Arabic E-Reading: Studies on Legibility and Readability for Personal Digital Assistants

Mrouj Almuhajri

A Thesis

in

the Department

of

Computer Science and Software Engineering

Presented in Partial Fulfillment of the Requirements
For the Degree of
Master of Computer Science
Concordia University
Montréal, Québec, Canada

December 2013

CONCORDIA UNIVERSITY
School of Graduate Studies

This is to certify that the thesis prepared

By: Mrouj Mohammad Almuhajri

Entitled: Arabic E-Reading: Studies on Legibility and Readability for Personal Digital Assistants

and submitted in partial fulfillment of the requirements for the degree of

Master of Computer Science

complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

Signed by the final examining committee:

Dr. O. Ormandjieva _____ Chair

Dr. T. Kasvand _____ Examiner

Dr. N, Tsantalis _____ Examiner

Dr. C. Y. Suen _____ Supervisor

Approved by   _____
               Chair of Department or Graduate Program Director

               _____
               Dean of Faculty

Date   December 16, 2013

Arabic E-Reading: Studies on Legibility and Readability for Personal Digital Assistants

Mrouj Almuhajri

Concordia University, 2013

Abstract

Electronic reading opens new avenues especially with the advance of modern reading devices. The new generation of Personal Digital Assistants PDAs becomes more popular and more affordable. Therefore, while displays keep shrinking in size, it is needed to re-evaluate typefaces used in these devices as they form a substantial component in the reading field. In this research, a survey was conducted to identify Arab community preferences of 13 selected fonts on PDAs. Also, it inferred the popularity of using these devices for reading. From the participation of 53 subjects in this survey, it was deduced that e-reading using PDAs among Arab communities is increasing dramatically, which necessitates the need of investigation for better fonts used in these devices. Moreover, the results from font evaluation based on people preferences reduced the number of studied fonts to six for further examination.

Three experiments have been conducted to investigate six Arabic fonts on PDAs from the perspective of legibility and readability to come up with the best fonts. In all three experiments, 138 subjects participated doing i3arabi Test over iPad and iPad mini devices. Two experiments were done to evaluate the legibility of the selected fonts. However, due to the nature of Arabic language, it was difficult to apply the same methods used to test Latin fonts. A pilot study was done to understand the problem, and results supported the mentioned difficulty. Therefore, a novel method named M-Short-Exposure method has been proposed to investigate the legibility of

isolated Arabic letters and connected letters. The results indicate Geeza Pro and Uthman SH fonts yielded the best performance in the first and second experiments respectively. Then an integration result has been concluded for legibility experiments confirming Geeza Pro and Uthman SH as the most legible fonts to be used on PDAs.

In readability experiment, reading speed and comprehension questions have been used over running texts of the selected fonts to measure their readability. It has been found that there is no correlation between reading speed and comprehension factors. Though, the results provide Yakout Reg and Uthman SH fonts as the most appropriate fonts to be used on PDAs for e-reading.

Finally, Our findings provide the most legible and/or readable font(s) among the tested set. Moreover, some recommendations have been made on better use of legible and/or readable Arabic fonts for different purposes.

To my dearest

Mother, Father,

and loving Brother

Acknowledgments

I would like to thank my supervisor Dr. Ching Y. Suen for the valuable guidance and advice for this thesis. His continuous feedback about my thesis drafts enlightened my research and writing. It has been an honour to work with him and get benefits from his great experience. I would not accomplish this thesis without his patience and support.

I would like to take this opportunity to thank my family who has never stopped supporting me since the first day I came to Canada. Great thanks to my loving parents (Mr.Mohammad Almuhajri and Mrs.Faiza Halawani) who surrounded me with their prayers to be safe and successful. Also, so many thanks to my sisters (Malak, Mashaer, Mead, and Mawadah) and brother (Moaid) who kept me happy whenever I felt down by just contacting them overseas. A special thank to my companion in my whole journey here in Canada, my dear brother Mutaz who stood by me through the long time of studying. I would not be able to achieve this without his personal support, encouragement and great patience. Thanks are never enough to express my deep appreciation feeling toward him.

I also would like to thank my colleagues in the Centre of Pattern Recognition and Machine Intelligence CENPARMI: Jehan Janbi who never hesitated to provide help and advice; Muna Khayyat who taught me many useful materials and shared critical moments; and the lab manager Nicola Nobile who was always available for any technical needs. Many thanks to all of my friends who never let me feel lonely, and they were as a second family to me: Alaa Alsaig, Sabreen Kalantan, Afnan Habash, Sarah Alkhodair, Ma'ab Attar; and friends abroad who kept encouraging me: Somayah Karsoum, Somaya Aldalaly, and Sara Albakry.

Last but not least, I would like to extend my gratitude to the Saudi Cultural Bureau for their financial support, and to Effat University and Umm Al-Qura University for facilitating data collection stage of my research. Thanks are also extended to Dr. Wadee Alhalabi who helped me in collecting data in Saudi Arabia and arranged necessary requirements to conduct my research experiments.

Contents

List of Figures

List of Tables

Chapter 1

Introduction

In this chapter, general information related to the thesis, motivation and objectives, and structure of this thesis are introduced. A brief introduction to e-reading and e-book is provided in section 1.1. Next, section 1.2 describes typography generally, and Arabic typographical structure especially in section 1.2.1 followed by section 1.2.2 which discusses historical movement of Arabic font styles. Then, font encoding system is briefly introduced in section 1.3. Section 1.5 states thesis motivation and objectives. Finally, a thesis outline is proposed in section 1.6.

1.1 E-Reading and E-Book

E-reading is not a machine that does the reading process. It is normal persons reading from digital devices in digital formats. Though, online reading activities like e-mails and performing assignments on computers are not considered reading [1]. An electronic book (known as e-book or digital book) is a digital format of book-length publication. It consists of texts, images, or a combination of them, and it can be published through and read from digital devices, such as computers, laptops, tablets, smart phones, and e-readers [2]. A digital book could be one of two types: e-book or digitized book in which the formal one contains digital texts of a specific structure, and it is published for digital reading devices or popular e-book reading applications, such as Mobipocket. Many facilities can be applied on the text like changing font type

and the size of viewing area. On the other hand, a digitized book is simply created by getting photographical images from hard book pages, and then an algorithm is applied to reduce the size (bytes) of the book with good looking pages [3]. Sometimes OCR systems are used in order to convert these images into editable and text-searchable format [4]. Between the two types, digitized books have poor usability while e-books could give a better chance to apply interactive features for users like flipping page and highlighting texts.

Currently, e-book market has blossomed because Personal Digital Assistance PDAs become more durable, more colorful, and more multifunctional. In fact, at the end of 2007, Amazon had introduced its e-book reader and e-book inventory, and it was the first eReader (Kindle) with free wireless access to search for e-books and download them [5]. Later on, many companies went to the same production line having their own readers whether with the e-ink technology like Kobo reader or tablet style devices like BlackBerrys playBook, Apple ipad, and Microsoft Surface. Thus, so many e-book formats are generated for these new devices, such as PDF, EPUB, TXT, MOBI, DOC etc. That would make a major problem due to the competition among producers. However, they improved features of these digital devices which flourish e-reading in a significant way.

1.2 Typography

Typography is a piece of art that conveys a language in a visual way. Bringhurst [6], an American typographer, defined typography as *"a craft by which the meaning of a text (or its absence of meaning) can be clarified, honored, and shared, or knowingly disguised"*. Usually, typography invites reader's attention to itself before it will be read. That emphasizes the importance of typography in which it should provide the following: grab reader's attention into the text; clarify content's meaning of the text; explain how the text is constructed and ordered; connect the text with other available elements; and finally make the best condition for reading.

1.2.1 Arabic Typographical Structure

The Arabic language is one of the most widespread languages around the world especially in the Middle East and North Africa with four million native speakers in 22 countries. In fact, it became one of the UNESCO official working languages by virtue of a United Nations General Assembly resolution on the 18th of December 1973. Recently, the 18th of December becomes the world Arabic language day due to its popularity[7]. Furthermore, some other languages like Farsi and Urdu are using the Arabic alphabet with slightly extended versions to express the written language. To work on Arabic typography, it is important to know the original Arabic script's characteristics and letterforms. Basically, the Arabic alphabet consists of 19 basic shapes which create with diacritic dots 29 letters. However, Arabic letters differ depending on their position in the word. Thus, the number of characters in the set becomes 106 in which 23 letters have the four different shapes, and the remaining 7 letters have only two different shapes and they are illustrated with their alternatives in Figure 1-1.

Arabic Writing Characteristics

Writing in Arabic is totally different than Latin. Several characteristics of Arabic writing are discussed as the following [8]:

Direction: unlike Latin, Arabic direction is written horizontally from right to left. However, numbers and some mathematical symbols are read from left to right.

Cursivity: letters must be connected within the word, and they differ depending on their position in the word (initial, middle, final, isolated).

Ligatures letters could be composite, and they are used a lot in Arabic for different purposes like font aesthetic, justification, or legibility.

Diacritic dot: gives the identity for some Arabic letters of the same basic glyph by its presence, number, and position.

Diacritic signs: (called vocalizations also)usually appear above or below the letters

#	Name	Relevant Sound	Isolated	Position		
				Initial	Middle	Final
1	Alif	a	ا	ا	ـا	ـا
2	Ba	b	ب	بـ	ـبـ	ـب
3	Ta	T	ت	تـ	ـتـ	ـت
4	Tha	Th	ث	ثـ	ـثـ	ـث
5	Jim	g	ج	جـ	ـجـ	ـج
6	Ha	ḥ	ح	حـ	ـحـ	ـح
7	Kha	kh	خ	خـ	ـخـ	ـخ
8	Dal	d	د	د	ـد	ـد
9	Dhal	dh	ذ	ذ	ـذ	ـذ
10	Ra	r	ر	ر	ـر	ـر
11	Zayn/Zay	z	ز	ز	ـز	ـز
12	Sin	s	س	سـ	ـسـ	ـس
13	Shin	sh	ش	شـ	ـشـ	ـش
14	Sad	ṣ	ص	صـ	ـصـ	ـص
15	Dad	ḍ	ض	ضـ	ـضـ	ـض
16	Ta	ṭ	ط	طـ	ـطـ	ـط
17	Za	ẓ	ظ	ظـ	ـظـ	ـظ
18	Ayn	-	ع	عـ	ـعـ	ـع
19	Ghayn	gh	غ	غـ	ـغـ	ـغ
20	Fa	f	ف	فـ	ـفـ	ـف
21	Qaf	q	ق	قـ	ـقـ	ـق
22	Kaf	k	ك	كـ	ـكـ	ـك
23	Lam	l	ل	لـ	ـلـ	ـل
24	Mim	m	م	مـ	ـمـ	ـم
25	Nun	n	ن	نـ	ـنـ	ـن
26	Ha	h	ه	هـ	ـهـ	ـه
27	Waw	w	و	و	ـو	ـو
28	Ya	y	ي	يـ	ـيـ	ـي
29	Hamza	-	ء	ء		ء

Figure 1-1: Arabic alphabet and alternatives depending on position

indicating the sound of those letters to help readers in pronouncing the letter in the right way beside knowing word's type or tense.

Allograph means that a letter may differ in its shape depending on its neighbors.

Kashida is not a character, it is a stretch of the previous letter. It is used for different reasons like legibility, justification, emphasis, and aesthetics. Some letters are prioritized to be stretched and they are called tansil.

Figure 1-2 shows examples for Arabic writing characteristics where the two sentences are exactly the same but in different ways of writing [1].
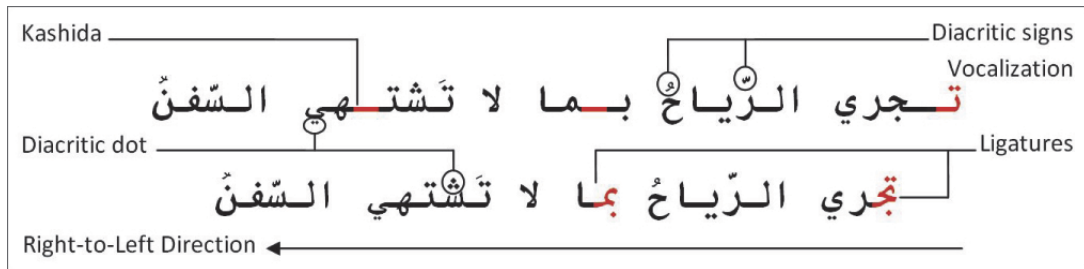

Figure 1-2: Arabic writing characteristics

Arabic Typeface Anatomy

In typography, typeface is a font family which includes a set of characters having specific design features in common. That is, design features could describe height, weight, condensation, style, slant, italicization, ornamentation, and designer or foundry. Typeface can have more than one font in more than one size. In contrast, font is a certain type of typeface with specified size, weight, and angle. For example, Times New Roman is a typeface in general, but specifying it to be bold or italic is going to give two different fonts of the same font family. Arabic typefaces have features and terms different than Latin. They are described in Table 1.1 and Figure 1-3

---

[1]The text shown in the Figure 1-2 is a part of an old Arabic Poetry written by Abu at-Tayyib Ahmad ibn al-Husayn al-Mutanabbi

Table 1.1: Description of common Arabic typographic terms

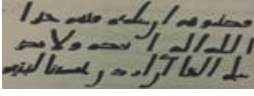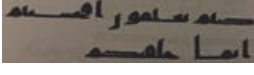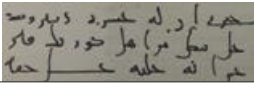| Typographic Term	Description
Baseline	The imaginary line in which most of the letters stand on.
Ascender	Parts of letters which take place over the loop-height and tooth-height, such as Alif.
Descender	Parts of letters which take place below the baseline, such as Waw.
Loop & tooth height	The distance from the baseline to the height of letters with loop or tooth, and it replaces the x-height in Latin.
Stem	The vertical stroke of letter.
Loop	The cursive style of the letters with closed loop like Fa.
Tooth	The short vertical stroke of letters reaching tooth height from the baseline like Ba and Sin.
Knot	The letter in which it is closed and filled like Ayn.
Shoulder	The horizontal stroke which takes place over the bowl.
Head	The elliptical part of a letter like Ayn.
Eye	The enclosed counter in letters like Waw.
Needle eye	The space inside the enclosed counter letters such as Waw.
Bowl	The rounded part of a letter.
Slack tail	The terminated stroke of letters which ends before the baseline like Mim.
Stiff tail	The terminated sharp curved letters which continue below the baseline like Waw.
Curled tail	The terminated upward curling stroke like letter Sad.
Flat tail	The flat horizontal stroke which stands on the baseline like Ba and Ta.
Diacritic dots	The dots which characterize the letter depending on their number, presence, and position.
Vocalization Marks	The didactic signs which represent as short vowels and placed either above or under the letters in order to help readers in proper pronunciation.
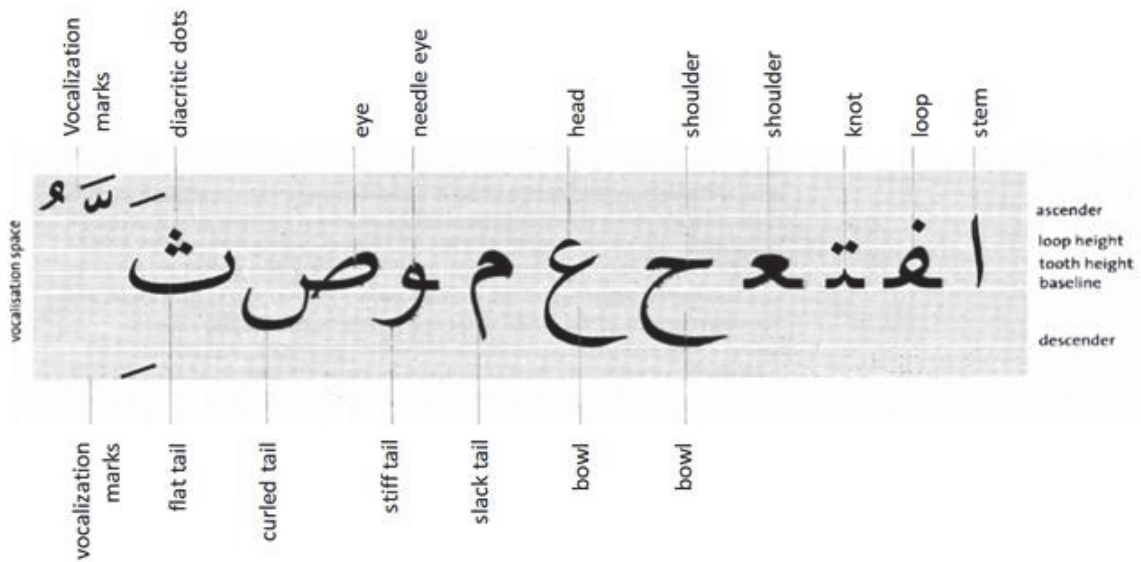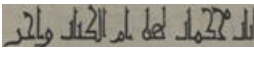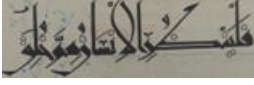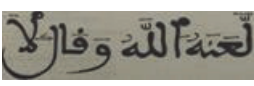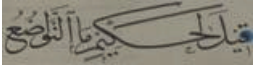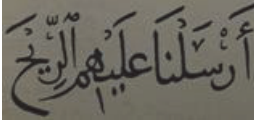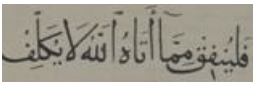
Figure 1-3: Common Arabic typographic terms [9]
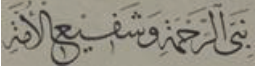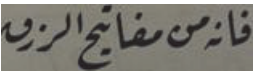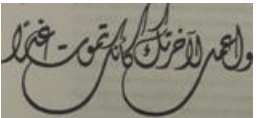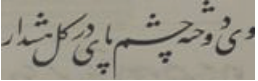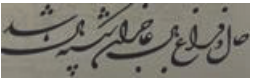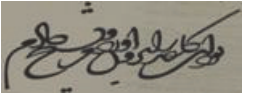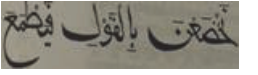
1.2.2 Historical Movements of Arabic Font Styles

Long time ago, writing was the main way of communication among world entities. Arabic writing went through many different stages. In fact, the flourishing of Islamic civilization had a great influence on calligraphy development. Many styles had been created from different Arabic cities like Kufa and Hira. According to Arab history, Arabic fonts can be categorized into five main styles: Archaic, Kufi, Maghrebi, Cursive, and Non-Arab [10]. Each style has specific characteristics that make it unique. The variety of styles and sub styles exists was because of different purposes of usage. For example, some of Non-Arab fonts like Diwani Al-Jali were for decoration while modern Naskh from Cursive style was for holy text reading owing to its high legibility. Table 1.2 summarizes Arabic font styles over the history.

Classifying Arabic type styles does not have a standard. In fact, it was based on cultural context, and then it becomes a self-consciously design. However, some categories have been created to inset named divisions. To explain, type styles could be categorized by functionality, general characteristics or history [10]. First, Arabic type styles could be classified according to typeface functionality into three main

Table 1.2: Historical Arabic font styles

Style	Font Name	Duration	sample	Characteristics
Archaic	Mail	7thC.AD		Angular shapes, no diacritic, vertical strokes slanted to the right.
	Mashq	7th C.AD		Very horizontal with thick horizontal strokes, thin-short vertical strokes and no diacritic.
	Old Naskh	7th C.AD		Fluid cursive, openness, clear, no diacritic.
Kufi	Old Kufi	7thC.AD		Angular geometric style, bold strokes, short ascender/descender, no diacritic.
	Oarmatian Kufi	8th C.AD		Smooth cursive style, rigid angular, no diacritic.
	Eastern Kufi	10th C.AD		Tall ascenders with tall vertical strokes slanted to right, diacritic exist.
Maghrebi	Western Kufi	10th C.AD		Rounding letterforms, small circular loops, long descender, large open shapes.
	Fasi/ Andalusian Kufi	13thC.AD		Thin lines, small letter forms, compact, diacritic exist, vocalised.
	Sudani Kufi	13th C.AD		Thick lines, irregular thickness, squarish angular, compact, diacritic exist.
Cursive	Thulth	7-9th C.AD		For heading, elegant, fluid and relatively thin strokes, diacritic exist.
	Naskh	7-10th C.AD		For Quranic text, highly legible, short horizontal strokes, equal ascender/ descender, full curves, straight vertical strokes, diacritics exist.
	Muhaqqaq	8th C.AD		Tall ascender, short horizontally inclined descender, slightly angular, smooth, compact.

Style	Font Name	Duration	sample	Characteristics
Cursive	Rayhani	9th C.AD	خلق الارض والسموات العلى	Large ending (descender), angular horizontal curves to left.
	Tawqii	9th C.AD	نبى ارحمة وشفيع الأمة	Rounded curves, thin lines, minimal use of vocalisation marks, words connected.
	Ruqqa	9th C.AD	فانه من مفاتيح الرزق	Rounded fluid curves, flat, short horizontal strokes, ascenders/descenders.
Non-Arab	Diwani	15th C.AD	واعمل الاخرتك كانك تموت غدا	Cursive, vertical and slanted letter connections, ending swashes extended below next letters, no vocalisation marks.
	Diwani Al-Jali	15th C.AD	فضل علم العلم الامير	Similar to Diwani, geometric shapes, gaps filled with delicate ornaments.
	Taaliq	15th C.AD	وى وحه چشم هاى در كل شدار	Extremely fluid cursive, letters hanging above others, slanted to right.
	Nastaaliq	15th C.AD	صل فرلاء عبدى غلام شريه بش	Elaborately fluid lines, elegant, wide horizontal swashes.
	Shikasteh	15th C.AD	دلكه لعم ابوى مح طهم	Exaggerated woven ligatures, fluid, continuous bold strokes, slanted ascenders, no vocalizations.
	Behari	14th C.AD	خصغن بالقول فيطمع	Heavy extended horizontal strokes, thin delicate vertical strokes, flat-curved swashes.
	Sini	14th C.AD	Non	Similar to Behari, more curved, rounded, bolder strokes, taller ascenders.

9

divisions: display, text, and script or decorative typefaces. Display typefaces are basically designed for big titles and posters; text typefaces are used for many purposes, however it should be hinted for on screen use; script or decorative typefaces have exclusive style usually and they are used on special occasions. Second, Arabic type styles can also be defined by the general characteristics like serif and sans-serif in Latin. In Arabic, geometric (Kufi) style and cursive style are two traditional divisions where the first one follows geometric letter structure with a flat baseline and the other is based on fluid handwritten calligraphy. Finally, the most well-known font styles according to history are: Kufi, Thuluth, Diwani, Naskh, Persian, Ruqaa, and Maghrebi [11]. Kufi style was named after the city Kufa in Iraq; Thuluth style, which means "1/3" in Arabic, was named because of its Alif letter which is measured as one third of Alif letter of an old font called Tumar; Diwani style was used in the political documents named Diwan" in Arabic in the Ottoman Empire; Naskh style refers to copy action in Arabic when scribes copied Arabic text; Persian style had been developed by Persians due to the similarity of most letters and writing ways; Ruqaa style named as the name of a piece of leather Ruqaa that was used to write on; Maghrebi style was developed in Morocco Maghreb in Arabic and it is an extension of Kufi script. Regarding the previous classification, we still face a lack of standards on defining Arabic fonts which would need more research to clarify each classification.

