

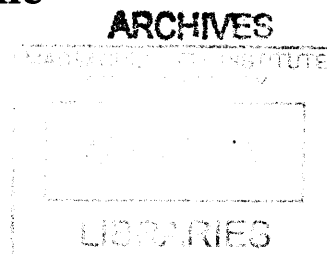
**Web Page Enhancement on Desktop and Mobile  
Browsers**

by

**Chen-Hsiang Yu**

B.S., Tamkang University (1998)

M.S., National Taiwan University (2000)



Submitted to the Department of Electrical Engineering and  
Computer Science  
in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

at the

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Author .....  
Department of Electrical Engineering and Computer Science  
November 30, 2012

Certified by .....  
Robert C. Miller  
Associate Professor  
Thesis Supervisor

Accepted by .....  
Professor Leslie Kolodziejski  
Chair, Department Committee on Graduate Students



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## Abstract

The Web is a convenient platform to deliver information, but reading web pages is not as easy as it was in 1990s. This thesis focuses on investigating techniques to enhance web pages on desktop and mobile browsers for two specific populations: non-native English readers and mobile users. There are three issues addressed in this thesis: web page readability, web page skimmability and continuous reading support on mobile devices.

On today's primarily English-language Web, non-native readers encounter some problems, even if they have some fluency in English. This thesis focuses on content presentation and proposes a new transformation method, Jenga Format, to enhance web page readability. A user study with 30 non-native users showed that Jenga transformation not only improved reading comprehension, but also made the web page reading easier.

On the other hand, readability research has found that average reading times for non-native readers has remained the same or even worse. This thesis studies this issue and proposes *Froggy GX* (Generation neXt) to improve reading under time constraints. A user study with 20 non-native users showed that *Froggy GX* not only enhanced reading comprehension under time constraints, but also provided higher user satisfaction than reading unaided.

When using the Web on mobile devices, the reading situation becomes challenging. Even worse, context switches, such as from walking to sitting, static standing, or hands-free situations like driving, happen in reading in on-the-go situations, but this scenario was not adequately addressed in previous studies. This thesis investigates this scenario and proposes a new mobile browser, *Read4Me*, to support continuous reading on a mobile device. A user study with 10 mobile users showed that auto-switching not only provided significantly fewer dangerous encounters than visual-reading, but also provided the best reading experience.

Thesis Supervisor: Robert C. Miller  
Title: Associate Professor



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# Chapter 1

## Introduction

The Web is a convenient platform to deliver information, but reading web pages is not as easy as it was in 1990s. Part of the reason are the pervasive usability issues happening on today's web pages. There are different needs from different user groups, such as disabled individuals suffering from blindness and dyslexia, and non-native readers. On a mobile device, information access is much more difficult. In this thesis, I enhance web pages on desktop and mobile browsers for two specific populations: non-native English readers, and mobile users. I enhance web pages from three directions: readability, skimmability, and mobile continuous reading.

### 1.1 Problems

On today's primarily English-language Web, non-native readers (whose first language is not English) encounter even more problems than native readers, even if they have some fluency in English. Problems include unfamiliar vocabulary, complicated grammatical structure, and long, crowded, or otherwise intimidating content display. Distracting content, such as ads, animations, logos, videos, and photographs, is constantly competing for the user's attention. Poor color contrast, tiny fonts, and unreadable font faces interfere with comfortable reading [69]. Some web sites are better, but many are worse. All of these problems



hinder non-native readers from reading content fluently. There is a need to make information on the Web easy to access and understand for non-native readers.

On the other hand, information overload on the Web and limited reading time force users to skim read web pages. For non-native English readers, it is challenging to understand first-hand information written in English under time constraints. Traditional readability enhancement research has focused on enhancing reading comprehension and user satisfaction, but average reading times for non-native readers have remained the same or even worse [89]. It is challenging to enhance web page skimmability for non-native readers, but it is necessary for today's Web.

When using the Web on mobile devices, the reading situation becomes worse for everyone. Compared with the traditional Web browser on the desktop environment, the mobile Web browser has different limitations on devices, including inputs, outputs and computation power. There has been some research focused on redesigning device hardware and interaction to provide better user experience [29, 60]. However, the problems in mobile reading remain, such as reading text-heavy content on a small display while walking. Even worse, context switches, such as from walking to sitting, static standing, or hands-free situations like driving, happen in reading in on-the-go situations, but this scenario was not adequately addressed in previous studies [84, 67]. This raises another challenge: how do we help mobile users have a continuous reading experience while reading on-the-go with frequent context switches.

