas of attention including the related keywords. A table presented an overview of the reviewed studies references organized by areas of attention. Based on findings: (i) Interaction design guidelines and parameters focus mainly on reading conceptual area, as the most popular conceptual area among the writing, numeracy, memory and organization conceptual areas. (ii) the high numbers of existing Android and iPad reading software applications corroborates the former trend, and (iii) from the dyslectic users' perspective, there is a need for developing designs and systems of high quality. One limitation, which we faced throughout our literature survey, was regarding the filtering process. We tried not to miss important literatures and this resulted in a time consuming back

and forth research until selecting the final number of the literature for reviewing. However, this was a study made by one person, so there is always the possibility of missing literatures. A second limitation was about the final selection of the studies. After collecting a number of 175 studies related to our study, we systematically applied four specific questions to all the 175 studies as rules for the final selection of the studies. Based on these questions, we came up with 71 studies, although there is always room for improvement of this method. Our literature study resulted in a trend on the Reading among five conceptual areas of Reading, Writing, Numeracy, Memory, and Organization. Considering the lack of finding any scientific evidence that excuse this trend, we believe that it would be beneficial a future research to finding why there is a focus on the reading conceptual area. Furthermore, Even though there is an agreement among the interaction design guidelines and parameters for developing designs of software applications for dyslectic users, then why did a number of dyslectic users express a need for higher quality of designs? This need indicates a further research on the efficiency of the existing interaction design parameters and guidelines. This indication can contribute a future research on this field with the aim of fulfilling at some point dyslectics' expectations. Based on our literature survey and on the existing software applications' users' complaints, this current literature survey will contribute a future empirical study of investigating how we could develop together with dyslectic users a design for a software application to enhance their reading skills. Furthermore, based on our literature survey's findings regarding the impact of the type of languages to the level of dyslexia, part of a future empirical study will be focused on investigating how the type of languages differentiates the efficiency-level of a software application's designs for dyslectic users.

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