1.3 Font Encoding System

Encoding system is the approach in which computers read and display text or files in an understandable way that humans can deal with. That is, for each single character or symbol in a language, a unique code is set in order to transmit numbers and text electronically. To explain, each character X is represented in a collection of binary numbers, and to get the appropriate display letter, an encoding system is applied giving the final result Y, see Figure 1-4.

A standard code has been invented to solve the problem of having many languages with a variety of glyphs and symbols. Unicode is one of the first encoding character
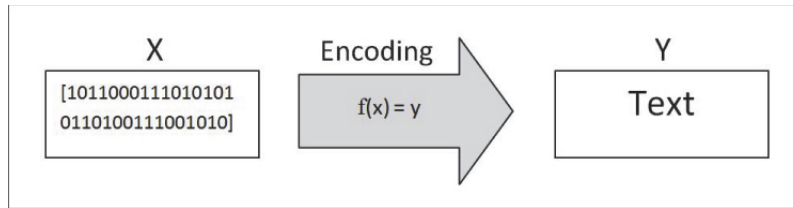
Figure 1-4: The process of encoding

that provide the ability to identify characters of most languages around the world including Arabic. For example, letter "mim" in Arabic has the unicode U+0645. There are several character registered maps for Unicode, such as UTF-8 and UTF-32 in which they differ in how they use the number of bytes to store the code [12].

1.3.1 Font Format

Rendering font on digital screens has some standard format to represent texts and data. There are two basic font formats: bitmap fonts and outline fonts [8]. Bitmap font format (Figure 1-5a) is based on a matrix of pixels where pixels are turned on for each specific face and size. It is easy to create and fast to represent; however they are not scalable and need for each size a set of glyphs. On the other hand, outline font format (Figure 1-5b) is based on a set of lines and curves using mathematical functions to make the font scalable. Adobe, Microsoft, and Apple have developed different font formats under this category. Adobe provided PostScript font format known as Type 1. It is used mostly for high quality printing purposes due to its smoothness. Next, Apple developed TrueType font format which is clear, resizable, and readable. Then, Microsoft and Adobe produced the OpenType font format which combines the advantages of TrueType and Type 1 font formats and adds more new features. Finally, Donald Knuth created METAFONT format which defines all the shape glyphs of fonts by geometric equations. The difference between METAFONT and the previous font formats is the usage of equations which describe the outline and the filled part as a pen of finite width.
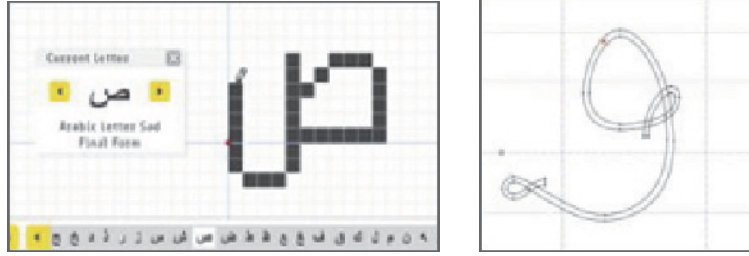
(a) Bitmap format of letter
"Sad" [13]

(b) Outline format for letter "Waw" [14]

Figure 1-5: Font format

1.4 Legibility and Readability

Reading legibility and readability are two important concepts in our study. Tracyas [15] defined legibility as the ability to read and recognize letters in a clear and an easy way. Comparing to readability, he stated that it describes how comfortable visual processing is while reading, and how comprehensible the long text is? In addition, Lieberman [16] mentioned in his book that legibility is basically the ease of distinguishing a letter from another. So, legibility of typefaces depends on their design characteristics. For example, a bigger x-height in Latin is considered to be more legible. Moreover, Lieberman added that readability is the level of ease in moving eyes with absorbing the meaning through lines. More details about legibility and readability will be mentioned in section 2.1

1.5 Motivation and Objectives

Personal Digital Assistants (PDAs) become more popular and more affordable. Reading on these devices, which is known as e-reading, has increased significantly in the last few years. However, studies have proved that reading from screen could lead to slower speed and less comprehension [17] even though electronic reading behaviour is similar to reading from printed material [18]. Therefore, while displays keep shrinking in the size, it is needed to re-evaluate typefaces used in these devices as they are a substantial component in the reading field. In particular, to ensure quality of reading

on small screen devices, i.e. tablets and phones, typefaces used in those devices are in need to be robust.

In this thesis, we have focused on the effect of Arabic typefaces on e-reading from the aspect of legibility and readability due to the insufficiency of studies on this area. In fact, because of differences among characteristics of languages, some problems are raised for specific scripts. So, it is difficult to apply the exact methods used to test legibility and readability for Latin on Arabic. Thus, adjustments for testing legibility and readability on Arabic typefaces are considered in our study.

In recent years, native Arab people, especially the young generation, tend to read e-books instead of traditional hard copy books using PDAs. That is, education system in some of Arabic countries is planned to be developed in the coming years in which all school books would be replaced by electronic ones. Thus, students will use portable digital devices to read and study. In fact, some schools in Saudi Arabia have started applying this step to examine the effects of using technology in the educational process. For example, King Faisal School [19] has lunched the trial stage of iPad Application Project for grade five and six students as a step of improving the educational system. Consequently, it is important to provide studies on one of the most important elements (font) to ensure better quality for Arabic e-reading.

Despite the fact that some Arabic publishing organizations have started to build their own digital libraries, they still need to get some recommendations about Arabic fonts. Sibawayh [20] is one of the most recent and successful projects of Arabic digital libraries by Quad Dimensions Tech. It has started publishing electronic books in June 2012. In less than a year, it has over a hundred Arabic books in its electronic library, and it provides an application suitable for iPhone and iPad for readers to buy and download books. That makes reading much easier than before especially with the existing features like highlighting and adding comments.

This research should answer the following question:

What is the best Arabic font(s) that will increase reading legibility and readability on PDAs?

To answer the question, objectives of this thesis are listed as the following: a) Prove

that fonts may affect the reading process on PDAs; b) Assess the appropriateness of different typefaces for different types of PDAs using proposed methods suitable for Arabic; and c) Provide recommendations on typefaces most suitable for PDAs.

1.6 Research Contributions and Thesis Outline

This thesis has implemented many phases in order to reach the objectives listed before in section 1.5. Figure 1-6 illustrates an overview of the plan of implementation. First phase discussed in Chapter 3 identifies Arab community preferences of fonts on PDAs through a survey, and the outcome goes to the following chapters for further experiments. The major contributions of this thesis are accepted to be published in [21], and they are summarized as the following:
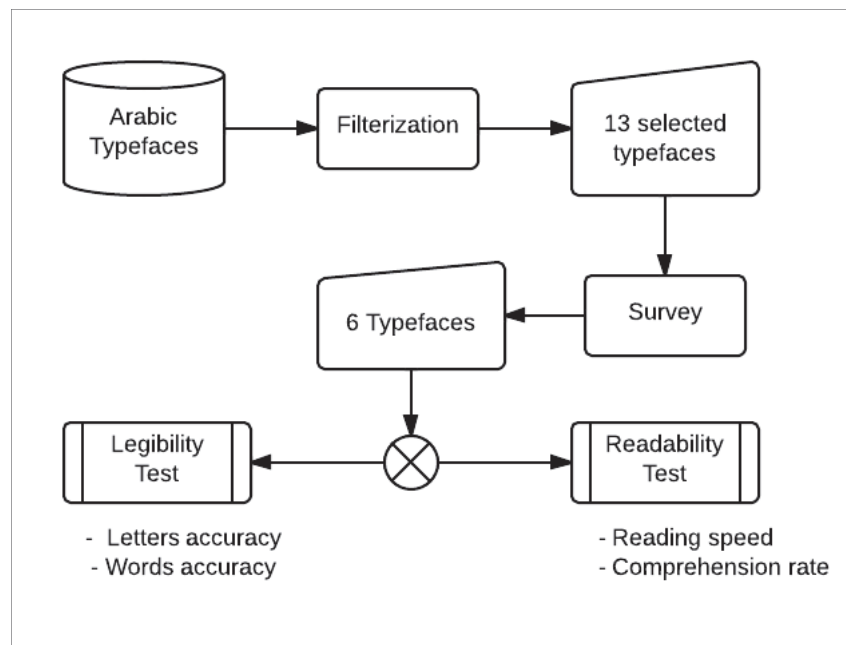
Figure 1-6: Overview of project flowchart

- *literature review:* Chapter 2 presents methods used in testing legibility and readability using the techniques mentioned in published studies. In addition,

14

studies on displays and their impacts on font types and sizes are explored from different angles.

- *Legibility and Readability Experiments:* A novel legibility method (M-Short-Exposure)is proposed and conducted in Chapter 4. Readability experiment on the selected Arabic fonts is demonstrated in Chapter 5. Data collection for all experiments has been done in different geographical areas.

- *Conclusion and Future Work:* The thesis concludes in Chapter 6 considering experimental results, recommendations and future work.

Chapter 2

Literature Review

In this chapter, legibility and readability are reviewed with related work done for Arabic and other languages in Section 2.1. Moreover, studies on different types of displays and their effects on reading are discussed in section 2.2

2.1 Legibility and Readability

High legibility is very important for reading as it affects reading speed and the effort needed to identify letters in the right way. Though, many factors can play important roles on legibility, such as illumination, foreground/background, and reader fatigue. Along the history, many methods have been declared to determine the level of legibility of typefaces. Based on [22] the main legibility test methods are continuous reading, search task, visual accuracy threshold, and reader's preferences. Moreover, readability is also related to reading performance as it tests the quality of text and the ability to recognize it in meaningful groupings. Nevertheless, many aspects can influence readability, such as spacing, margins, use of words, and reader knowledge and skill. To test readability, several methods are used including reading speed, word-search speed, eye-tracking, comprehension, and reader fatigue. However, confusion between the two concepts of legibility and readability always happens due to some overlapping in test methods and relationship between them. In fact, when a text is not legible, it is not readable too. However, when it is with low readability, it is still

possible to be highly legible.

2.1.1   Test Methodology

The main methods used many scientific studies on legibility and readability, and they are summarized in the following:

Search Task: This approach is used to measure legibility by assigning a task to readers to locate specific words or letters in a text. In Bernard, Liao, and Mills study [23], substituted words were designed intentionally to be clearly seen as inappropriate grammatically within the context like replacing the noun "cake" with the adjective "fake". So, legibility can be determined by recording the accuracy of locating these words and by registering the time needed to finish the task. Despite the results of studies applied this method, it is stated in [22] that it tests the scanning ability rather than normal reading. Thus, it is not recommended for experiments testing typeface legibility.

Reader's Preferences: People's opinion is a concern in this method where participants are asked to rank their preferences based on typefaces, sizes, styles...etc. Some studies personalized typefaces according to readers' rate. Shaikh [24] has evaluated 40 Latin typefaces through 15 semantic differential scales (SDS) as pairs of opposite adjectives including legibility. Results reveal that serif and sans serif typefaces are more legible than others. Following the same procedure, Nikfal [25] has investigated 20 Arabic typefaces using readers' opinion on four personalities: legible, comfortable, artistic, and formal). As a result, highly legible fonts: Times New Roman, Simplified Arabic, Microsoft Sans Serif, and Courier New, are recommended to be used in official documents, reports, and forms. Another experiment has been conducted by Alsumait, Al-Osaimi, and AlFedaghi [26] to investigate which Arabic font and size are legible for children of 7-9 years old in order to be used in designing e-learning programs. Five fonts have been examined: Arial Unicode MS, Courier New, Microsoft Sans Serif, Simplified Arabic, and Traditional Arabic in two sizes 12

and 14 pt. Students satisfactions have been recorded to estimate legibility beside reading speed. Therefore, students' preferences show Arial Unicode MS with 14 pt is more attractive.

Visual Accuracy Threshold: In this way, the focus is on identifying letter and word regardless of comprehension. To detect visual accuracy, several methods have been suggested. Rapid exposure is a known method where participants are exposed to the stimulus in a very short time in which the eye is unable to move from one fixation to another. Tachistoscope was one of the earliest tools, known as Flash Recognition Training (FTR), used to measure recalling of visual information [27]. It is used in [28] to rank legibility of a set of characters and numerals. Nowadays, There is no need for using these tools while we have computers. Short-exposure method of a single character was used in Beier and Larson study [29]. Actually, they used Macromedia Flash MX to create and apply the experiments rather than tachistoscope. By exposing each of which letters for 43 milliseconds, each participant had been asked to name it. Thus, accuracy of visual characters can be measured, and hence type legibility. Furthermore, the same approach has been used in [30] to test legibility of selected Chinese fonts. Results show a significant relation between high legibility and font design features like contrast. Moreover, the legibility of two Latin ClearType fonts Cambria and Constantia have been investigated compared to traditional serif font Times New Roman in [31] using short-exposure method. a collection of letters, digits, and symbols have been exposed to the 10 participants for 34 milliseconds with 1.5 seconds of blanking time. Findings were positive for the new fonts Cambria and Constantia. However, the old style digits used in Constantia like 0, 1, and 2 caused confusion with letters o, l, and z. Times New Roman gave the worst accuracy especially on digits, and symbols.

Continuous Reading: This method is used to measure readability of typefaces by testing them in running texts. One technique used to evaluate the reading process is measuring the reading speed and comprehension or accuracy. However, many

factors could be considered in these measurements. One factor is leading and spacing in text which usually interact with each other, so making them either way static or dynamic can affect the usability of typefaces. In [32], margins surrounding the text and leadings, which are spaces between lines, have been tested in four white space manipulations. Then, reading speed and comprehension have been measured for participants read text in screen in order to find out the impact of spacing factor on reading. Using margins gave better results despite the slower speed. On the other hand, leading did not affect the performance of reading but influenced the participant's satisfaction. Another factor is font size and style which are considered in measuring legibility and readability. Ramadan [33] has conducted an experiment on 40 male university students where they have been asked to read 24 passages on a computer screen. Four Arabic font styles have been used: Simplified, Traditional, Kufi, and Naskh in three font szies: 10, 12, and 14 pt. Next, reading speed has been calculated automatically while reading, and comprehension is tested using questions. By using some statistical ways like ANOVA, results show that both effects font style and size are significant. Regarding reading speed, Simplified font performed better among all used styles, and 14 pt font size gave faster reading. Kufi style of different sizes is discouraged to be used in e-reading due to its obvious weak performance in both reading speed and accuracy. In addition, in [23] the effect of font type and size on legibility and reading duration have been studied for online text by older people. Two serif: (Time New Roman and Georgia) and two sans serif: (Arial and Verdana) Latin typefaces of two sizes: 12 and 14 pt have been tested on PC computer monitor with 27 participants of a mean age 70. They were asked to read eight passages of the same length and margins. Reading times have been recorded, and results showed that serif fonts and bigger size (14 pt) provide faster reading. In 2012, similar experiments [34] have proceeded to find the optimum Arabic font type and size for students aged 9-12 years. Two typefaces (Arabic Traditional and Simplified Arabic) have been examined in four sizes (10, 14, 16, and 18) using Arabic continuous texts. Then, reading-aloud technique is used to detect accuracy. Also, reading speed has been recorded for each participant using a timer. So, their findings show that size 10 is not readable while

size 16 and 18 are doing so. Moreover, regarding the fonts, Simplified Arabic beats Arabic Traditional especially in sizes 14 and 18 pt.

Another technique to estimate reading performance and behaviour in running text is eye-tracking. It provides rich data from eye movements related to the process of reading. Basically, human gaze moves continuously over the text while reading. Though for some words, the subjects looked at them more than others by one or two seconds [35]. Also, series of jumps around 3-4 per second (which known as saccades) with fixation (the short stops in between) are happening during reading. According to [36], font characteristics have an impact on fixation duration and fixation count. A study [37] has been done to examine if font size and font type can affect online reading. it applied eye-tracking method on 82 subjects reading stories in English. As a result, fixation durations were significantly longer with smaller size (10 pt) leading to slower reading. Also, serif fonts gives slightly better reading performance than sans serif fonts. In addition, another study [38] has been conducted on Arabic typography (Traditional Arabic and Simplified Fixed Arabic) of different sizes (12, 14, and 16 pt) using eye-tracking measurement. Participants were asked to read 6 electronic passages on a computer screen out load. Then, eye movements and oral reading have been recorded. So, fixation duration, fixation number, and words accuracy have been analysed. Therefore, this finding suggests bigger size (16 or 14 pt) for better reading performance. Also, it has been found that Simplified Fixed Arabic font provided low readability with larger number of fixation due to its width.

All these methods are used for the purpose of measuring legibility and readability. Although methods have been mentioned separately, combination among them can be implemented. Different ways and different factors are a matter of what is under examination.

2.2 Displays

Many new possibilities have been opened in the field of reading because of the advance of reading devices. The new generation of Personal Digital Assistance PDAs have influence on e-reading. Different types of displays can produce an important impact on studies that test typeface legibility and readability. Hence, research on reading on different kinds of displays considering the used typefaces have been published. In 2011, Voorhees [39] has evaluated the congeniality of reading on digital platforms: laptop, iPad, iPod touch, and Kindle3 in comparison with paper of high resolution. Then, 19 entrants had read five short text stories (one per device) in different order. Feedback was collected from participants regarding the devices and features available for reading. Therefore, Kindle was recorded as the most favourite, but laptop and iPod touch were the least ones. Regarding the reading features on these devices, the ability to change typeface and page layout have been rated the most. In the same year, another study [18] compared the process of reading on displays that use e-ink technology (e-readers) with print materials. Five participants of a mean age of 42 read a total of 12 pages from a novel on five e-readers: iRex iLiad, Sony PRS-505, BeBook, ECTACO jet-Book, and Bookeen Cybook Gen 3. Eye-tracking method has been applied to measure the reading process. Thus, it is observed that reading behaviour on e-readers is too much similar to reading on printed paper. Moreover, Ramadan, Mohammed, and El-Hariry [40] have examined the effects of Cathode Ray Tube Displays (CRT) on legibility and readability of three selected typefaces Simplified Arabic, Traditional Arabic, and Monotype Koufi in 10, 13, and 16 pt. By measuring reading speed, comprehension rate, and discomfort subjective rate for participants, 13 pt Simplified Arabic font had the highest level of reading comprehension and the lowest discomfort rate compared to others.

Another dimension that is considered in displays and font studies is the age group. For older adults, Tsai, Ro, Chang, and Lee [41] scrutinized font size and page presentation of e-books reading on mobile phones. In particular, HTC HD2 device was used

to test three different font sizes: 10, 12, and 14 pt in two presentation styles: scrollbar page and flip page coming up with 6 articles in Chinese. Subjects with a mean age of 65 participated. After measuring reading speed and accuracy of recall-type questions plus getting the feedback, it is found that font of size 14 pt performs better. Also, flip page method increases the speed of reading. In addition, differences between two groups young and old people while reading on handheld computers have been studied [42]. In particular, HP iPAQ hx4700 device have been used to display short and long texts in English using Microsoft Sans Serif font on eight sizes varying from 2 to 16 pt. An older group of age 61-78 years have yielded about smaller size (less than 6) and the majority did not complete reading in the small size texts. In contrast, a younger group of age 18-29 years have given better performance starting from size 4 pt. Reading speed and accuracy have been tested, and there were no significant differences for sizes 6-16 pt. Therefore, it is suggested for small screen displays to provide three different font sizes: 8, 10, and 12 pt to ensure the satisfaction of all ageing users .

Chapter 3

Survey of Arab Community Preferences of Fonts on PDAs

Having some facts about e-reading in the Arab communities was a target due to the lack of this information. In this survey, we tried to collect data about two main concerns regarding our research. The first concern is the popularity of using Personal Digital Assistance PDA, such as iPad for reading especially for the new generation in Arab Communities. The second concern is about Arab Preferences regarding the fonts used in those electronic devices. Thus, a survey has been conducted and reported in order to answer our questions for further steps in our research.

In this chapter, selection font process has been explained in section 3.1. Then, methodology of conducting the survey is demonstrated in section 3.2. Next, in section 3.3 survey results are discussed. Finally, the whole survey is concluded in section 3.4.

3.1 Font Selection

Choosing among a huge number of Arabic typefaces is not an easy task. In the market, Arabic typefaces are presented and marketed badly. It is really hard to make a decision based on a short line of text [43]. Arabic Font Specimen Book [9] was

published to get rid of this problem and to help designers/users making the right decisions about the typefaces they need. That is, it has a wide collection of fonts including concise information about them, like designer, style, and technical info. Also, text of different sizes is shown in the book to make the decision much easier.

In our selection, we used the mentioned book as a base for the fonts. Therefore, we came up with a big set of Arabic typefaces exceeding five hundred typefaces. Then, many filters were applied to reduce this number. For each typeface, six filters were used to guide our selection process: type function, style classification, publisher, compatibility with platforms, format, and multi-script support. Furthermore, previous studies were taken into account. Each filter has been explained as the following:

Type Function: To satisfy specific usage of the font, two major categories are considered: Display fonts and Text fonts. Display fonts are designed for titles and large size texts like in advertising. In contrast, Text fonts are designed to be used in a small size, such as books, newspaper and small electronic devices. Text typefaces only were selected in our study as it is related to Personal Digital Assistance PDAs.

Style Classification: The main Arabic style classification‿ as mentioned in Chapter 1‿ are: Naskh, Kufi, Thuluth, Diwani, Ruqaa, and Persian. In our study, we have chosen Naskh style due to its high legibility.

Publisher: The reputation of well known publishers was considered in order to guarantee the quality of the selected typefaces. For example, Linotype and Hiba Studio are renowned publishers in this field.

Compatibility with Platforms: Cross platforms typeface were targeted in order to ensure the enhanced usage of the selected font faces. To be specific, Mac and Windows operating systems were the main concern in the selection process due to their popularity. Though, Droid, which is based on Lunix, was also countered but with less attention.

Format: Three main font formats as described in Chapter 1 are: Type 1, True

Type, and Open Type. In this study, we were looking for the most developed format (Open Type) in order to get the benefits of having Unicode character. Furthermore, some selected typefaces are True Type (with Open Type flavour) format because some software does not facilitate Open Type format.

Multi-Script Support: Despite focusing on Arabic script in this research, multi-script support is still important as it provides a character set in more than one script. This is because in Arabic e-reading, Latin text especially is commonly used with special terms fitting with the Arabic context. Therefore, having this script combination should increase the readability of the selected typefaces. However, some of the selected fonts support Latin partially. That means, they depend on the system to use suitable Latin font available in the used machine as a substitution.

Furthermore, previous studies have been taken into account while choosing the typefaces. Particularly, Nikfal [25] has studied people preferences among a set of fonts using personality traits including legible and comfortable. Therefore, by re-sorting the results of that study according to our needs we have listed the top six fonts with high legible and comfortable scores. So, we consider them in the selection process. Table 3.1 is showing the fonts sorted by legible scores in descending order.

Table 3.1: Scores of Arabic fonts related to traits from previous study

#	Font Name	Legible	Comfortable
1	Tahoma	4.59	4.20
2	Times New Roman	4.54	4.16
3	Simplified Arabic Fixed	4.44	4.00
4	Microsoft Sans Serif	4.20	3.71
5	Advertising Light	4.10	3.77
6	Diwani Letter	4.05	3.48

Finally, after applying all mentioned filters and making some observational assessment like avoiding decorative typefaces, we ended up with 13 Arabic typefaces shown in Table (3.2) with all related information.

Table 3.2: Fonts used in the survey

#	Font Name	Sample	Designer	Vendor	Format	Style	Purpose	Function	Multi-script	OS
1	Almahanad	نحن حكيم لا سر قاطع	Regenerated by Nadim Shaikli	Arabeyes Kasr Collection	True Type	Naskh	N/A	Text	Yes	Win Mac
2	Badiya Regular	نحن حكيم لا سر قاطع	Nadine Chahine	Linotype	Open Type	Modulated Naskh	magazine	Text	Yes	Win Mac
3	Deco Type Naskh	نحن حكيم لا سر قاطع	Thomas Milo	DecoType	True Type	Naskh	Designed for Mac OS	Text	Partial	Mac
4	Geeza Pro	نحن حكيم لا سر قاطع	Diwaan software for Apple computer Inc	Apple computer Inc	True Type	Naskh	Deisgned for Mac OS	Text	Partial	Mac
5	Hasan Enas	نحن حكيم لا سر قاطع	Hasan Abu Afash	Hiba Studio	True Type	Naskh	Magazines, newspapers, books, on screen text	Text	Yes	Win Mac
6	Hemear Light	نحن حكيم لا سر قاطع	Sultan Maktari	Sultan Fonts	Open Type	Naskh	N/A	Text	Yes	Win Mac
7	Janna Regular	نحن حكيم لا سر قاطع	Nadine Chahine	Linotype	Open Type	Kufi incorporates with Ruqaa & Naskh	Display devices, advertising, branding app	Text	Yes	Win Mac

#	Font Name	Sample	Designer	Vendor	Format	Style	Purpose	Function	Multi-script	OS
8	Myriad Arabic	نص حکیم لا سر قاطع	Robert Slimbach	Adobe Inc	Open Type	Classic Naskh	Print & on screen text	Text	Yes	Win Mac
9	Tahoma	نص حکیم لا سر قاطع	Matthew Carter	Microsoft	Open Type	Naskh	Designed for Microsoft Corp.	Text	Yes	Win Mac
10	Tanseek Modern Pro	نص حکیم لا سر قاطع	A. Boutros, M. Boutros, R. Dawson, D. Farey	Monotype	Open Type	Naskh	On screen text	Text	Yes	Win Mac
11	Times New Roman	نص حکیم لا سر قاطع	Originally by William Burgess	Monotype	Open Type	Naskh	Books, magazines, reports, displays, advertising	Text	Yes	Win Mac
12	Uthman Script Hafs	نص حکیم لا سر قاطع	King Fahad Glorious Quran Printing Complex	Quran Complex Fonts	Open Type	Naskh	Quran printing and displaying	Text	Partial	All
13	Yakout Regular	نص حکیم لا سر قاطع	Developed by Linotype & Machinery	Linotype	Open Type	Naskh	Newspaper	Text	Yes	Win Mac

3.2 Methodology

3.2.1 Participant

Participants were recruited through the Arab association living in Montreal, Canada. The final analysis was based on 53 participants (68% male and 32% female). The majority of participants (96%) speak Arabic as their native language. Their ages ranging from 18 to 50 years in which the majority ranged between 25 and 34 years old. In addition, 90.5% of participants are post secondary students.When the participants have been asked about using PDAs for reading, 73.58% of them reported that they do use PDAs for reading including general and e-book reading.

3.2.2 Materials

The used text has two components shown in Figure 3-1. The upper Component is a part of a poem written by one of the earliest Arab lexicographers and philologists: Al-Khalil Al-Farahidi [1]. He wrote this part with the purpose of having all Arabic alphabetical letters in the same text. Thus, we ensure that all letters have been shown to participants in different positions while doing the survey. The second component, which is located below, is showing all alphabetical letters in isolated shape standing alone beside each other. This is because some letters do not appear in the isolated form in the upper component.

3.2.3 Font Normalization

Although the size was fixed for all 13 fonts in this survey, the height of each font was different. That is, some font like Myriad Arabic has a small height comparing to Badiya. Therefore, we needed to normalize all used fonts to the same height considering the ratio between height and width. First of all, we take screen shots of the text samples shown in Figure 3-1 for the 13 fonts written in TextEdit software

---

[1] https://en.wikipedia.org/wiki/Al-Khalil_ibn_Ahmad_al-Farahidi

صف خلق خود كمثل الشمس إذا بزغت
يحظى الضجيج بها نجلاء معطار

أ ب ت ث ج ح خ د ذ ر ز س ش ص ض
ط ظ ع غ ف ق ك ل م ن ه و ي
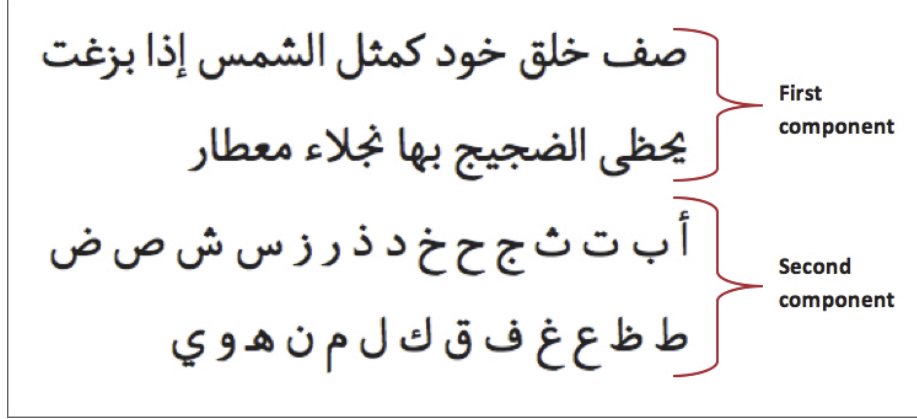
First component

Second component

Figure 3-1: The text used in the survey

using MacBook Pro device OS X 10.8.4 with Intel HD Graphics 4000 512 MB. Then, we removed the white edges of each font image using Matlab 7.5. After that, we got the measurements (width and height) for all the processed images and calculated the average width and the average height. Finally, we resized all font images in which the new height is the average of the 13 fonts height. However, due to the cursive nature of Arabic language, the width was calculated rationally with the new height to ensure the original font dimensions do not change especially that Arabic is a cursive language and the horizontal stretch would make different shapes of text. Thus, we have all font images with a static height but with rational width according to its original size. Figure 3-2 is showing examples of two fonts (Deco Type Naskh and Uthman Script Hafs) before and after normalization.

3.2.4 Apparatus

Two Apple iPad OS 6.1.3 devices with retina display have been used to run the survey. The chosen device was used in order to show the selected fonts on a kind of commonly used PDAs. Furthermore, among several Apple survey applications, iSurvey v 2.10.7 has been chosen to build and run the survey. The reason behind picking iSurvey app was based on specific criteria: Arabic support, Image display, branching and skip logic, multiple devices, and offline survey features.
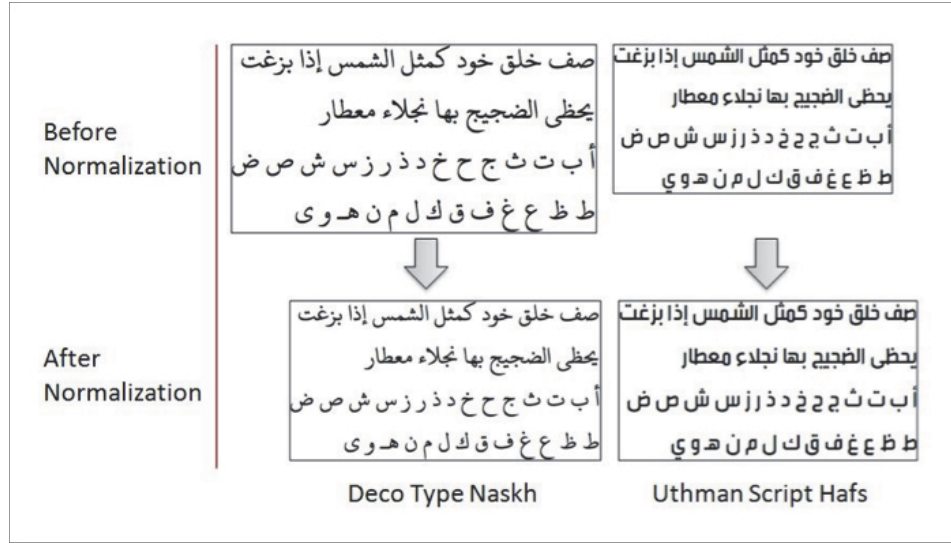
Figure 3-2: Normalization process for two different fonts

3.2.5 Design and Procedure

The survey has been conducted through Arab association in Montreal. Each participant went through two different sections in the survey and completed them on an iPad device. The first section was about personal information and reading habits using Personal Digital Assistance PDAs. The second section introduced the 13 selected fonts to be rated. Each font image was shown once at a time in the middle of the screen and followed by three descriptions: Legible, Easy to read, and Comfortable for eyes. Participants were asked to rate each font image using five scales: Strongly Agree, Agree, Neutral, Disagree, and Strongly Disagree as shown in Figure 3-3 .Responses were taken using a radio button for each description. The approximate time to complete the survey was 5-8 minutes. The Full survey of "Arab Community Preferences of Fonts on PDAs" is available in Appendix A.

3.3 Results and Discussion

The first section regarding personal information and reading habits using PDAs shows that Apple devices, iPad and iPhone in particular, are the most commonly used
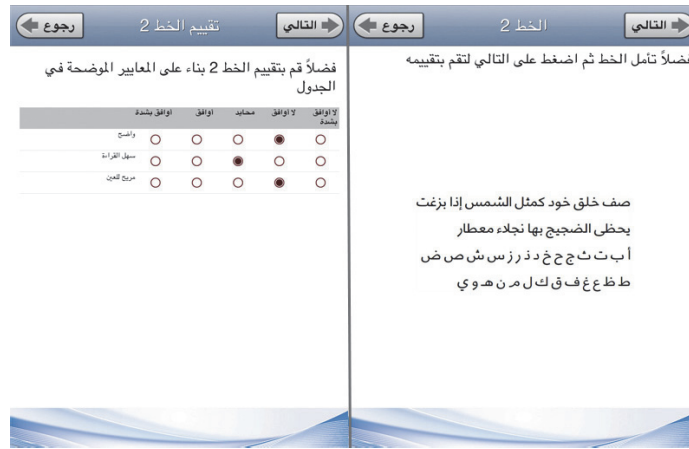
Figure 3-3: Print screen of rating font in the survey

devices in personal Arabic e-reading activities with a total of 73.02%. Android devices (Samsung Galaxy) are coming after with total of 19.05%. Kindle and similar devices which use e-ink give low usability, and the reason behind this is suggested because of the lack of Arabic language support up to the survey period of time. Figure 3-4 illustrates the number of users for each specified gadget. Furthermore, the results show that the average number of hours per day for the majority of participants is 1-3 hours. That makes demanding on finding good Arabic fonts for practical use in PDAs especially with the growth of Arabic e-reading.
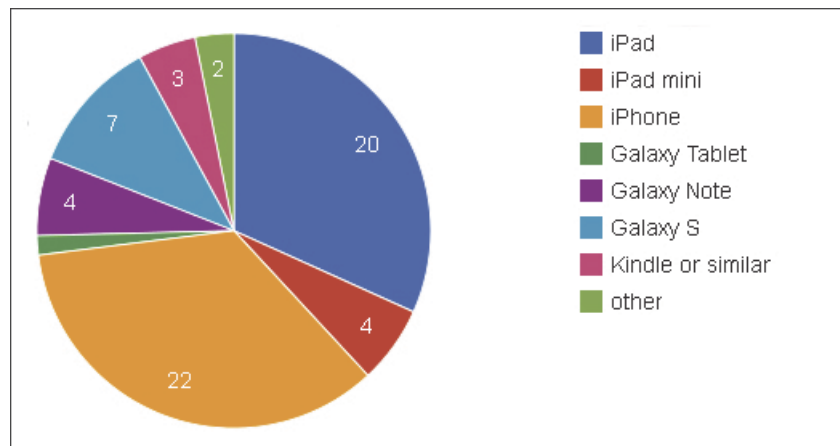
Figure 3-4: Number of users for each specified gadget in the survey

After collecting data from the second section related to the 13 selected fonts,

some statistical calculations have been done for observation purpose. First of all, the average of agreement of both scales Strongly Agree SA and Agree A, and the average of disagreement of Strongly Disagree SD and Disagree D for all three descriptive features have been calculated. Table 3.3 lists these average values in which the agreement Table (a) is sorted increasingly based on the agreement total and the disagreement Table (b) is sorted decreasingly based on the disagreement total. Thus, fonts come first are the most preferable in both tables. Figure 3-5 visualizes font performance in this survey, and disagreement points are much less than agreement points in general. This is because the selected fonts are carefully chosen to fit the concept of legibility and readability in this study. Then, when we take intersection of the top six fonts in both tables, we come up with the same set but with a different order: Almohanad, Geeza Pro, Hasan Enas, Time New Roman, Uthman SH, and Yakout Reg. These fonts get the highest agreement and lowest disagreement scores for the average of all descriptive characteristics.

Table 3.3: Average of agreement and disagreement scales

(a) Agreement table

Font Name	SA	A	Total
Geeza Pro	28.3	17.6	46.0
Uthman Script Hafs	26.6	19.0	45.6
Yakout Reg	23.3	20.6	44.0
Times New Roman	22.6	18.3	41.0
Almohanad	14.6	24.3	39.0
Hasan Enas	12.0	21.6	33.6
Myriad Arabic	6.0	25.6	31.6
Tahoma	12.6	16.3	29,0
Janna Reg	7.0	21.6	28.6
Hemear Light	7.3	19.3	26.6
Badiya Reg	5.0	20.6	25.6
Deco Type Naskh	4.6	18.6	23.3
Tanseek Modern Pro	5.6	17.3	23.0

(b) Disagreement table

Font Name	D	SD	Total
Yakout Reg	1.0	0.0	1.0
Uthman Script Hafs	1.0	1.0	2.0
Geeza Pro	2.3	0.6	3.0
Hasan Enas	3.0	0.3	3.3
Almohanad	2.6	1.3	4.0
Times New Roman	3.3	2.6	6.0
Myriad Arabic	7.3	1.6	9.0
Tahoma	7.0	4.6	11.6
Badiya Reg	9.0	3.0	12.0
Hemear Light	10.6	1.3	12.0
Janna Reg	10.6	1.6	12.3
Tanseek Modern Pro	9.3	6.3	15.6
Deco Type Naskh	16.6	1.0	17.6

Moreover, scores of descriptive features for each font in this survey have been analysed from Table 3.4. Then, maximum agreement total and the minimum disagreement total values have been obtained for each characteristic (legible, easy to read, and comfortable for eyes) among the 13 selected fonts. Thus, Table 3.5 summa-
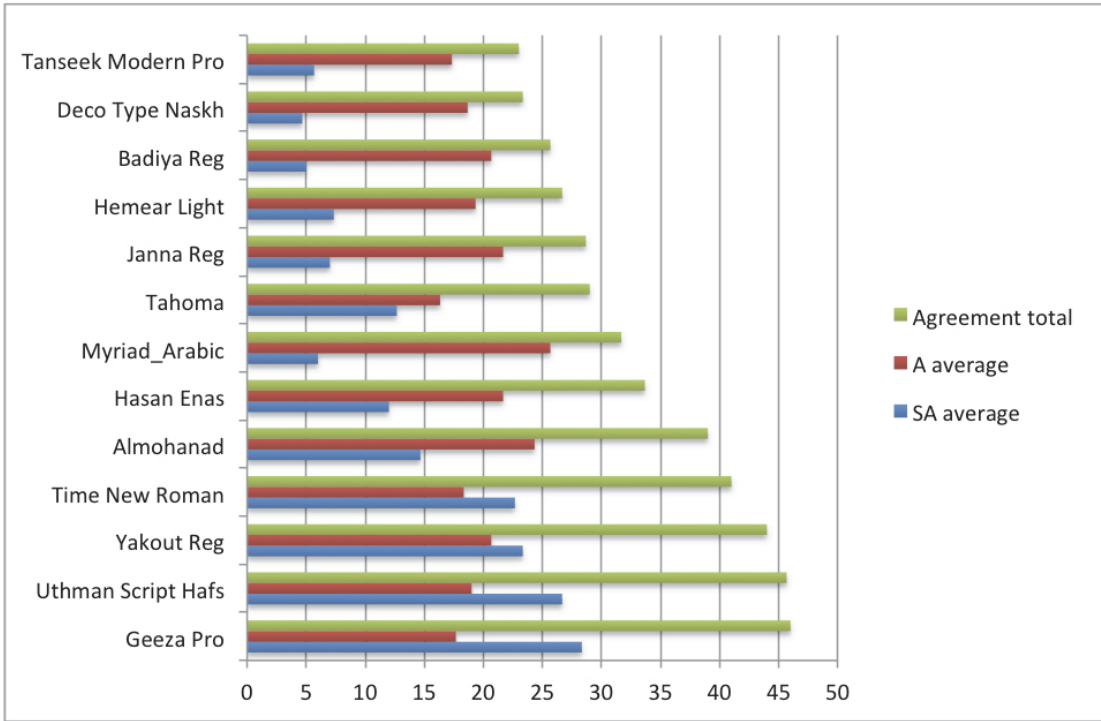
(a) Agreement chart
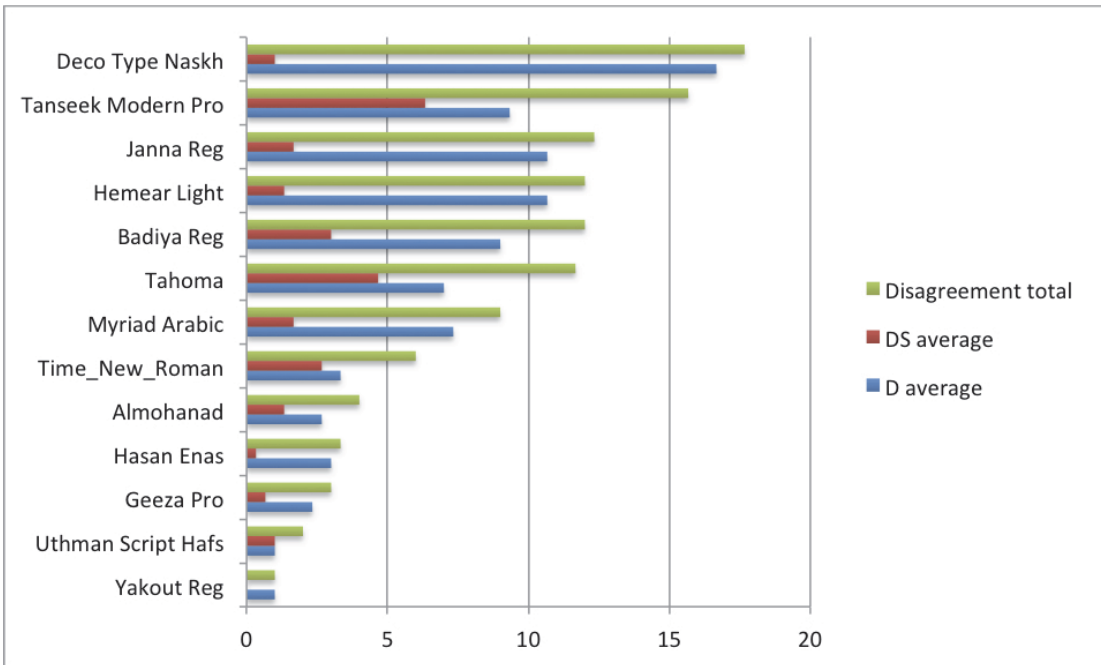
(b) Disagreement chart

Figure 3-5: Fonts performance

rizes these values with the related fonts. According to participant rating, Geeza Pro is listed as the most legible font, and Uthman Script Hafs is the most comfortable font for eyes. Both of them score the same as the easiest to read. In contrast, Tanseek Modern Pro has the lowest legibility rate. Also, Deco Type Naskh was considered as the hardest to read and the least comfortable for eyes. Therefore, we avoided these two fonts in our final decision due to their weak performance.

Table 3.4: Scores of descriptive characteristics for studied fonts

Fonts	Legibile		Readable		Comfortable	
	A	D	A	D	A	D
Almohanad	44	1	40	2	33	9
Badiya Reg	33	6	24	12	20	18
Deco Type Naskh	31	11	22	20	17	22
Geeza Pro	50	0	47	2	41	7
Hasan Enas	36	3	37	2	28	5
Hemear Light	31	6	29	10	20	20
Janna Reg	33	8	32	12	21	17
Myriad_Arabic	38	7	31	8	26	12
Tahoma	38	5	29	10	20	20
Tanseek Modern Pro	28	14	23	15	18	18
Times New Roman	45	4	42	5	36	9
Uthman Script Hafs	46	2	47	2	44	2
Yakout RegTanseek Modern Pro	44	0	45	1	43	2

*A: Agreement total; D: Disagreement total

Table 3.5: Maximum and minimum scores for descriptive characteristics

(a) Agreement table

Descriptive Characteristics	Max	Font Name(s)	Min	Font Name(s)
Legible	50	Geeza Pro	28	Tanseek Modern Pro
Easy to read	47	Geeza Pro,Uthman SH	22	Deco Type Naskh
Comfortable for eyes	44	Uthman SH	17	Deco Type Naskh

(b) Disagreement table

Descriptive Characteristics	Max	Font Name(s)	Min	Font Name(s)
Legible	14	Tanseek Modern Pro	0	Geeza Pro, Yakout Reg
Easy to read	20	Deco Type Naskh	1	Yakout Reg
Comfortable for eyes	22	Deco Type Naskh	2	Uthman SH, Yakout Reg

*Note: Uthman SH = Uthman Script Hafs

Finally, we minimized the number of fonts regarding our results and analyses. The target number of typefaces for the next experiments is set at six in order to be focussed for intensive studies. The five most preferable typefaces from this survey: (Almohanad, Geeza Pro, Hasan Enas, Uthman Script Hafs, and Yakout Reg) were chosen to go to the next stage. After avoiding two typefaces (Deco Type Naskh and Tanseek Modern Pro), six typefaces were left for evaluation to come up with the last nominated typeface for next studies. Actually, there was an inevitable trade-off among these typefaces. Badiya typeface was chosen to be the last candidate for many reasons. Comparing to Times New Roman and Tahoma, Badiya is designed for Arabic scripts originally. That is, Times New Roman and Tahoma typefaces are based on Latin characters, and then Microsoft added Arabic characters to their set with Vista OS and upper systems. Furthermore, although Myriad Arabic is designed for easy readability on screen with classic Naskh characteristics and other suitable features like internal spaces, it works better and clearer at larger sizes[44][45]. In contrast, Badiya is designed carefully with open counters in order to get excellent performance when used in small sizes[46]. Also, its special design excels Janna Reg and Hemear Light from the point of legibility and clarity. In particular, while Badiya is designed to be modulated Naskh, Janna is 'humanist kufi 'which refers to *"handwriting structure and slight modulation to achieve a more informal and friendly version of the otherwise highly structured and geometric Kufi styles"*[47]. It is discouraged to use Kufi style of different sizes in e-reading because of its negative impact on reading speed and accuracy [33]. In addition, Hemear Light has shorter ascender to descender ratio comparing to Badiya, and according to[4] it reduces legibility.

At the end, decision has been finalized with six typefaces to be involved in legibility and readability experiments: Almohanad, Badiya Reg, Geeza Pro, Hasan Enas, Uthman Script Hafs, and Yakout Reg.

3.4   Conclusion

To sum up, this survey has been built and carried out to reveal some facts about Arabic e-reading habits on PDAs in the Arab society, and to evaluate some selected fonts for more studies. As a result, a high percentage near to three-quarters of participants use PDAs in reading has recorded. This creates a need for examining legibility and readability of fonts used or designed to be used in PDAs. Font selection process has taken place at the beginning, and it results in 13 carefully selected fonts based on specific filters. Then, Evaluation process has been done by participants through some descriptive characteristics. From font rates, we come up with six typefaces in order to conduct more experiments on them regarding their legibility and readability.

Chapter 4

Legibility Experiments

In this chapter, a novel legibility method has been proposed to conduct experiments for Arabic fonts. At the beginning, pilot study in section 4.2 will be discussed. Following that are experiments 1 and 2 in sections 4.3 and 4.4 respectively. Then, an integrated discussion of legibility experiments has been analysed in section 4.5 Finally, a conclusion for legibility conducted tests is stated in section 4.6.

4.1 Overview

Before the actual investigation, a pilot study has been done (section 4.2) to assist the research idea regarding visual accuracy threshold method mentioned in a previous chapter, in section 2.1.1. In particular, short-exposure method of a single character is used to test the font's legibility for many languages including Latin and Chinese. Although it has not been tested on Arabic yet, we suggest that it might not work with the same proficiency on Arabic for many reasons. First of all, Arabic language has different features which influence the way of recognizing letters. Usually, Arabic isolated letters are easy to recognize because of their clear structure. They could be simply identified if they are shown in a single presentation. For example, although the letters in Figure 4-1 have the same structure, the number and position of diacritic dots would distinguish a letter and make it recognizable from others. In addition, unlike Latin language, letters should be connected in order to create words and hence sen-

tences. To explain, one Arabic letter can have several forms depending on its position as it is described in Chapter 1 section 1.2. It has been claimed that when an Arabic word contains two or more connected letters which have dots, it becomes difficult to differentiate among them especially in smaller sizes[34]. Thus, recognizing letters within words is more difficult than recognizing them while isolated. So, applying the same method or technique with Arabic typefaces to discover their legibility might give inaccurate result. Therefore, we applied the pilot study using short-exposure method of a single character on a small number of subjects to emphasize thoughts we suggested for Arabic.

Figure 4-1: Different letters of the same shape but different number and position of diacritic dots, from left to right letter "Tha", "Ta", "Ba"

Typefaces involved in this chapter's experiments are the outcome from the previous survey. The six fonts are listed in Table 4.1. The name Uthman SH will be used for font Uthman Script Hafs as an abbreviation.

Table 4.1: Typefaces chosen for legibility and readability studies

#	Font Name	Sample
1	Almohanad	نص حكيم له سر قاطع
2	Badiya Reg	نص حكيم له سر قاطع
3	Geeza Pro	نص حكيم له سر قاطع
4	Hasan Enas	نص حكيم له سر قاطع
5	Uthman SH	نص حكيم له سر قاطع
6	Yakout Reg	نص حكيم له سر قاطع

4.2 Pilot Study

Participants

A number of 12 subjects (6 male and 6 female) participated in this study. They were all students from Concordia University with Arabic mother tongue, and their age ranged between 18 and 35.

Material and Apparatus

For each letter in each font, an image of 1.3 X 1.3 inch has been created in size 18 pt where the letter stands in a fixed virtual baseline in the middle. Therefore, we came up with 28 letter images for each font, and a total of 168 letter images for the whole set of fonts. MacBook Pro device OS X 10.8.4 with Intel HD Graphics 4000 512 MB had been used to apply the test. A small tool had been coded in order to implement the test on Google Chrome browser.

Design and Procedure

Test material has been located in the area of fixation point where participants have been asked to focus on. The distance between the subjects and screen has been set to 50 cm approximately. At the beginning, a trial set has been generated for entrants to get used to the test, and they got as much as they need from this set. Then, the instruction was to focus on the screen, press next button to trigger an exposure of a single character, and name it aloud. Exposing time was fixed for each letter at 50 milliseconds which is half of the time suggested for human eye to not only receive photon, but to pass a signal to the brain for conscious response[48]. Each participant got six exposures in which each one represents one font with a random chosen letter and in a random order. A mask of black dots was exposed after each letter in order to remove the afterimage appearance in one's vision after the original image ceased to control the timeframe on the retina[29]. The size of black dots was enlarged to avoid confusion with Arabic letter diacritic dots. Figure 4-2 shows an example of a test character and the after image.

Results and Discussion

Short-exposure method of a single character was applied to Arabic fonts in the present
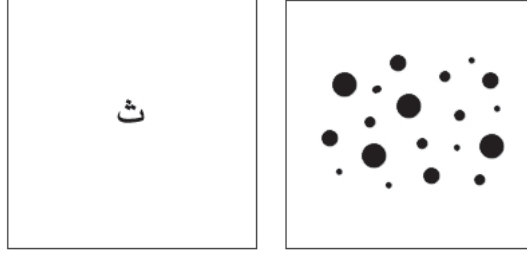
Figure 4-2: The test character (left) and after image (right) sample

pilot study did not detect many errors of identifications. As expected, accuracy of all the 72 exposures gave 97.2% correct results with a total of two errors only. That supports the need for a modified method to suite Arabic font features.

4.3 Experiment 1: Letter Legibility

This experiment was designed to assess the needs of modification to short-exposure method for Arabic typefaces to test their legibility on PDAs. Isolated letters are tested using the proposed method M-Short-Exposure, in which M refers to modified. A Full description of the experiment is available in Appendix B.

4.3.1 Participants

A total number of 154 participants engaged in the whole legibility and readability experiments. However, after cleaning the data collected from their participation, the number was reduced to 138 (53 male and 85 female). All entrants were students, and they speak Arabic as their native language. The majority 68.8% of participants aged 18-25 years; then the group of age 26-35 with 27.5%. The samples were collected from three different geographical areas and universities: Effat University (28.3%) in Jeddah Saudi Arabia, Umm Al-Qura University (33.3%) in Makkah Saudi Arabia, and Concordia University (38.4%) in Montreal Canada. In Effat University, participants had been rewarded by credits for extra curriculum activities; but in the other universities, entrants were volunteers and they got some treats after. In addition,

most participated students were under the major of Engineering and Computer Science with 70.3%. Other majors were Business (9.4%), Applied Science (7.2%), Social and Human Science (7.2%), Religious Science (3.6%), and Education (2.1%). Furthermore, undergrad participants were the majority with 72.5%, grads with 23.9%, and diploma students with 3.6%.

4.3.2   Materials

For each font, a 3 X 3 matrix has been prepared using Adobe Photoshop CS6 for Mac Version 13.0 with nine Arabic isolated letters in which each letter takes a place in a single cell. The size of matrix image was fixed to 4.5 X 4.5 inch. Letters have been normalized in size to avoid the influence of font size on its legibility. Six common used Arabic nouns of three letters, which is the basic word structure, and with positive meanings have been assigned to each matrix. One and only one word can be generated from each matrix in some specific directions. The six remaining cells in each matrix were filled with random letters which do not contradict with one-word only rule. Figure 4-3 shows an example of the matrix used in this experiment. Numbers and symbols are excluded in this study.

ن	س	ح
أ	ش	ف
ذ	ج	ض

Figure 4-3: Matrix sample for letter legibility experiment

Directions for words assigned in each matrix are limited to right-left, top-down, and diagonals from right to left only. All other directions are discarded from this study due the nature of Arabic language. Figure 4-4 illustrates the allowed and eliminated directions.

41
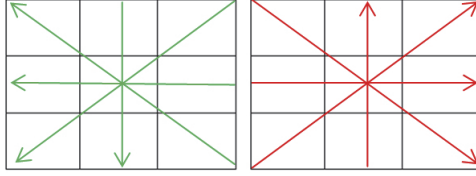
Figure 4-4: Allowed directions (left) and eliminated directions (right)

4.3.3 Apparatus

Two Apple iPads and one iPad mini OS 6.1.3 devices with retina display had been used to conduct the experiment. Each device had been set to full bright display however, subjects were able to adjust the brightness setting as they prefer. Also, landscape mode and auto correction and completion had been turned off. Noticeably, all subjects know how to deal with PDA devices.

Statistical analyses were performed using the IBM SPSS software for mac. Independent samples have been employed due to the size differences between devices.

In this research, an application we named it i3arabi had been designed and coded using Xcode and Objective-C programming language to implement the experiments. The chosen name for application refers to the meaning "I am Arabic", and the "i" refers to Apple devices we had tested. A simple logo shown in Figure 4-5 had been designed for the test to merge the word Arabic as it is written in Arabic with the letter "i" to indicate the same concept. This logo had been used in all published posters in the universities hosting us to conduct the experiments. In all hosted universities, a room of common conditions had been occupied: i.e. quite room, well-lit, air-conditioned, and has a round table with comfy chairs.

Figure 4-5: Logo of i3arabi Test

4.3.4 Task Design and Procedure

Three subjects at a time were taking the test using the three available PDAs. At the beginning, instructions had been given to participants for the whole test including legibility and readability parts. They went through explanatory example and trial example to familiarize themselves to the idea before starting the real test. Then, the six matrix samples were shown respectively. Each matrix image has been located in the fixation point on which subjects had been asked to focus. Distance between entrants and devices was flexible according to their personal preferences. Though, they had been asked to hold the device from a comfortable position, and to use their eye glasses or lenses if they do so. Once the start button is pressed, a matrix is exposed for one second (1000 millisecond) which is the time we used in pilot study to expose a single character multiplied by nine characters and added to 550 millisecond for direction complexity. Next, a mask of black dots is exposed too for the same period of time to remove afterimage effect on retina. After that, multiple choices were given including three different words of the same number of letters to choose from. Though, participants had been discouraged to make an arbitrary answer, and choose "I can not recognize the word" if they do not. Each subject got six exposures in the same order in which each one represents a font involved in this study.

4.3.5 Results and Discussion

In the M-Short-Exposure method of Arabic isolated letters, 80 results have been recorded for iPad devices and 58 results for iPad mini for each font. So, we employed independent samples and got the Z-score-table which is shown in Table 4.2, and they presented no differences between iPad and iPad mini at $p > 0.01$. Therefore, if the subject correctly identified the word from the presented letters at any device, the trial was counted as correct. For more demonstration, the mean values for all fonts in the two devices has shown in Figure 4-6. It is clear that Geeza Pro and Hasan Enas fonts were the most legible fonts respectively in both devices. In contrast, Badiya Reg was the least legible font on iPad, and Uthman SH font on iPad mini. Moreover,

Almohanad and Badiya Reg fonts showed better performance on the smaller device iPad mini, and this is suggested due to their larger design on smaller preview.

Table 4.2: Statistical data of legibility (letter) experiment in the two devices

	Statistic	Almohanad	Badiya Reg	Geeza Pro	Hasan Enas	Uthman SH	Yakout Reg
iPad	$Variance$	0.249	0.237	0.233	0.239	0.243	0.252
	$Mean$	0.41	0.34	0.65	0.63	0.43	0.51
	N	80	80	80	80	80	80
iPad mini	$Variance$	0.254	0.249	0.239	0.247	0.239	0.253
	$Mean$	0.5	0.43	0.62	0.59	0.38	0.47
	N	58	58	58	58	58	58
	Z	0.586	0.636	-0.203	-0.264	-0.386	-0.314
	Two-sided Z at 99%	2.576	2.576	2.576	2.576	2.576	2.576
	Conclustion	H_0	H_0	H_0	H_0	H_0	H_0

	Almohanad	Badiya Reg	Geeza Pro	Hasan Enas	Uthman SH	Yakout Reg
iPad	41	34	65	63	43	51
iPad mini	50	43	62	59	38	47
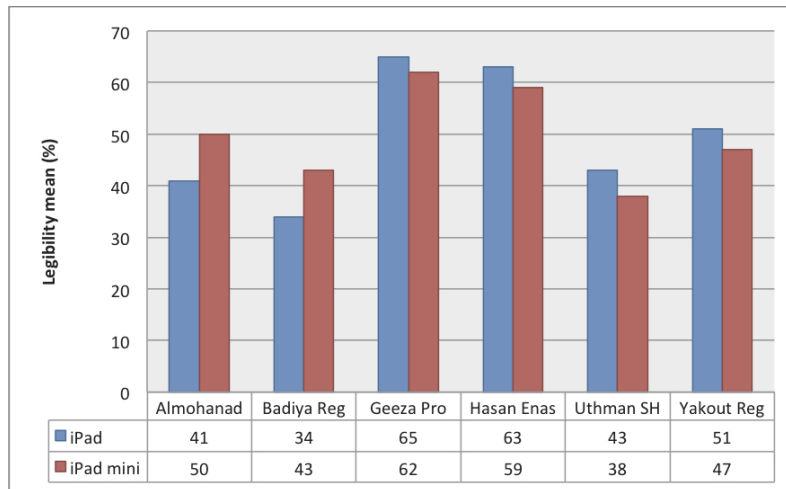
Figure 4-6: The mean values chart of legibility (letters) test on iPad and iPad mini of the tested fonts

4.4 Experiment 2: Word Legibility

This experiment is an extension to the previous experiment to promote M-Short-Exposure method considering connected Arabic letters. Legibility is also measured for each of the six chosen Arabic fonts at different complexity levels. Full experiment is available in Appendix B.

4.4.1 Participants

The same 138 participants of the previous experiment (section 4.3.1) were a part of this experiment.

4.4.2 Materials

Three text materials have been prepared for this experiment. A collection of 18 common used Arabic words (nouns) of different complexity have been chosen. The complexity is measured by the number of letters in the word. Least complex word (A) consists of three letters; medium complex word (B) with four letters; and most complex word (C) with five or six letters. Words have been scattered among the three groups with the same balance of complexity. Then, fonts have been assigned in which each font appears once only within a group, but three times at three different complexity levels within all groups, i.e. in a group, six words were written in six fonts with different complexity. Table 4.3 shows words assigned for each font with their complexity level in each group.

The final text materials have been prepared using Adobe Photoshop CS6 for mac. For each group, words have been scattered randomly in a bounded area of size 3 X 1.7 inch. Figure 4-7 shows a sample of the text material for the first group.

4.4.3 Apparatus

The same pieces of equipment of the previous experiment (section 4.3.3) were used in this experiment. For the statistical analyses, IBM SPSS software was used to apply

Table 4.3: Words assigned for fonts with their complexity level

Fonts	Group1		Group2		Group3	
	Word	CL	Word	CL	Word	CL
Almohanad	بيت	A	ضيوف	B	مشروع	C
Badiya Reg	ورق	A	كتاب	B	مستشفى	C
Geeza Pro	خضار	B	رمضان	C	يوم	A
Hasan Enas	مصحف	B	اختبار	C	عيد	A
Uthman SH	فستان	C	موز	A	مطبخ	B
Yakout Reg	كهرباء	C	مال	A	زواج	B

*CL: Complexity Level
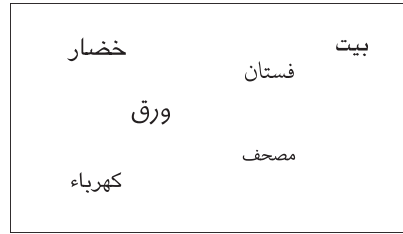
Figure 4-7: A sample text material for word legibility experiment

multiple univariate ANOVA in order to examine dependent factors.

4.4.4 Task Design and Procedure

This experiment has followed the previous one in order, so the same general instructions were given at once. Subjects had a trial sample to absorb the idea, then three samples were displayed sequentially in the fixation zone they were asked to focus on. Once the sample is triggered, it lasts for one second (1000 millisecond) which is the same period used in the previous experiment. As done before, a mask of black dots is displayed after for the same time to control the afterimage impact. Next, participants were asked to fill six text boxes using virtual touch keyboard with words they remember. It has been defined by Murdock [49] that if a participant can generate all possible alternatives without a cue using information stored in the brain, it is called recognition. That is, language knowledge here is the information and remembering seen words is the recognition process. Although abilities of short-term memory in subjects may differ, it has been found that the average number of items

people may remember after short appearance is four [50]. By this way, we ensure that the most recognizable font among six words will catch the subject's attention first. So, there is no problem at all if participants do not remember all the words. Although spelling mistakes could lead to incorrect results, the selected words had been chosen to be easy to spell and commonly used. Therefore, typos possibility was expected to be low, and it did.

4.4.5   Results and Discussion

First of all, the results have been gathered for the six tested fonts based on subjects' correct answers in each group over both PDAs. Then, the mean value of all groups for each font was calculated. Figure 4-8 illustrates the fonts' performance of all groups on both devices. In fact, statistical conclusion showed no significant differences between iPad and iPad mini at the null hypothesis H_0. As it is shown, differences among devices do not differ much in the highest fonts performance among groups. That is, Uthman SH and Geeza Pro were the best in group one and group two sequentially. Furthermore, Almohanad and Badiya Reg had high legibility scores in group three with neglected difference between both devices.

The differences in results among three groups were analysed using ANOVA method to see the impact of complexity levels on the results. Thus, significant difference within each font has been caught of the F critical at 99%. That means, complexity level had its impact on fonts legibility. Therefore, we took the mean of all three groups for both devices as shown in Figure 4-9 to deduce the most legible font in this study. Hence, Uthman SH was the most legible font regarding connected letters (words) while Yakout Reg font was the least.

4.5   Final Legibility Results and Discussion

In the previous sections: 4.3 and 4.4, legibility of the six chosen fonts has been tested for isolated letters and connected letters (words) separately using M-Short-Exposure method. The results yield the best font in each zone. However, integration

(a) Fonts performance on iPad

	Group1	Group2	Group3	Mean
Almohanad	58	25	63	48.67
Badiya Reg	46	29	59	44.67
Geeza Pro	24	57	33	38.00
Hasan Enas	49	33	20	34.00
Uthman SH	61	53	51	55.00
Yakout Reg	14	35	24	24.33

(b) Fonts performance on iPad mini

	Group1	Group2	Group3	Mean
Almohanad	37	16	38	30.33
Badiya Reg	34	16	39	29.67
Geeza Pro	10	44	18	24.00
Hasan Enas	28	16	12	18.67
Uthman SH	47	31	33	37.00
Yakout Reg	11	22	14	15.67
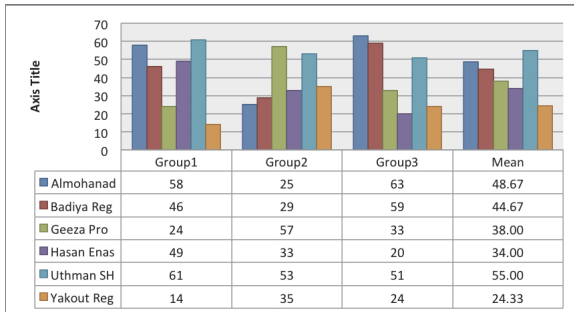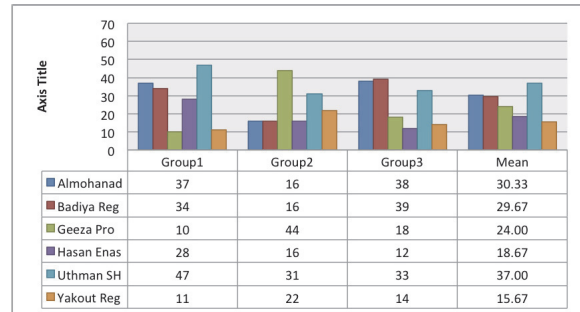
Figure 4-8: Fonts performance for legibility (words) experiment of all groups over both devices

	Group1	Group2	Group3	Mean
Almohanad	95	41	101	79.00
Badiya Reg	80	45	98	74.33
Geeza Pro	34	101	51	62.00
Hasan Enas	77	49	32	52.67
Uthman SH	108	84	84	92.00
Yakout Reg	25	57	38	40.00
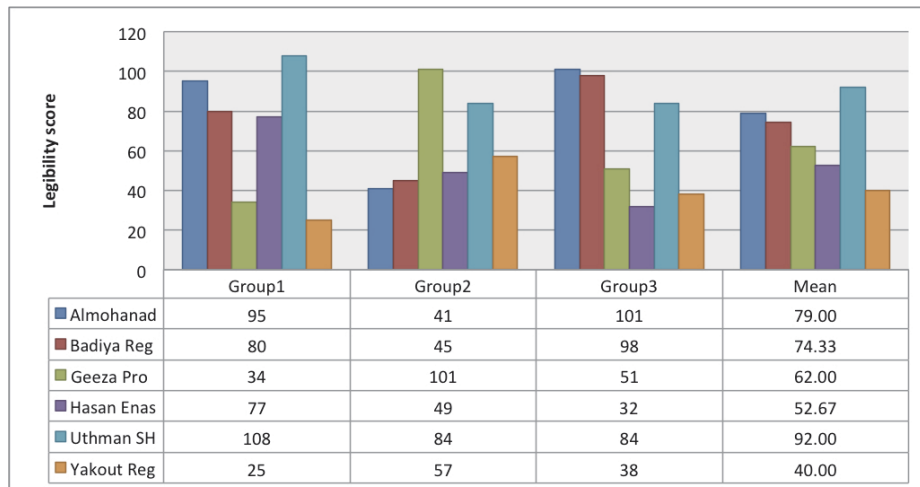
Figure 4-9: Results of legibility (words) experiment

between the two experimental results is needed to get legibility result as a one component. Therefore, letter legibility results and word legibility results are added to each other for each font. In particular, the average of results coming from the three groups of words experiment has been calculated and then added to letter legibility results. Figure 4-10 demonstrates the combined results of the first and second legibility experiments for the examined fonts. Legibility of Geeza Pro, Uthman SH and Almohanad fonts in order was the best. The remaining fonts showed lower legibility with large differences.
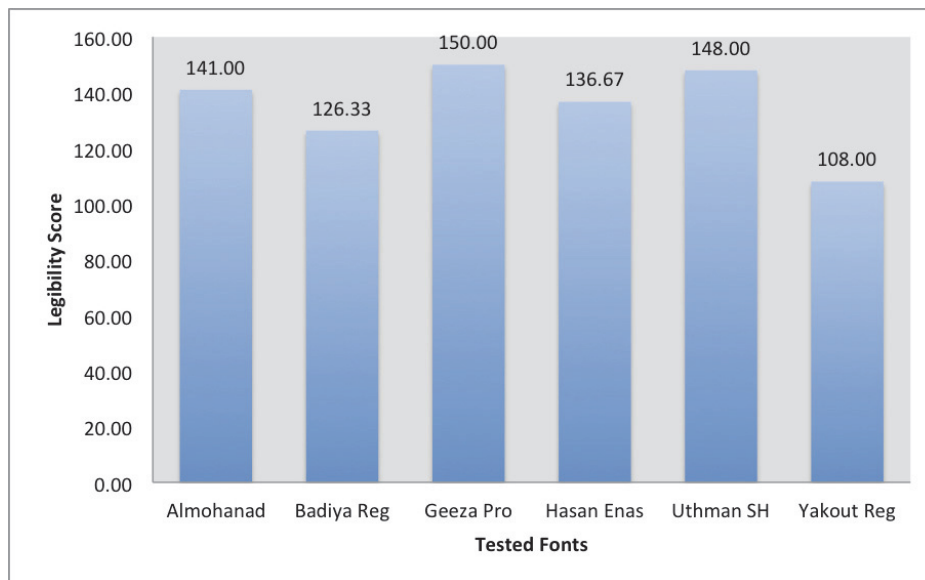
Figure 4-10: The results of legibility expeiments as a one component

4.6 Conclusion

To conclude, two experiments have been conducted on six Arabic fonts to test their legibility over PDAs. A novel method has been proposed to measure legibility over isolated letters and connected letters due to the nature of Arabic script. Legibility test has been done on 138 subjects using iPad and iPad mini devices. Results of the first experiment provided Geeza Pro font as the best font regarding isolated letters.

Then, the results from the second experiment testing font legibility over words showed that Uthman SH font performed better. An integrated score from both experiments revealed that Geeza Pro, Uthman SH and Almohanad fonts are the most legible Arabic fonts on PDAs.

Chapter 5

Readability Experiment

In the previous legibility experiments, Arabic letters and words have been tested for the six nominated fonts. However, it is important to test them in a real reading process using running texts. Thus, readability experiment should take care of that to find out the best fonts suitable for reading on PDAs. A readability experiment for Arabic fonts has been introduced in this chapter. Experimental details are demonstrated in section 5.1. Lastly, a conclusion on readability experiment is summarized in section 5.2.

5.1   Experiment

This experiment tests the readability of the same selected fonts mentioned in section 4.1 which are: Almohanad, Badiya Reg, Geeza Pro, Hasan Enas, Uthman SH, and Yakout Reg. Comprehension questions and reading speed have been measured on purpose. The full experiment available in Appendix C.

5.1.1   Participants

The subjects employed readability experiment were the same who did legibility test mentioned in section 4.3.1. They were counted as 38.4% male and 61.6% female in a total of 138 participants.

5.1.2   Materials

Text passages for readability experiment have been taken from Qiyas test [51]. It is a test offered by National Center for Assessment in Higher Education to assess students' abilities before enrolling undergrad studies in Saudi Arabia. This test has a linguistic section which measures reading, analysing, and comprehension abilities for native and non-native Arabic speakers. Thus, the used materials met our needs and, we slightly modified them to be all at the same level of difficulty with a mean number of 113 words. Six passages of different general topics have randomly assigned to each font we test. The contents do not contain extremely rare words or technical terms. Although we discard margin factor in this study to focus on fonts themselves, all texts are prepared with very small margins in which a text line stretch at the maximum appearance on device display. The size for all used texts was fixed to 18 pt as it is the biggest size from the range suggested by [34] and [38] for better readability for on screen running texts. For each passage of each font, two multiple-choice comprehension questions have been picked with slight modification to ensure the same level of difficulty.

5.1.3   Apparatus

The same pieces of equipment used in legibility experiments mentioned in section 4.3.3 were used in readability experiments. The test has been done on two iPad devices and one iPad mini using "i3arabi" application. The same environment conditions have been applied while conducting the experiment. Also, the same statistical package IBM SPSS for mac has been used to find correlations between factors.

5.1.4   Design and Procedure

The subjects were given the same general instruction mentioned in section 4.3.4 regarding device position and vision lenses. For readability test, they were instructed to read at normal speed as they usual do, and they informed that reading speed will be automatically recorded. They were also instructed to read silently to avoid

inaccurate results due to the fact that the eye is faster than voice while reading [22]. Furthermore, participants have been told to read with concentration because if they passed the passage to the question page, they can not go back. That is because post-reading comprehension test may lead subjects to scan text rather than reading it looking for the answers [42]. No trial sample for this experiment was given due to the clear and simple tasks they were asked to perform.

The application used to conduct the experiment has a "Start Reading" button which is pressed by participants to display a passage and trigger the timer. Upon completing the passage, a "Done" button is pressed and reading speed is recorded for that specific text. Figure 5-1 demonstrates "Start Reading" and "Done" button strategy. Then, comprehension questions page is displayed. Subjects kept reading passages displayed in order and written in different fonts, and answer questions related to them.

Figure 5-1: Sample from readability experiment shows "Start Reading" button at the top and "Done" at the bottom with no text (left) and with text present (right)

5.1.5   Results and Discussion

Two main factors were studied in this readability experiment: reading comprehension and reading speed. For each font, the results of two comprehension questions were used in total to measure the comprehension level. Furthermore, reading speed (RS) was calculated by dividing the total number of words included in the passage by the total time elapsed to finish reading in seconds. To analyse these results, we tried to find the correlations between these two factors. The correlation coefficient value of all fonts showed a very small correlation (actually negligible) between comprehension and reading speed. That is, it is not necessary for a font to perform faster to be comprehended better and via versa.

$$ReadingSpeed(RS) = \frac{TotalWords}{TotalTime}$$

	Almohanad	Badiya Reg	Geeza Pro	Hasan Enas	Uthman SH	Yakout Reg
iPad	1.70	1.08	1.47	1.24	1.39	1.66
iPad mini	1.60	0.88	1.48	1.14	1.38	1.52
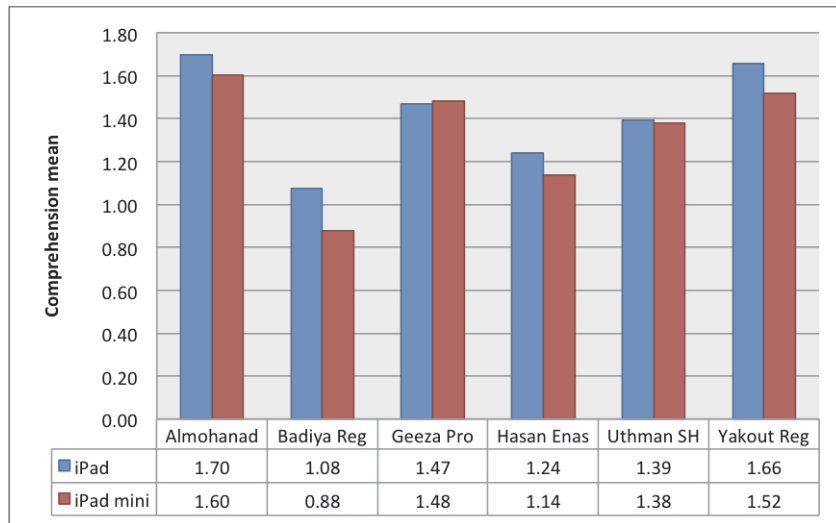
Figure 5-2: Mean of reading comprehension for all tested fonts

With respect to devices, the effect of device display size has been studied statistically. For both factors: reading comprehension and reading speed, we employed two independent samples regarding device type with a different number of observations to all the tested fonts. Table 5.1 lists all calculated terms in order to get a statistical inference. At p>0.01, there is no significant difference for comprehension factor of

all fonts. However, some fonts showed significant differences (H_A) in reading speed. In particular, Almohanad, Geeza Pro, and Yakout Reg fonts showed a positive impact when devices were varied in which the reading speed increased when the size of display becomes smaller. That could suggest awareness of font usage based on the targeted display type. Figure 5-2 and Figure 5-3 illustrate comprehension and reading speed means for all tested fonts. Almohanad and Yakout Reg fonts were the most comprehended one. In contrast, Badiya Reg was the least comprehended font. In addition, the fonts which achieved the highest reading speed were Yakout Reg and Uthman SH. On the other hand, Almohanad font got the slowest reading speed. It was not expected to have low reading speed for Almohanad due to its positive feedback gotten from the subjects. Though, it is possible that this happened because the passage written in Almohanad font was the first one given to the subjects in readability experiment. Thus, they started reading carefully and slowly, but eventually they got used to the reading process which hastened reading speed for the coming passages.

	Almohanad	Badiya Reg	Geeza Pro	Hasan Enas	Uthman SH	Yakout Reg
All PDAs	3.66	3.84	4.25	4.18	4.82	4.83
iPad	3.18	3.44	3.53	3.79	4.25	4.02
iPad mini	4.33	4.38	5.24	4.71	5.59	5.94
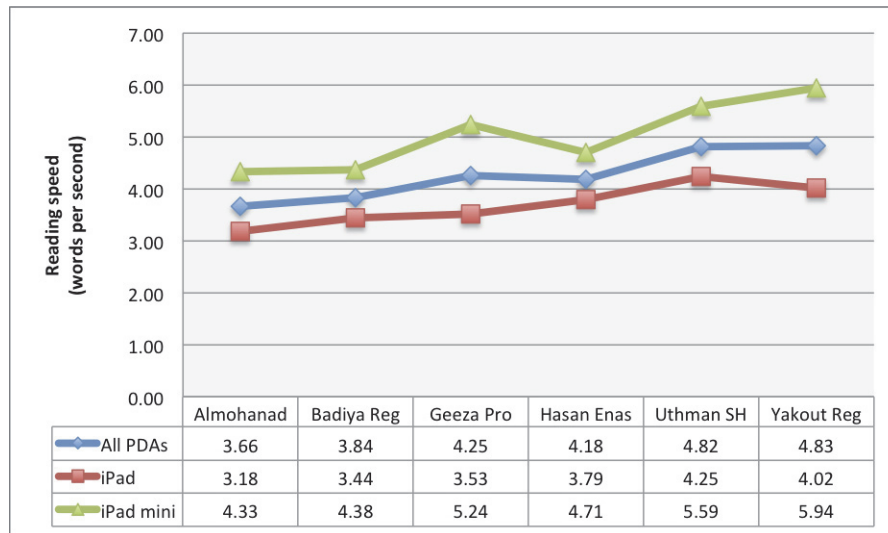
Figure 5-3: Mean of reading speed for all tested fonts

Table 5.1: Statistical calculated terms used for readability experiment

	Statistics	Almohanad		Badiya Reg		Geeza Pro		Hasan Enas		Uthman SH		Yakout Reg	
		C	RS	C	RS	C	RS	C	RS	C	RS	C	RS
ipad	$Mean$	1.70	3.18	1.08	3.44	1.47	3.53	1.24	3.79	1.39	4.25	1.66	4.02
	$Variance$	0.34	5.14	0.53	6.55	0.48	6.21	0.49	9.72	0.52	13.32	0.3	10.45
	N	80	80	80	80	80	80	80	80	80	80	80	80
iPad mini	$Mean$	1.60	4.33	0.88	4.38	1.48	5.24	1.14	4.71	1.38	5.59	1.52	5.94
	$Variance$	0.35	6.63	0.53	6.9	0.36	14.47	0.47	6.31	0.42	12.91	0.36	15.83
	N	58	58	58	58	58	58	58	58	58	58	58	58
	Z	-0.986	2.721	-1.593	2.098	0.091	2.990	-0.838	1.917	-0.085	2.148	-1.403	3.022
	Two-sided Z at 99%	2.576	2.576	2.576	2.576	2.576	2.576	2.576	2.576	2.576	2.576	2.576	2.576
	Conclusion	H_0	H_A	H_0	H_0	H_0	H_A	H_0	H_0	H_0	H_0	H_0	H_A

*C: Comprehension, RS: Reading Speed

5.2 Conclusion

To sum up, readability has been tested for six Arabic fonts on PDAs. A hundred and thirty eight subjects were involved in this readability experiment. Participants were asked to read different passages of different fonts and answer related questions. Two main factors have been measured: comprehension and reading speed, in order to evaluate font readability. Then, some statistical methods have been applied on the results to reveal the correlations between factors and effects of using different sizes of displays. Therefore, it is concluded that Yakout Reg and Uthman SH fonts are the most readable fonts. Some recommendations (will be mentioned in Chapter 6) can be provided from the results for a better usage of the fonts.

Chapter 6

Conclusion

In this chapter, we summarize work done in this research and link it together as a whole in section 6.1. In section 6.2, interpretation of results and recommendations are dicussed. Then, challenges faced in this thesis are mentioned in section 6.3. Finally, future work related to this thesis is listed in section 6.4.

6.1   Summary of Results

In this study, legibility and readability of Arabic typefaces were examined. First of all, thirteen Arabic fonts have been chosen carefully based on some selected criteria. Then, a survey was conducted to evaluate these fonts through three descriptions: legible, easy to read, and comfortable for the eyes. The results reduced the number of fonts to six for further investigation.

In addition, three systematic experiments were conducted to investigate six Arabic digital typefaces on PDAs regarding their legibility and readability. All experiments have been conducted using the same subjects and under the same conditions with "i3arabi Test" application. The results of the first experiment of legibility indicate that Geeza Pro font was the most legible font in terms of isolated letters. In the second experiment of legibility regarding words, Uthman SH font performed the best among the tested fonts. Then, an integrated result of both legibility experiments were calculated, and it yielded Geeza Pro and Uthman SH fonts as the most legible fonts.

Finally, the results of readability experiment showed Yakout Reg and Uthman SH fonts to be the most readable one based on the two factors studied: comprehension and reading speed. However, Almohanad, Geeza Pro and Yakout Reg provided better performance on a smaller display of iPad mini. This is might happened because of the fact that the number of words per line is reduced on smaller display of iPad mini which leads to read words faster in shorter lines. Another justification for having some fonts with better reading speed on a smaller device is that the mentioned fonts have thicker strokes compared to the other studied fonts. Thus, their similar design may feature them on iPad mini with clearer view.

6.2   Interpretation of Results and Recommendations

From survey results the following can be deduced:

- Arabic e-reading becomes more popular among Arab communities using Apple devices at 73% and Samsung devices at 19%.

- The average time of e-reading over mentioned devices was reported to be one to three hours per day which increase the demand of fonts usage investigation. Also, it should motivate Arab writers and publishers to provide more electronic versions of books using recommended fonts for e-reading on PDAs.

- Naskh font style is proven to be the most legible style in which almost all selected fonts of Naskh style get very high legibility scores.

Based on legibility and readability results, we can infer the following:

- There was no significant difference between reading from iPad and iPad mini as long as the font is legible. However, differences may appear regarding the reading speed when the display size is varied.

- It is not important for a font to be legible and readable at the same time. That is, readability does not necessarily indicate legibility. For example, Yakout Reg font showed high readability even though it got low legibility.

- Recommendations could be provided for Uthman SH and Geeza Pro fonts to be used in e-books which require high legibility.

- Uthman SH font is advised when high legibility and readability are demanded.

- For smaller size displays near to iPad mini, it is recommenced to use Almohanad, Geeza Pro, or Yakout Reg due to their better performance on smaller size.

6.3 Challenges

This thesis had gone through some challenges including technical issues and unexpected problems. At the stage of designing experiments, Adobe Photoshop CS6 on Mac was used to prepare the materials, and Xcode software was used to code the application. Both of them at that time did not support Arabic completely. That is, Arabic words were shown in reverse and in disjoint forms. Many tricks have been used to solve such a problem like utilizing external tools. Though, the new update of Photoshop CS6 and Xcode which recently released has Middle Eastern features which include supporting Arabic! Therefore, for future work this challenge would not be available. In addition, during data collection stage which took place in Saudi Arabia, the target was to collect 200 participants approximately (50% male and 50%female). However, due the regulations over there, it was not allowed for me as a female researcher to access the male section of the universities. Therefore, the experiments have been re-conducted again back in Montreal targeting males only. That reduced the number of males compared to female subjects. Nevertheless, the ratio between males and females participants was not big. At the end, these difficulties had motivated our research to find solutions, and they do so!

6.4 Future Work
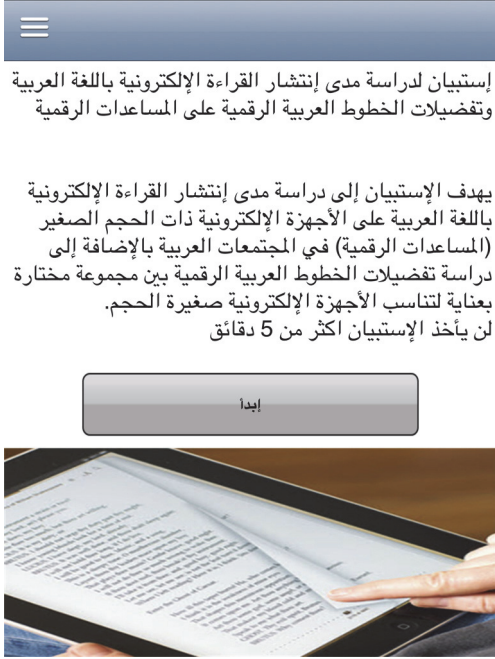
This study focuses on Arabic fonts on personal digital assistants PDAs, and specifically on Apple iPads. Further work could be done considering other types of tablets, such as Samsung tablets. Moreover, smart phone would be a continuous variable in this study to assess which font(s) is better to be used for smaller screens.

In addition, other factors may be considered in future research regarding legibility and readability experiments. In legibility experiment of isolated letters, the allowed directions can be reduced to a single direction (right-to-left). According to participants' feedback, it was difficult to look at all allowed directions in the limited time. So, either applying more time for exposures or reduce the number of possible directions is to be changed. While short time is very important in this method we suggest to reduce directions in future studies. Moreover, it has been found that words complexity played a significant role in the second legibility experiment which consider connected letters (words). Therefore, it would be suggested for work ahead to set fixed complexity level of words in order to keep the focus on font performance.

Finally, some factors like page layout might be considered in further research for readability. That is, margins, flipping or scrolling pages, spacing, and leading could affect the reading process. So, it is good to count them beside fonts presentation.

Appendix A

Full Survey with Results

إستبيان لدراسة مدى إنتشار القراءة الإلكترونية باللغة العربية
وتفضيلات الخطوط العربية الرقمية على المساعدات الرقمية

يهدف الإستبيان إلى دراسة مدى إنتشار القراءة الإلكترونية
باللغة العربية على الأجهزة الإلكترونية ذات الحجم الصغير
(المساعدات الرقمية) في المجتمعات العربية بالإضافة إلى
دراسة تفضيلات الخطوط العربية الرقمية بين مجموعة مختارة
بعناية لتتناسب لتناسب الأجهزة الإلكترونية صغيرة الحجم.
لن يأخذ الإستبيان اكثر من 5 دقائق

إبدا

English script: The target of this survey is to study the popularity of Arabic e-reading on electronic devices of small screens (digital assistants) in Arab communities. In addition, preferences for a collection of Arabic fonts will be investigated. Your Participation in this survey will take 5 min approximately.

يرجى تحديد الجنس؟

English script: Please select your gender

Male

Female
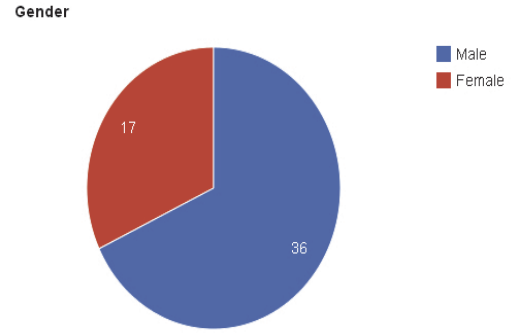
○ ذكر

○ أنثى

Pick 1

Gender

الفئة العمرية

English script: Age group

○ اقل من 18 سنة

○ 18 - 24

○ 25 - 34

○ 50 - 35

○ اكثر من 50

Pick 1

Age group
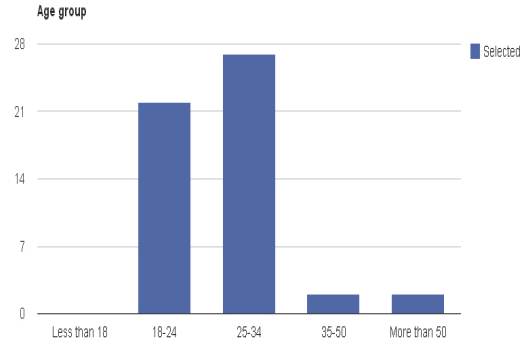
المستوى التعليمي

○ ثانوي أو اقل
○ جامعي أو اعلى

Pick 1

English script: Educational level

Secondary or less

Post secondary

Education Level

- Secondary or less
- Post secondary

5

48
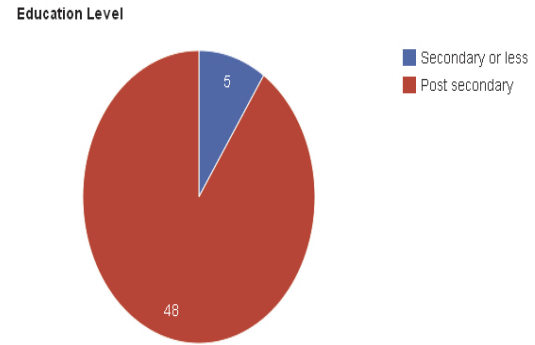
هل العربية هي لغتك الأم؟

◉ نعم
○ لا

Pick 1

English script: Is Arabic your native language?

Yes

No

Is Arabic your Native language?

- Selected
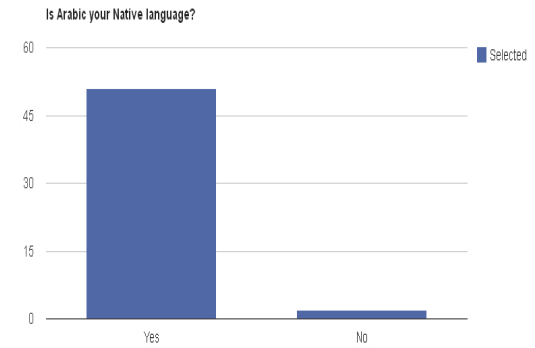
هل تستخدم أجهزة الكترونية كفية في القراءة (مثل الآيباد, الجالكسي تاب ... الخ)؟

○ نعم

○ لا

Pick 1

**branching and skip logic question

English script: Do you use PDAs for reading? i.e. iPad, Galaxy tab...etc

Yes

No

Do you use PDAs for reading?
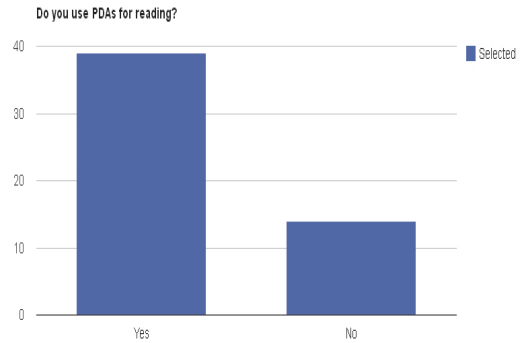
مانوع الأجهزة الإلكترونية التي تستخدمها في القراءة؟

☐ iPad

☐ iPad mini

☐ iPhone

☐ Galaxy Tablet

☐ Galaxy Note

☐ Galaxy S

☐ أو اي جهاز مشابه Kindle

Pick at least 1

**Yes branch

What kind of PDAs do you use in reading?

Type of PDA used
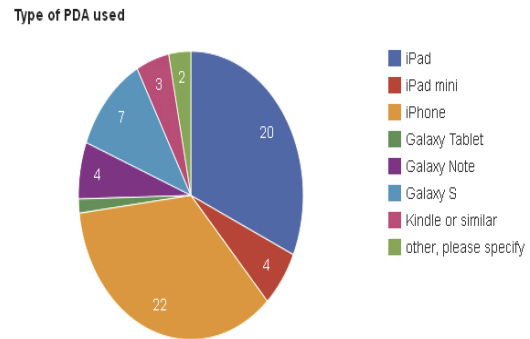
ماهو معدل عدد الساعات الذي تقضيه خلال القراءة
الإلكترونية بإستخدام الأجهزة الالكترونية السابقة الذكر
(ويستثنى منها الكمبيوتر الشخصي أو اللاب توب)؟

○ اقل من ساعة
○ 1 - 3 ساعة
○ 3 - 5 ساعة
○ اكثر من 5 ساعات

Pick 1

**Yes branch*

What is the average time you spend while reading from the mentioned devices (this does not include PC and laptop)
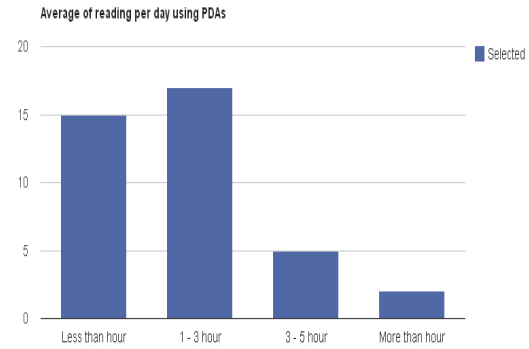
بأي لغة تقرأ معظم الأوقات

○ العربية
○ الإنجليزية
○ كلاهما

Pick 1

**Yes branch*

In which language do you read most of the time?
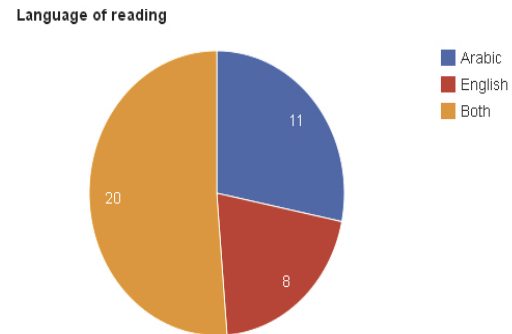
Pick 1

**Yes branch

Do you find difficulties in finding Arabic resources for e-books?
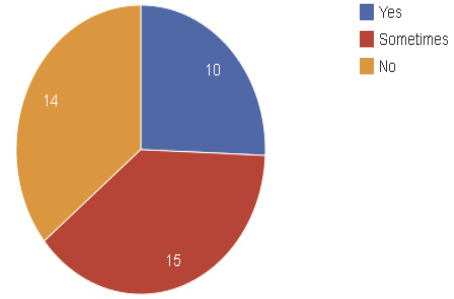
Pick 1

**No branch

Why you do not use PDAs in reading?
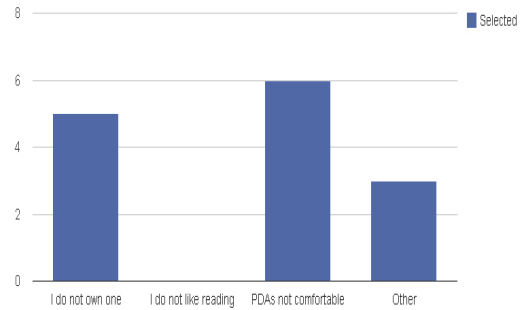
ستظهر أمامك عبارة نصية + أحرف باللغة العربية لمجموعة
من الخطوط العربية (عدد 13 خط) بالتتابع.

بعد كل ظهور للخط العربي قم بالضغط على التالي لتظهر لك
معايير لتقييم الخط. فضلاً قم بتقييم جميع الخطوط واحداً تلو
الآخر.

English script: A text sentience will be shown in the screen + Arabic alphabet in different Arabic fonts (13 fonts) in sequence. After each font appearance, please press on next to evaluate the font. You will have to evaluate all fonts respectively.

Almohanad Font Evaluation

فضلاً قم بتقييم الخط 1 بناء على المعايير الموضحة في الجدول

	أوافق بشدة	أوافق	محايد	لا أوافق	لا أوافق بشدة
واضح	○	○	○	○	○
سهل القراءة	○	○	○	○	○
مريح للعين	○	○	○	○	○

التالي → الخط 1 ← رجوع

التالي → تقييم الخط 1 ← رجوع

فضلاً تأمل الخط ثم اضغط على التالي لتقم بتقييمه

صف خلق خود كمثل الشمس إذا بزغت

يحظى الضجيج بها نجلاء معطار

ا ب ت ث ج ح خ د ذ ر ز س ش ص ض

ط ظ ع غ ف ق ك ل م ن هـ و ي

Evaluation of Almohanad font

Badiya Regular Font Evaluation

Evaluation of Badiya Regular font

Legend:
- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

Categories: Legible, Easy to read, Comfortable for eyes
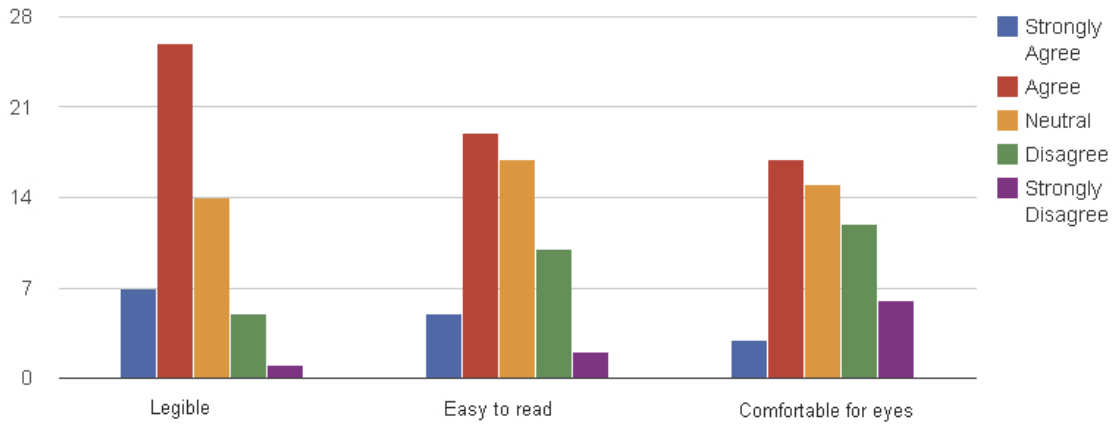
Deco Type Naskh Font Evaluation

Evaluation of Deco Type Naskh font

Geeza Pro Font Evaluation

فضلاً قم بتقييم الخط 4 بناء على المعايير الموضحة في الجدول

	لا اوافق بشدة	لا اوافق	محايد	اوافق	اوافق بشدة
واضح	○	○	○	○	○
سهل القراءة	○	○	○	○	○
مريح للعين	○	○	○	○	○

فضلاً تأمل الخط ثم اضغط على التالي لتقم بتقييمه

صف خلق خود كمثل الشمس إذا بزغت
يحظى الضجيج بها نجلاء معطار
أ ب ت ث ج ح خ د ذ ر ز س ش ص ض
ط ظ ع غ ف ق ك ل م ن هـ و ي

Evaluation of Geeza Pro font
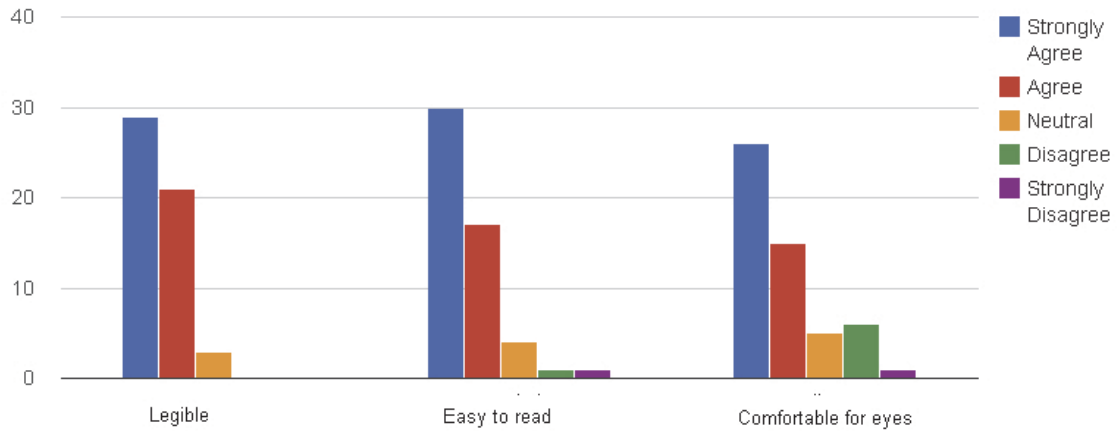
Hasan Enas Font Evaluation

فضلاً تأمل الخط ثم اضغط على التالي لتقم بتقييمه

صف خلق خود كمثل الشمس إذا بزغت
يحظى الضجيج بها نجلاء معطار
أ ب ت ث ج ح خ د ذ ر ز س ش ص ض
ط ظ ع غ ف ق ك ل م ن ه و ي

فضلاً قم بتقييم الخط 5 بناء على المعايير الموضحة في الجدول

	لا اوافق بشدة	لا اوافق	محايد	اوافق	اوافق بشدة
واضح	○	○	○	○	○
سهل القراءة	○	○	○	○	○
مريح للعين	○	○	○	○	○

Evaluation of Hasan Enas font
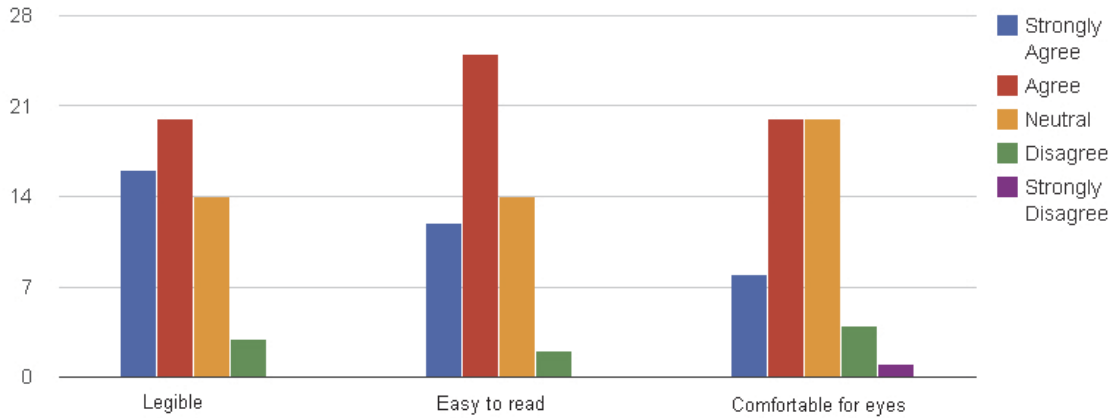
Hemear Light Font Evaluation

Evaluation of Hemear Light font

Janna Regular Font Evaluation

صف خلق خود كمثل الشمس إذا بزغت

يحظى الضجيج بها نجلاء معطار

أ ب ت ث ج ح خ د ذ ر ز س ش ص ض

ط ظ ع غ ف ق ك ل م ن هـ و ي

Evaluation of Janna Regular font
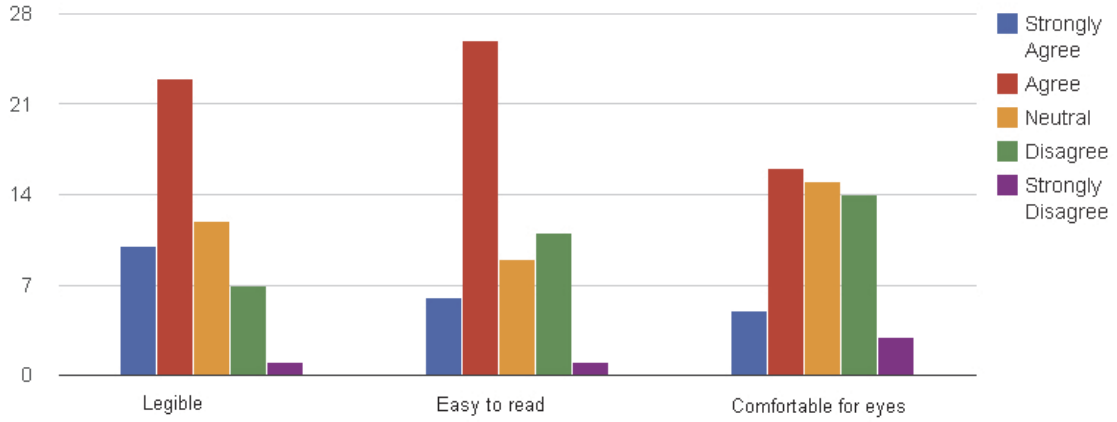
Myriad Arabic Font Evaluation

فضلاً تأمل الخط ثم اضغط على التالي لتقم بتقييمه

فضلاً قم بتقييم الخط 8 بناء على المعايير الموضحة في الجدول

	لا اوافق بشدة	لا اوافق	محايد	اوافق	اوافق بشدة
واضح	○	○	○	○	○
سهل القراءة	○	○	○	○	○
مريح للعين	○	○	○	○	○

صف خلق خود كمثل الشمس إذا بزغت
يحظى الضجيج بها نجلاء معطار
أ ب ت ث ج ح خ د ذ ر ز س ش ص ض
ط ظ ع غ ف ق ك ل م ن هـ و ي

Evaluation of Myriad Arabic font

Legend: Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree

Categories: Legible, Easy to read, Comfortable for eyes

Tahoma Font Evaluation

فضلاً قم بتقييم الخط 9 بناء على المعايير الموضحة في الجدول

	لا اوافق بشدة	لا اوافق	محايد	اوافق	اوافق بشدة
واضح	○	○	○	○	○
سهل القراءة	○	○	○	○	○
مريح للعين	○	○	○	○	○

تقييم الخط 9

التالي ← رجوع

فضلاً تأمل الخط ثم اضغط على التالي لتقم بتقييمه

الخط 9

التالي ← رجوع

صف خلق خود كمثل الشمس إذا بزغت
يحظى الضجيج بها نجلاء معطار
أ ب ت ث ج ح خ د ذ ر ز س ش ص ض
ط ظ ع غ ف ق ك ل م ن هـ و ي

Evaluation of Tahoma font

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Legible					
Easy to read					
Comfortable for eyes					
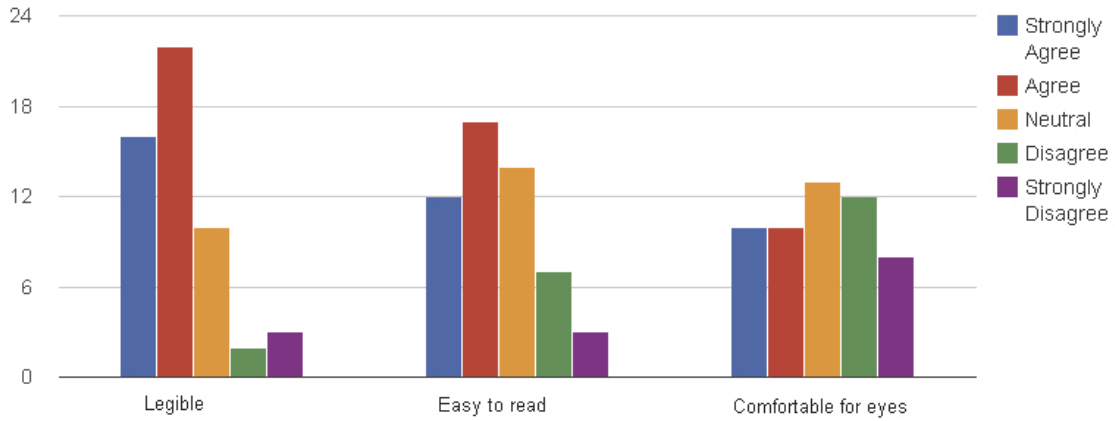
Tanseek Modern Pro Font Evaluation

فضلاً قم بتقييم الخط 10 بناء على المعايير الموضحة في الجدول

	لا أوافق بشدة	لا أوافق	محايد	أوافق	أوافق بشدة
واضح	○	○	○	○	○
سهل القراءة	○	○	○	○	○
مريح للعين	○	○	○	○	○

تقييم الخط 10   التالي   رجوع

فضلاً تأمل الخط ثم اضغط على التالي لتقم بتقييمه

الخط 10   التالي   رجوع

صف خلق خود كمثل الشمس إذا بزغت

يحظى الضجيج بها نجلاء معطار

أ ب ت ث ج ح خ د ذ ر ز س ش ص ض

ط ظ ع غ ف ق ك ل م ن هـ و ي

Evaluation of Tanseek Modern Pro font
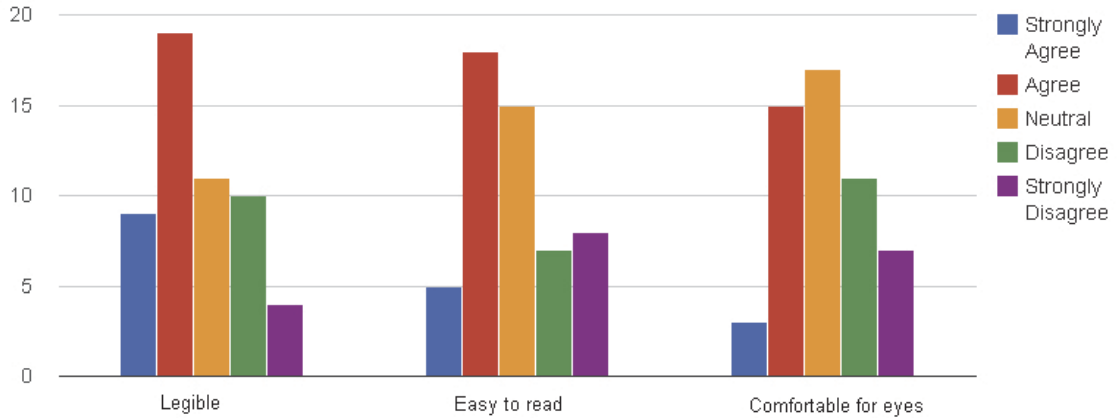
Time New Roman Font Evaluation

فضلاً قم بتقييم الخط 11 بناء على المعايير الموضحة في الجدول

	لا اوافق بشدة	لا اوافق	محايد	اوافق	اوافق بشدة
واضح	○	○	○	○	○
سهل القراءة	○	○	○	○	○
مريح للعين	○	○	○	○	○

فضلاً تأمل الخط ثم اضغط على التالي لتقم بتقييمه

صف خلق خود كمثل الشمس إذا بزغت
يحظى الضجيج بها نجلاء معطار
أ ب ت ث ج ح خ د ذ ر ز س ش ص ض
ط ظ ع غ ف ق ك ل م ن هـ و ي

Evaluation of Time New Roman font

79
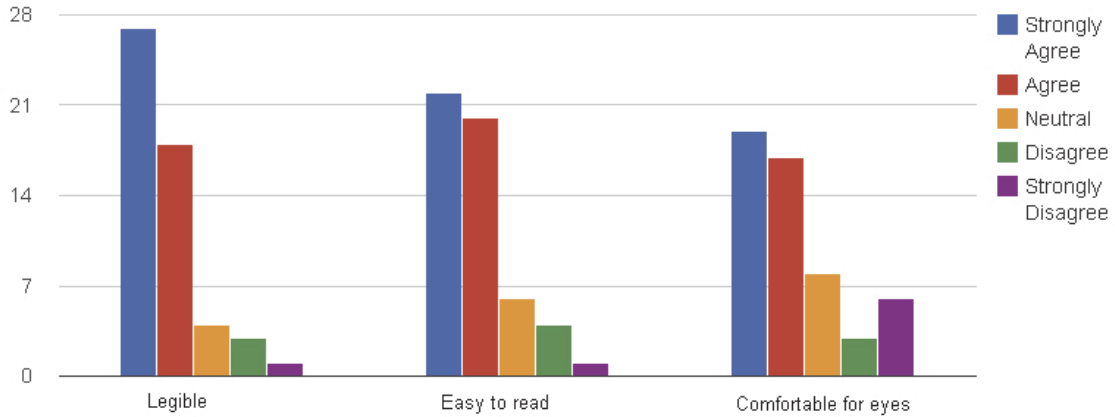
Uthman Script Hafs Font Evaluation

Evaluation of Uthman Script Hafs font

Yakout Regular Font Evaluation

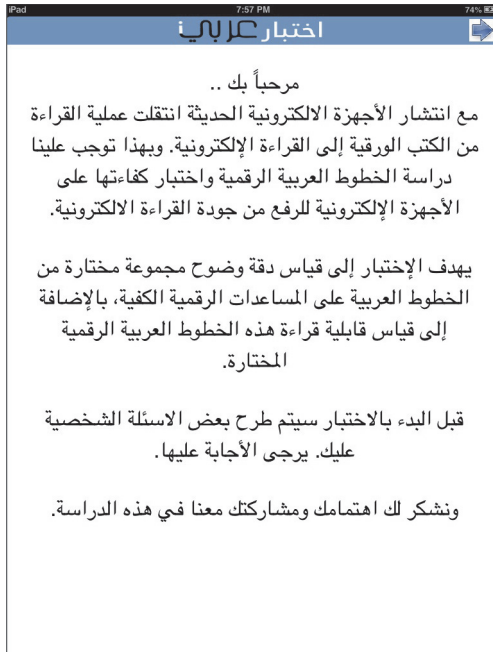**Evaluation of Yakout Regular font**
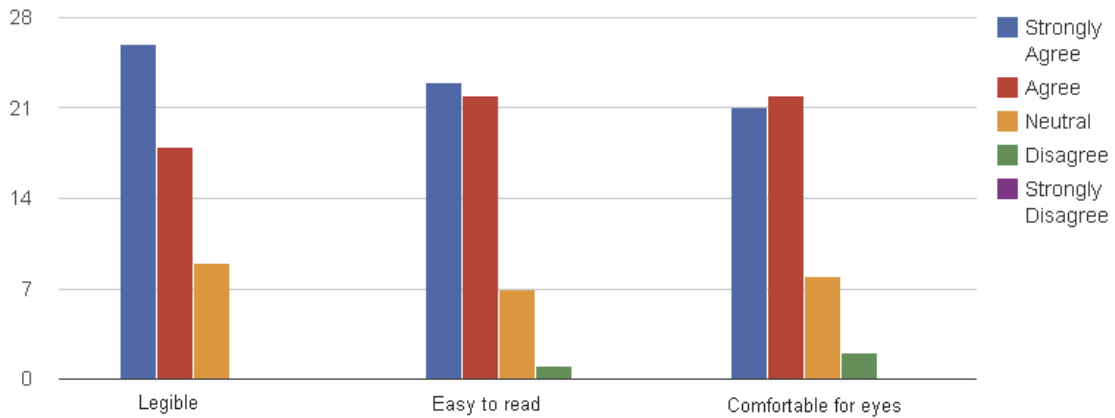
Appendix B

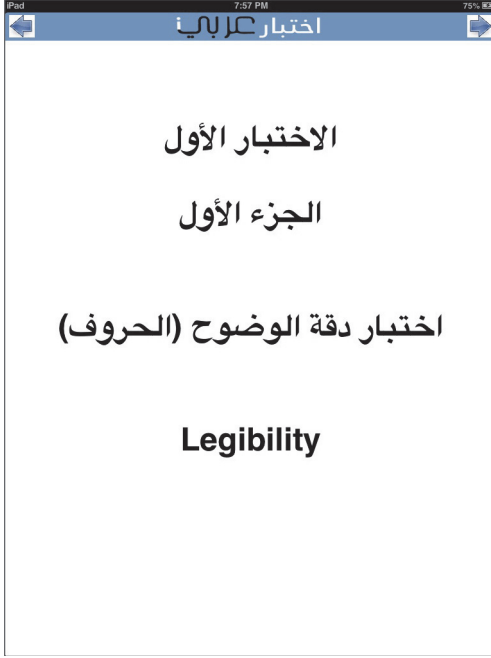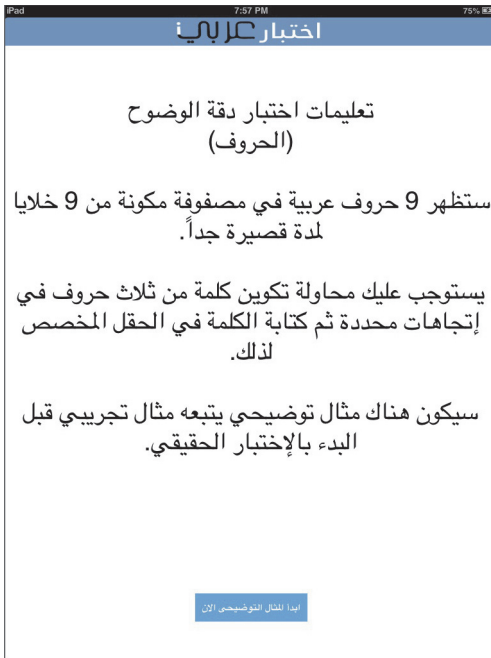# Legibility Experiments

Log in screen.

Hello..

Reading has been transformed to e-reading due to the spread of electronic devices. Thus, it is important to re-evaluate digital Arabic font on PDAs to increase the quality of e-reading.

The test aims to measure legibility and readability of selected Arabic fonts.

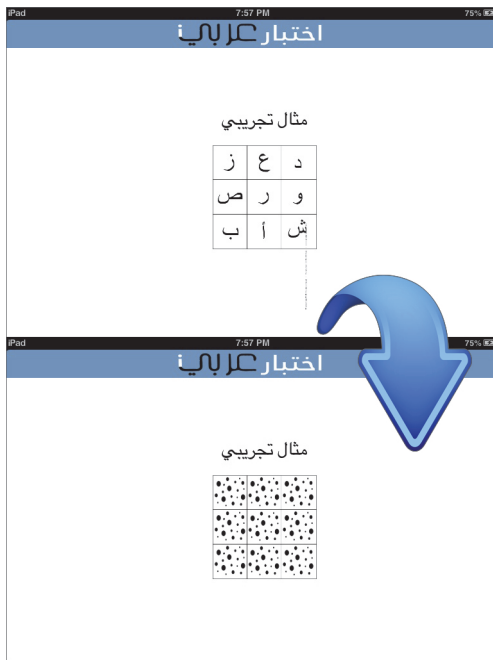We appreciate your participation in this study

الاختبار الأول

الجزء الأول

اختبار دقة الوضوح (الحروف)

Legibility

First Test

Part I

Legibility (Letters)

تعليمات اختبار دقة الوضوح
(الحروف)

ستظهر 9 حروف عربية في مصفوفة مكونة من 9 خلايا
لمدة قصيرة جداً.

يستوجب عليك محاولة تكوين كلمة من ثلاث حروف في
إتجاهات محددة ثم كتابة الكلمة في الحقل المخصص
لذلك.

سيكون هناك مثال توضيحي يتبعه مثال تجريبي قبل
البدء بالإختبار الحقيقي.

ابدأ المثال التوضيحي الآن

Instructions of Legibility Test (letters)

Nine Arabic letters will be displayed in a matrix for a very short time. You should try to generate a word of three letters in specific directions.

Before starting the real test, there is an explanatory example followed by a trial test.
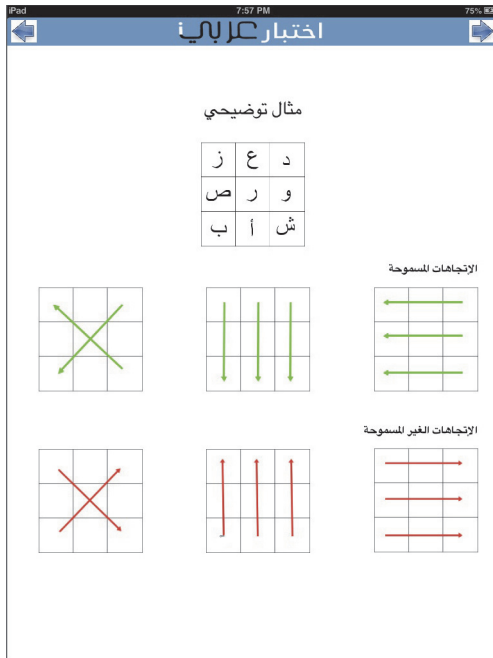
Explanatory Example

Allowed directions (top)

Eliminated directions (bottom)

Trial Test

Sample matrix (top)

Afterimage mask (bottom)

اختبار عربي

كلمة واحدة يمكن تمييزها من المصفوفة وهي:

○ قمر

○ درب

○ بصل

○ لم استطع التمييز

تسليم

Trial Test - Continuous

One word can be generated from the matrix:

"Qamar"

"Drb"

"Basal"

I could not recognize it

اختبار عربي

مثال تجريبي

ز	ع	د
ص	ر	و
ب	أ	ش

الكلمة الصحيحة هي:

درب

انتقل للاختبار
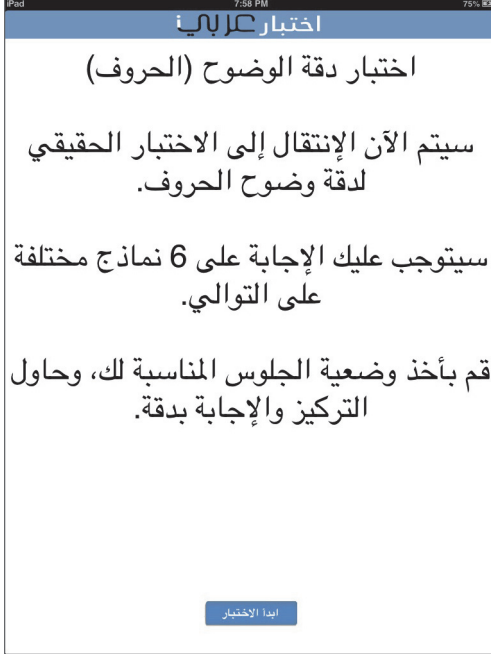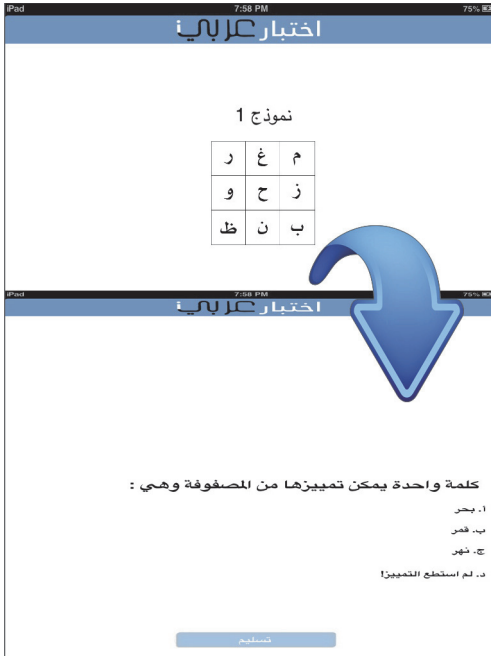
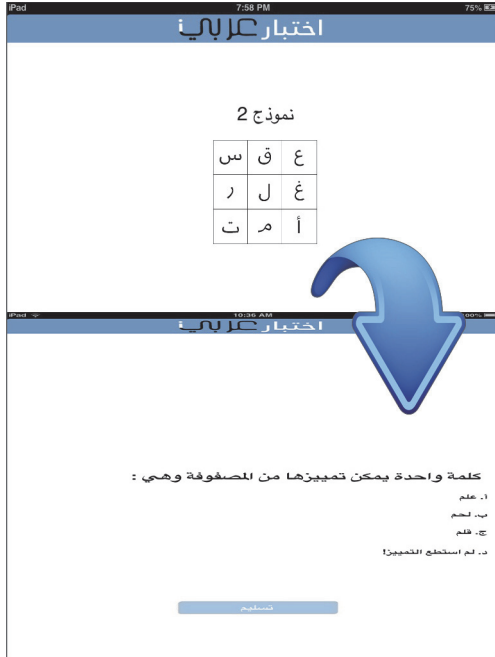Trial Test - Continuous

The correct answer is: "Drb"

Legibility Test (letters)

Now you will go to the real test. You have to answer six samples respectively. Please take your comfortable position and focus.
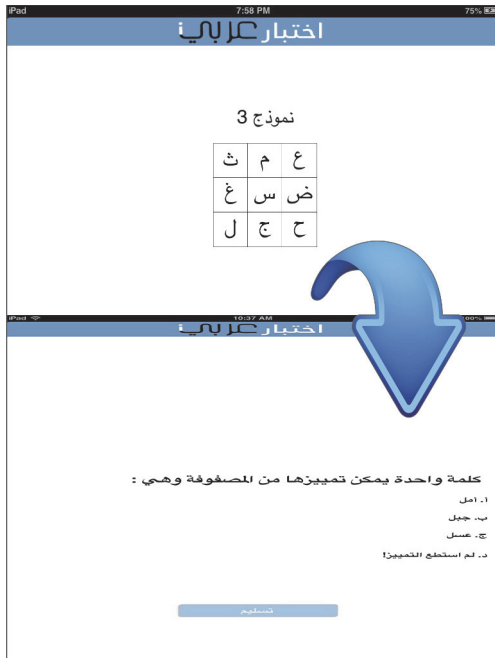

Sample 1 (top)

Multiple answers (bottom)

نموذج 2

ع	ق	س
غ	ل	ر
أ	م	ت

اختبار عربي

كلمة واحدة يمكن تمييزها من المصفوفة وهي :

ا. علم

ب. لحم

ج. قلم

د. لم استطع التمييز!

تسليم

Sample 2 (top)

Multiple answers (bottom)

نموذج 3

ع	م	ث
ض	س	غ
ح	ج	ل

اختبار عربي

كلمة واحدة يمكن تمييزها من المصفوفة وهي :

ا. اصل

ب. جبل

ج. عسل

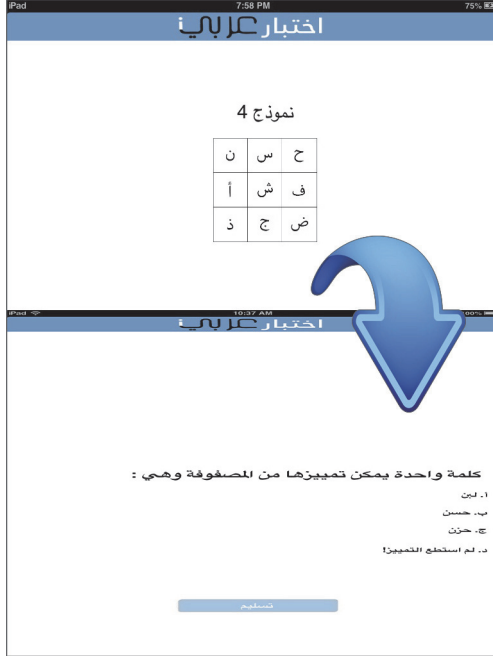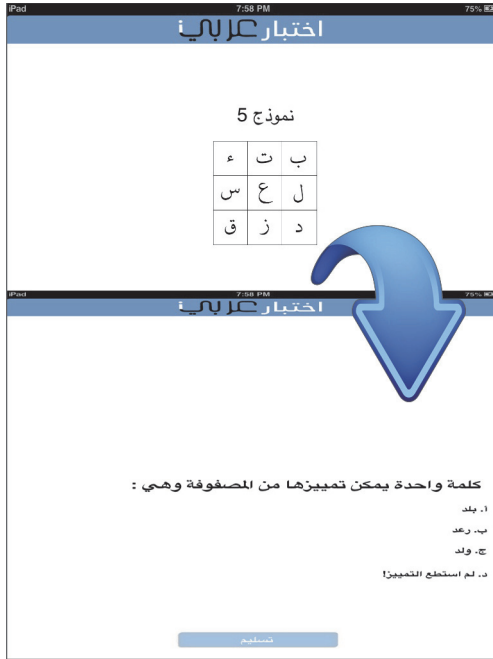د. لم استطع التمييز!

تسليم

Sample 3 (top)

Multiple answers (bottom)

Sample 4 (top)

Multiple answers (bottom)

Sample 5 (top)

Multiple answers (bottom)
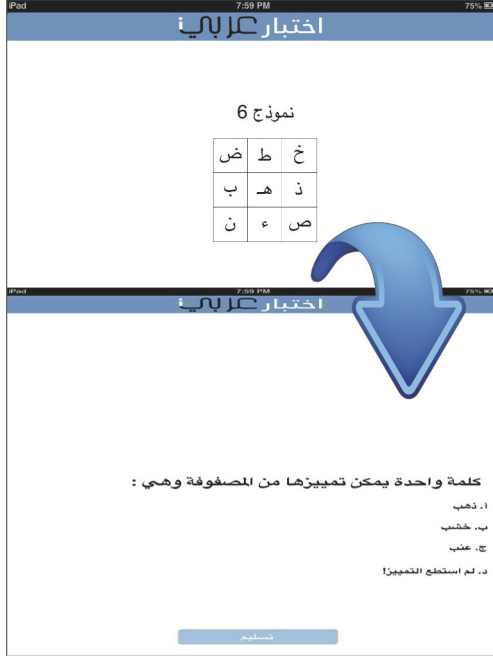
Sample 6 (top)

Multiple answers (bottom)
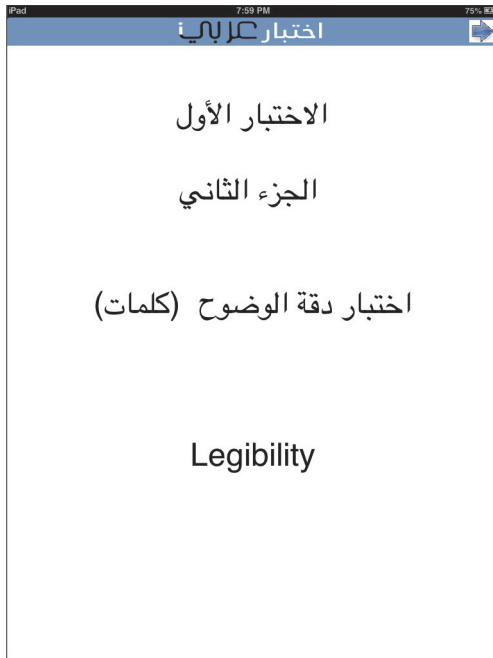
First Test

Part II

Legibility (words)
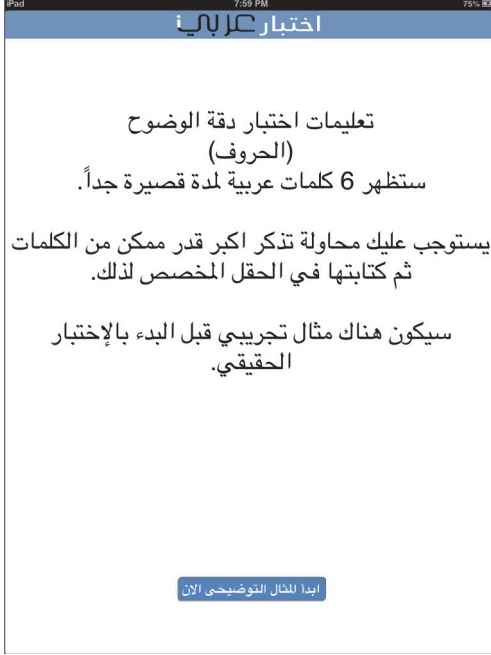
Instructions of Legibility Test (words)

Nine Arabic words will be displayed at once for a very short time. You should try to remember as much as you can and write them in the text boxes.

Before starting the real test, there is a trail test.
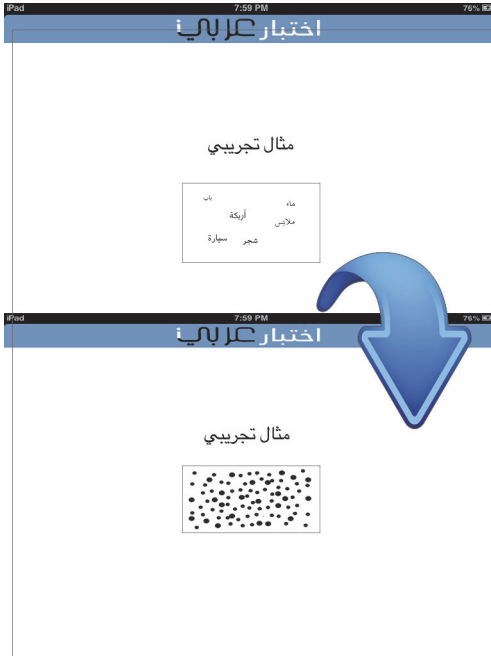
Trial Test

Trial Sample (top)

Afterimage mask (bottom)

Trial Test - Continuous

What were words displayed?

If you do not recognize the word, leave the
text box empty

Legibility Test (words)

Now you will go to the real test. You
have to answer three samples respectively.
Please take your comfortable position and
focus.

نموذج 1

بيت فستان خضار
ورق
مصحف
كهرباء

ماهـي الكلمـات التـي ظهـرت؟
إذا لم تستطيع تمييز اي كلمة اترك المربع خاليًا

الكلمة ١ :
الكلمة ٢ :
الكلمة ٣ :
الكلمة ٤ :
الكلمة ٥ :
الكلمة ٦ :

تسليم
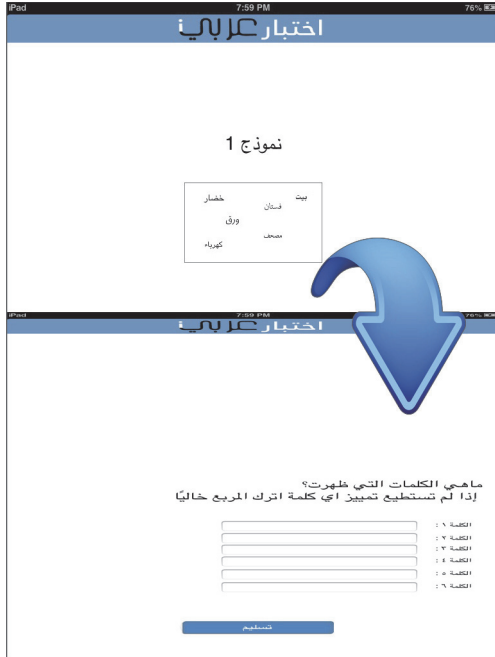
Sample 1 (top)

Text boxes (bottom)

نموذج 2

موز مال
رمضان
كتاب أخبار
شيوف

ماهـي الكلمـات التـي ظهـرت؟
إذا لم تستطيع تمييز اي كلمة اترك المربع خاليًا

الكلمة ١ :
الكلمة ٢ :
الكلمة ٣ :
الكلمة ٤ :
الكلمة ٥ :
الكلمة ٦ :

تسليم
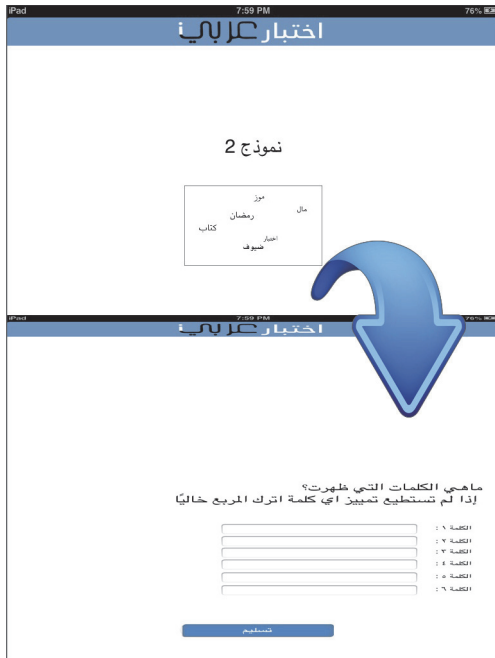
Sample 2 (top)

Text boxes (bottom)
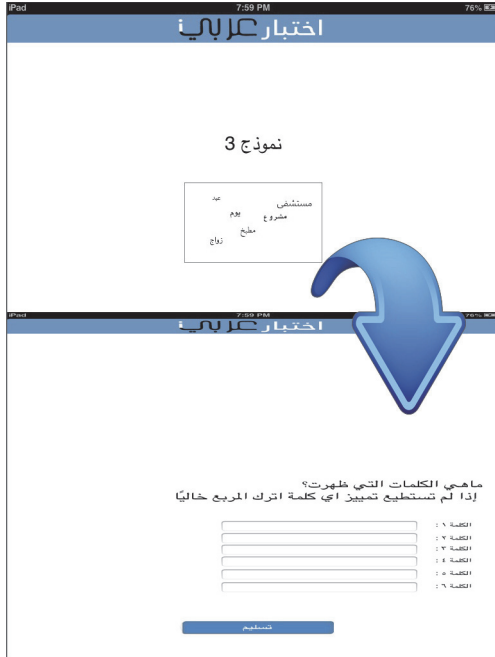
Sample 3 (top)

Text boxes (bottom)

Appendix C

Readability Experiment
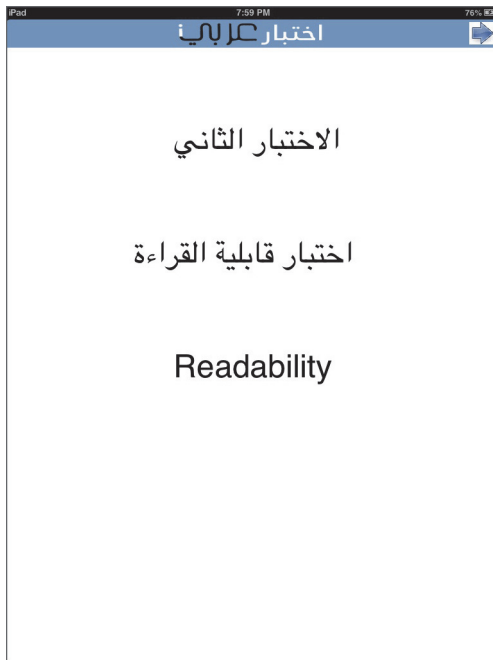
Second Test

Readability
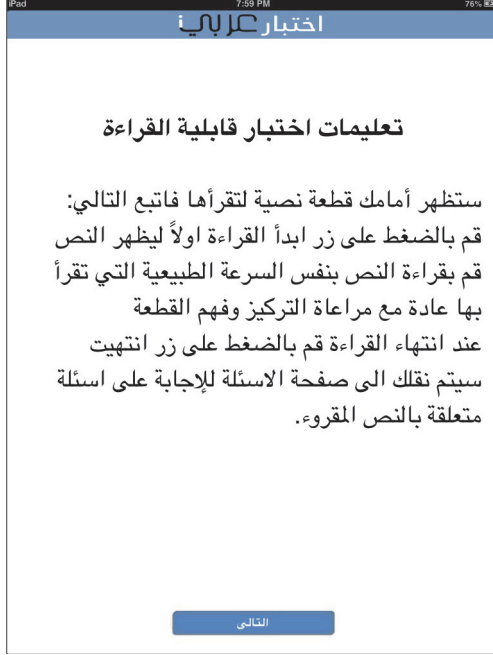
Instructions of Readability Test

A text passage will be displayed for reading. First of all, you have to press "Start Reading" button to display passage. So, read at same normal speed you usual use. Try to understand while reading to be able to answer the questions. Once you are done from reading press "Done" button to go to questions section.
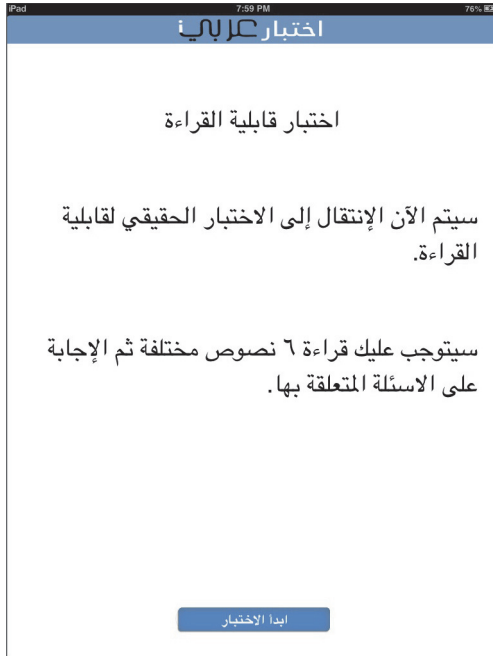
Readability Test

Now you will start the real test. You have to read six different passages and answer related questions.

First Passage

اختبار عربي

النص لأول

ابدأ القراءة

عصرنا عصر انفجار المعرفة: فالإعداد الهائلة من العلماء الذين يشتغلون بالبحث العلمي والوسائل المتطورة في حفظ المعلومات ونقلها وبثها والتواصل الكوني الفريد والمتزايد كل ذلك جعل الناس مغمورين بالأخبار والمعلومات والمفاهيم التي ترد إليهم كل لحظة من شتى أصقاع الأرض.
ويكفي أن تعلم أن متوسط ما يطبع من معظم الكتب في البلاد العربية لا يتجاوز ٣٠٠٠ نسخة للكتاب الواحد وهذا العدد المحدود لا ينفد في الغالب في أقل من ثلاث سنوات على حين تتجاوز أرقام التوزيع في الدول المتقدمة ذلك بكثير.

انتهيت

First Passage Questions

اختبار عربي

اسئلة النص الأول

س١: يفهم من النص أن عصرنا اليوم عصر:

أ. كثرت فيه المعلومات ومصادرها

ب. ازدادت فيه المعلومات في مجالات معينة

ج. حصل فيه انفجار سكاني هائل

د. توسعت فيه التخصصات الإعلامية

س٢: يدل متوسط ما يتم طبعه من أغلب الكتب العربية على مستوى القراءة في البلاد العربية:

أ. ضعيف

ب. متوسط

ج. مرتفع

د. عالي

تسليم

Second Passage

اختبار عربي

النص الثاني

ابدأ القراءة

صحراء الربع الخالي إحدى صحاري شبه الجزيرة العربية، وتقع في المنطقة الجنوبية الشرقية من المملكة العربية السعودية وهي أكبر بحر رملي في العالم كله، تمتد من المرتفعات الغربية في الغرب حتى مرتفعات عمان في الشرق، ومن هضبة نجد في الشمال إلى مرتفعات حضرموت في الجنوب. وكان ياقوت الحموي الجغرافي المسلم المشهور يسميها "صحراء يبرين" نسبة إلى " واحة يبرين" التي تقع في أطرافها الشمالية، وتقول العرب في وصف الكثرة: " مثل رمل يبرين" يقصدون رمل هذه الصحراء. وعلى الرغم من قسوة البيئة الطبيعية في هذه المنطقة وخلوها من النشاط البشري، فإنها تزخر بثروات ضخمة من النفط والغاز الطبيعي والمعادن والطاقة الشمسية.

انتهيت

Second Passage Questions

اختبار عربي

اسئلة النص الثاني

س٣: يدل قول العرب "مثل رمل يبرين" الوارد في النص على:

أ. الشدة

ب. الاتساع

ج. الجفاف

د. الكثرة

س٤: يفيد النص أن صحراء الربع الخالي تحيط بها المرتفعات من:

أ. جميع الجهات

ب. الجهات الغربية والشرقية والجنوبية

ج. الجهتين الغربية والجنوبية

د. الجهات الشمالية والجنوبية والغربية

تسليم

Third Passage

اختبار عربي

النص الثالث

ابدأ القراءة

يغطي الماء ٧٠٪ من كوكب الأرض، غير أن ٩٧٪ من حجم الماء على وجه الأرض ماء مالح، ولا يبقى للاستخدامات البشرية إلا ٣٪ هي نسبة الماء العذب. ويذكر أن ٧٠٪ من الماء العذب متجمد في القطبين أو موجود في الطبقات الجوفية البعيدة جداً ويبقى للاستعمال الانساني مايقل عن ١٪ فقط من مجموع الموارد المائية الموجودة على سطح الكرة الأرضية.

وتقوم دورة المياه في الطبيعة بالمحافظة على الثبات النسبي لمخزون الماء العذب المتوافر في الكرة الأرضية. حيث يحدث التبخر من سطوح المحيطات والبحيرات والأنهار إلى الغلاف الجوي لتتشكل الغيوم التي تتحول بفعل البرودة والتكثيف إلى امطار تغذي مصادر المياه، ثم تتبخر من جديد وهكذا دواليك.

انتهيت

Third Passage Questions

اختبار عربي

اسئلة النص الثالث

س٥: يفيد النص أن نسبة الماء العذب في الكرة الأرضية تمثل:

ا. اقل من ٣٪

ب. ٣٪

ج. ٩٧٪

د. ٧٠٪

س٦: يفهم من النص أن دورة المياه في الطبيعة:

ا. تنقي الماء المستخدم من التلوث

ب. تبقي على نفس كمية الماء العذب

ج. تزيد من نسبة الماء العذب

د. تقلل من نسبة الماء العذب

تسليم

Fourth Passage

اختبار عربي

النص الرابع

ابدأ القراءة

للألوان في عالمنا تأثير متعدد الوجوه. فتعددها يضفي على أنفسنا بهجة من نوع خاص. ونستخدمها في أشياء عملية في حياتنا. فها نزين طعامنا وشرابنا وملابسنا، ونستعين بها في تيسير حركة سيرنا في مدننا وقرانا وطرقنا. ونستعملها كثيراً في أغراضنا التعليمية. بل إننا نحول الألوان إلى مفاهيم ذهنية مجردة، فنجعل البياض رمزاً للنماء والسواد للحزن.

وتبدو معظم الأشياء ملونة بسبب تركيبها الكميائي. فهي تمتص أطوالاً موجية معينة من الضوء، وتعكس الأطوال الموجية المتبقية. فعندما تسقط أشعة الشمس على جسم نباتي كالجزر، فإن مكونات الجزر تمتص معظم الضوء ذي الطول الموجي القصير، وتعكس معظم الضوء ذي الطول الموجي الأطول، وعندما يصل هذا الضوء إلى أعيننا، فإن نبات الجزر يبدو لنا برتقاليا.

انتهيت

Fourth Passage Questions

اختبار عربي

اسئلة النص الرابع

س٧: يفهم من النص أن أشكال تاثير الألوان على الإنسان نفسياً وحسياً:

ا. كثيرة

ب. قوية

ج. خطيرة

د. خاصة

س٨: يتحدد لون الفاكهة الذي تراه أعيننا بناء على:

ا. لونها الطبيعي

ب. كمية الضوء المتصة والمعكوسة معاً

ج. كمية الضوء المتصة فقط

د. كمية الضوء المعكوسة فقطي

تسليم

Fifth Passage

اختبار عربي

النص الخامس

ابدأ القراءة

بلغت الحضارة الإسلامية ما بلغته من تطور ورق بالعلم والمعرفة وعناية المسلمين بالمكتبات. ومن ذلك أن الخليفة المأمون كان يرسل مبعوثيه إلى بلدان متعددة للبحث عن المخطوطات وترجمتها إلى العربية. وتقول بعض المصادر التاريخية: إن المكتبة التي أسسها المأمون ضمت مليون مخطوطة، وهي التي سميت "بيت الحكمة". ولكن كان مصير كتبها نفس مصير مكتبات أخرى كثيرة، إذ احرقها المغول والقوها في مياه النهر عند اجتياحهم بغداد في القرن السابع الهجري.

وختم بقصة طريفة فقد قال احد العلماء: سمعت أن كتاباً كنت مهتما بشرائه وصل إلى سوق الكتب بقرطبة فتوجهت للسوق، وعندما عرض الكتاب للبيع أخذت أزيد في ثمنه، وشخص آخر يبدو عليه الثراء يزيد على زيادتي، حتى تجاوز ثمن الكتاب قدرتي فقلت له: ليس معي من المال مايساوي ثمن الكتاب، فهل تأذن لي بقراءته بعدك؟ فقال: لست بعالم ولا أدري مالكتاب، ولكني ابتنيت بيتاً جديداً ووضعت فيه خزانة كتب، وبقي فيها موضع بحجم هذا الكتاب، فلما رأيت حسن خطه وتجليده أردت شراءه لأجمل به مكتبتي. فقلت لنفسي: "يحصل على البندق من لا نواجذ له".

انتهيت

Fifth Passage Questions

اختبار عربي

اسئلة النص الخامس

س٩: مكتبة "بيت الحكمة" التي أسسها المأمون تعرضت إلى:

أ. الإهمال

ب. الحرق

ج. السرقة

د. الاعتداء

س١٠: مقولة "يحصل على البندق من لا نواجذ له" تعني:

أ. حدة التفاوت المادي بين الأغنياء والفقراء

ب. الحصول على الشيئ بلا عناء

ج. العجز عن الاستفادة من الشيئ

د. خطر الثراء مع الجهل على العلم.

تسليم

Sixth Passage

اختبار عربي

النص السادس

ابدأ القراءة

تختلف الانهار فيما بينها اختلافا كبيرا من حيث الحجم، فبعضها صغيرا جدا حتى انها تجف خلال فصول الجفاف، واطول نهر في العالم هو نهر النيل في افريقيا، ويليه من حيث الطول نهر الآمازون في امريكا الجنوبية، إلا أن كمية المياه التي يحملها نهر الآمازون تفوق كمية المياه في أي نهر آخر، بل وتفوق كمية المياه في نهر النيل ونهرالميسيبي ونهر يانجستي مجتمعة.

وتعد الانهار مهمة للزراعة كذلك كما أنها مصدر مهم للطاقة، اذ يمكن استخدام قوة تدفق المياه على امتداد النهر، عند المساقط وغيرها من المناطق المنحدرة لتشغيل الآلات وتوليد الكهرباء، حيث تحول السواقي والدواليب المائية قوة المياه المتدفقة إلى طاقة. وفي الوقت الحاضر، تنتج محطات القوة الكرومائية ذات التوربينات المائية نحو ربع القوة الكهربائية التي يحتاجها العالم.

انتهيت

Sixth Passage Questions

اختبار عربي

اسئلة النص السادس

س١١: يفهم من النص ان نهر النيل من حيث طوله وكمية مائه مقارنة بنهر الآمازون:

أ. اقصر منه واقل ماء

ب. اطول منه واكثر ماء

ج. اقصر منه واكثر ماء

د. اطول منه واقل ماء

س١٢: يفهم من النص ان المسبب في توليد الطاقة من الانهاء هو:

أ. طول مجراها

ب. قوة اندفاع مياهها

ج. سرعة جريان مياهها

د. عرض مجراها

تسليم

النهاية

نشكر لك مشاركتك القيمة في هذه
الدراسة ونسأل الله لك التوفيق

تم
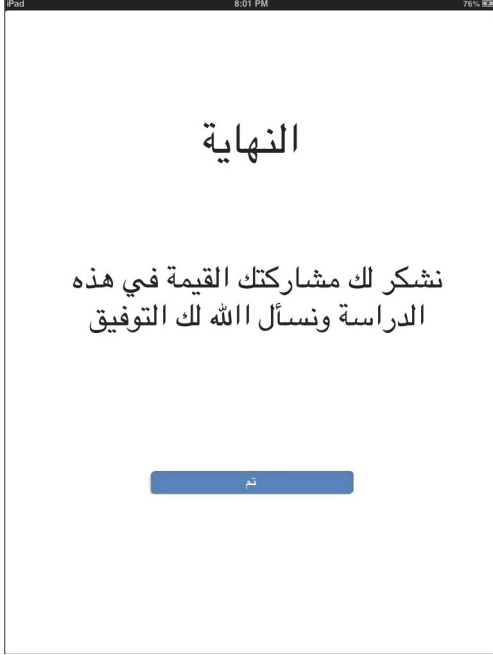
The End

Thanks for your participation

References

[1] NEA. To read or not to read: A question of national consequence. Research Report 47, National Endowment for the Arts, United States, Washington, 2007.

[2] M. F. Suarez and H. R. Woudhuysen. *The Oxford companion to the book*. Oxford: Oxford University Press, Reading, Massachusetts, 2010.

[3] K. Coyle. Managing technology: E-reading. *The Journnal of Academic Librarianship*, 34(2):160–162, 2008.

[4] J. Janbi, M. Almuhajri, and C. Suen. Discovering legible digitized fonts for computer human interaction. In *Proceeding of International Conference on Multimedia and Human-Computer Interaction (MHCI'13)*, pages 131:1–8, Toronto, Canada, July 2013.

[5] PC Magazine Encyclopedia. E-book definition from pc magazine encyclopedia. `http://29letters.wordpress.com/2007/05/28/arabic-type-history/`, January 2013. [Accessed 10 Jan 2013].

[6] R. Bringhurst. *The Element of Typographic Style*. HARLEY & MARKS, Point Roberts, Whatcom, USA, 1997.

[7] UNESCO Web Corporate Services. 18 December - World Arabic language day. `http://www.unesco.org/new/en/media-services/single-view/news/world_arabic_language_day/`, October 2012. [Accessed 11 February 2013].

[8] A. Azmi and A. Alsaiari. Arabic typography: A survey. *International Journal of Electrical & Computer Sceiences IJECS*, 9(10):23–27, 2009.

[9] E. Smitshuijzen. *Arabic Font Specimen Book*. Uitgeverij de Buitenkant, Amsterdam, 2009.

[10] H. S. AbiFares. *Arabic Typography a comprehensive sourcebook*. Saqi Books, Singapore, 2007.

[11] P. Zoghbi. History of Arabic type evolution from the 1930's till present. `http://29letters.wordpress.com/2007/05/28/arabic-type-history/`, May 2007. [Accessed 19 November 2012].

[12] Y. Haralambous. *Fonts & Encodings*. O'REILLY, 1005 Gravenstein Highway North, Sebastopol, CA 95472, 2007.

[13] G. Ferreira. Updates to fontstruct live and fontstructor. `http://fontstruct.com/news/2009/08/21/updates-to-fontstruct-live-and-fontstructor/`, August 2009. [Accessed 8 July 2012].

[14] P. Zoghbi. Experimental Arabic/Latin font adaptation workshop - 29letters. `http://29letters.wordpress.com/2009/08/10/experimental-arabiclatin-font-adaptation-workshop/`, August 2009. [Accessed 8 July 2012].

[15] W. Tracy. *Letters of Credit: A View of Type Design*. David Godine, London, 1986, pp. 30-32.

[16] J. B. Lieberman. *Types of typefaces and how to recognize them*. Sterling PublisherCo., New York, 1967, pp. 85-127.

[17] M. C. Dyson and M. Haselgrove. The influence of reading speed and line length on the effectiveness of reading from screen. *International Human-Computer Studies*, 54:585–612, 2001.

[18] E. Siegenthaler, P. Wurtz, P. Bergamin, and R. Groner. Comparing reading processes on e-ink displays and print. *Displays*, 32(5):268 – 273, 2011.

[19] KFS. King faisal school-ipad application project. `http://www.kfs.sch.sa/en/tabid/188/Default.aspx`, December 2012. [Accessed 15 August 2013].

[20] Quad Dimensions. Sibawayh books. `http://sibawayhbooks.com/`, 2012. [Accessed 3 July 2013].

[21] M. Almuhajri and C. Suen. Arabic e-reading: Studies on legibility and readability on personal digital assistance. In *ScienceOne ICIT*, Dubai, UAE, 2014.

[22] S. Beier. *Reading Letters designing for legibility*. BIS Publishers, 1057 DT Amsterdam, 2012, pp. 10-20.

[23] M. Bernard, C. H. Liao, and M. Mills. The effects of font type and size on the legibility and reading time of online text by older adults. In *Proceedings of ACM CHI 2001, ACM*, volume II, pages 175–176, 2001.

[24] A. D. Shaikh. *Psychology of onscreen type: investigations regarding typeface personality, appropriateness, and impact on document perception.* PhD thesis, Department of Psycgology, Wichita State University, May 2007.

[25] S. Nikfal. English and Arabic typeface personas and arabic typefaces design charactersitics. Master's thesis, Department of Computer Science and Software Engineering, Concordia University, 2011.

[26] A. Alsumait, A. Al-Osaimi, and H. AlFedaghi. Arab children's reading preference for different online fonts. In *HCI (4)*, pages 3–11, 2009.

[27] E. C. Godnig. The tachistoscope: Its history and uses. *Journal of Behavioral Optometry*, 14:39–42, 2003.

[28] C. Y. Suen. Human recognition of handprinted characters and distance measurements. In *Graphonomics: Contemporary Research in Handwriting*, pages 213–223. Elsevier Science Publishers B. V., 1986.

[29] S. Beier and K. Larson. Design improvements for frequently misrecognized letters. *Information Design Journal*, 18(2):118–137, 2010.

[30] B. Zhang. Discovering legible and readable Chinese typefaces for reading digital documents. Master's thesis, Department of Computer Science and Software Engineering, Concordia University, 2012.

[31] B. Chaparro, A. Dawn Shaikh, and A. Chaparro. Examining the legibility of two new ClearType fonts. *Usability News*, 8(1), 2006.

[32] B. Chaparro, J. R. Baker, A. D. Shaikh, S. Hull, and L. Brady. Reading online text: A comparison of four white space layouts. `http://psychology.wichita.edu/surl/usabilitynews/62/whitespace.htm`, Usability News 2004. [Accessed 22 October 2013].

[33] M. Z. Ramadan. Evaluating college students' performance of Arabic typeface style, font size, page layout and foreground/backgroujnd color combinations of e-book materials. *Journal of King Saud University - Engineering Sciences*, 23:89–100, 2011.

[34] A. Abubaker and J. Lu. The optimum font size and type for students aged 9-12 reading arabic characters on screen: A case study. *Journal of Physics: Conference Series*, 364, June 2012. Paper presented at COMADEM2012, University of Huddersfield, 18th - 20th June 2012.

[35] R. Thibadeau, M. Just, and P. Carpenter. Real reading behavior. In *Proceedings of the 18th annual meeting on Association for Computational Linguistics*, ACL '80, pages 159–162, Stroudsburg, PA, USA, 1980. Association for Computational Linguistics.

[36] K. Rayner. Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, pages 372–422, 1998.

[37] D. Beymer, D. Russell, and P. Orton. An eye tracking study of how font size and type influence online reading. In *BCS HCI (2)*, pages 15–18. BCS, 2008.

[38] A. Al-Wabil and R. George. An eye tracking study of arabic typography readability. In *Interfaces and Human Computer Interaction (IHCI) 2010 conference*, pages 309–312. IADIS, 2010.

[39] G. Voorhees. Congeniality of reading on digital devices. Master's thesis, Rochester Institute of Technology/ School of Print Media, 2011.

[40] M. Ramadan, A. Mohamed, and H. El-Hariry. Effects of cthode ray tube display formats on quality-assurance auditor's performance. *Human Factors in Ergonomics and Manufacturing*, 20(1):61–72, Jan 2010.

[41] W. Tsai, Y. Ro, Y. Chang, and C. Lee. The effects of font size and page presentation method of e-book reading on small screens for older adults. 6767:94–101, 2011.

[42] I. Darroch, J. Goodman, S.A. Brewster, and P.D.G. Gray. The effect of age and font size on reading text on handheld computers. *Lecture Notes in Computer Science*, 3585:253–266, September 2005.

[43] H. S. AbiFares and L. Khoury. *Arabic Type Design for Beginners*. Khatt Books, Dubai & Amesterdam, 2013, pp. 119-121.

[44] Adobe Systems Incorporated. Adobe - fonts: Myriad Arabic. `http://store1.adobe.com/cfusion/store/html/index.cfm?store=OLS-US&event=displayFontPackage&code=1954`, 2012. [Accessed 28 May 2013].

[45] J. D. Berry. Myriad arabic. `http://www.adobe.com/content/dam/Adobe/en/products/type/pdfs/Myriad-Arabic-Online-Specimen.pdf`, 2012. [Accessed 28 May 2013].

[46] Linotype. Badiya font family. `http://www.linotype.com/341148/badiya-family.html`, 2007. [Accessed 28 May 2013].

[47] Linotype. Janna font family. `http://www.linotype.com/341162/janna-family.html`, 2007. [Accessed 28 May 2013].

[48] P. Gibbs. Can a human see a single photon? `http://math.ucr.edu/home/baez/physics/Quantum/see_a_photon.html`, 1996. [Accessed 17 June 2013].

[49] B. Murdock. Short-term memory. *Psychology of Learning and Motivation*, 5:67–127, 1972.

[50] M. Machizawa, C. Goh, and J. Driver. Human visual short-term memory precision can be varied at will when the number of retained items is low. *Psychological Science*, 23:554–559, 2012.

[51] National center for assessment in higher education. `http://www.qiyas.sa/Sites/English/Pages/default.aspx`, 2001. [Accessed 6 June 2013].

[52] M. Ziefle. Information presentation in small screen devices: The trade-off between visual density and menu foresight. *Applied Ergonomics*, 41(6):719–730, 2010.