## **1.2 Solutions and Results**

### **1.2.1 Readability Enhancement**

In terms of web page readability enhancement, this thesis focuses on content presentation as opposed to content rewriting, font factors (size,color or type) or the contrast of page content , and proposes a new transformation method,

Jenga Format , to enhance web page readability. (Figure 1-1) Jenga Format is a content transformation that breaks traditional blocks of text into separated sentences with spacing. To evaluate the Jenga Format, I conducted a user study with 30 Asian users, who have moderate English fluency, on three conditions: Standard Format (SF), Visual-Syntactic Text Formatting (VSTF) [86] and Jenga Format (JF). The results indicated that the proposed transformation method, Jenga Format, improved reading comprehension without negatively affecting reading speed for non-native English readers. Furthermore, compared with Standard Format, Jenga Format makes the web page reading easier.

### **1.2.2 Skimmability Enhancement**

In readability enhancement project, I have successfully demonstrated the way to enhance web page readability for non-native readers without negatively affecting their reading speed. However, the results indicated that non-native readers' reading speed, about 2 words/second, is still relatively lower than native readers' normal reading speed, which is around 3.33-3.83 words/second [20]. In addition to reading speed, this thesis hypothesizes that non-native readers' reading comprehension is also relatively lower than native readers' under time constraints. I conducted a preliminary study with six users (3 non-native and 3 native) to understand this issue. The performance indicated that there was a 20% difference in reading comprehension between native and non-native users.

To enhance web page skimmability, I investigate useful techniques for non-native readers to use when reading web pages under time constraints, i.e., providing a good reading strategy to non-native readers. I propose four techniques to help non-native readers to skim read web pages: (1) content spotlight; (2) salient sentence selection; (3) contextual referencing; and (4) in-place translation. Content spotlight provides spotlighting effect to show main text content, and salient sentence selection differentiates important and unimportant sentences. Contextual referencing integrates semantic data to link name entities and their pro-

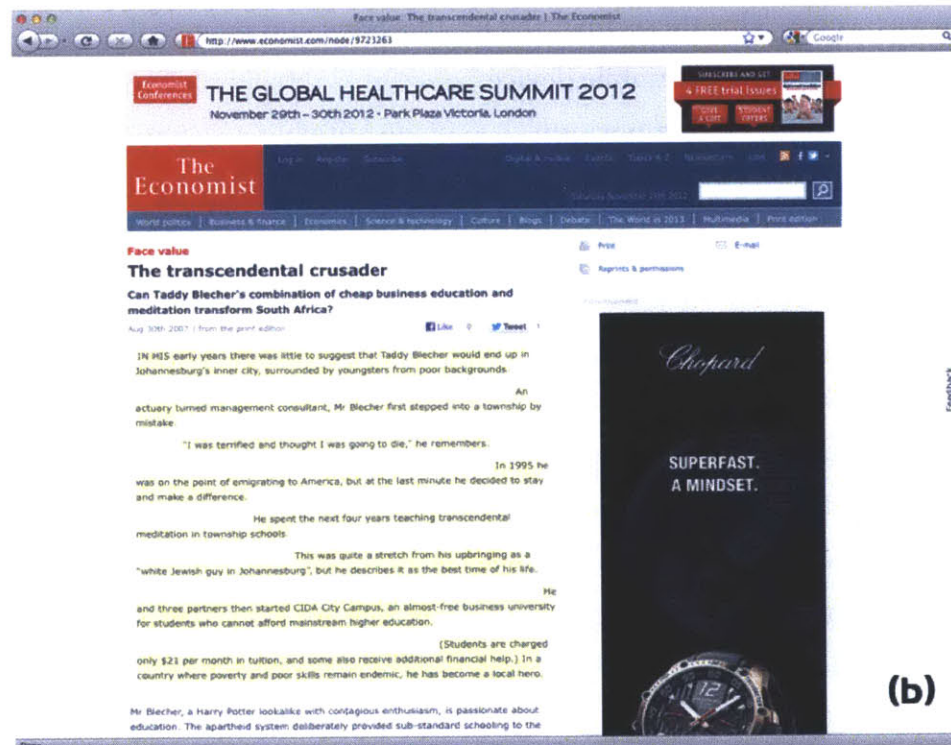


Figure 1-1: A comparison of reading a web page in (a) original format; and (b) Jenga format.

nouns into current viewing web page. Since it is difficult to know all vocabulary words for non-native readers, in-place translation provides an instant support in translation for reading. Froggy GX [3] is a prototype system that implements proposed techniques. (Figure 1-2)

A user study with 20 non-native Asian users showed that Froggy GX not only enhances non-native readers' reading comprehension (12% improvement), but it also improves the readers' satisfaction in ease of reading, self-evaluation of understanding and enjoyability of reading measurements.

### **1.2.3 Mobile Continuous Reading Support**

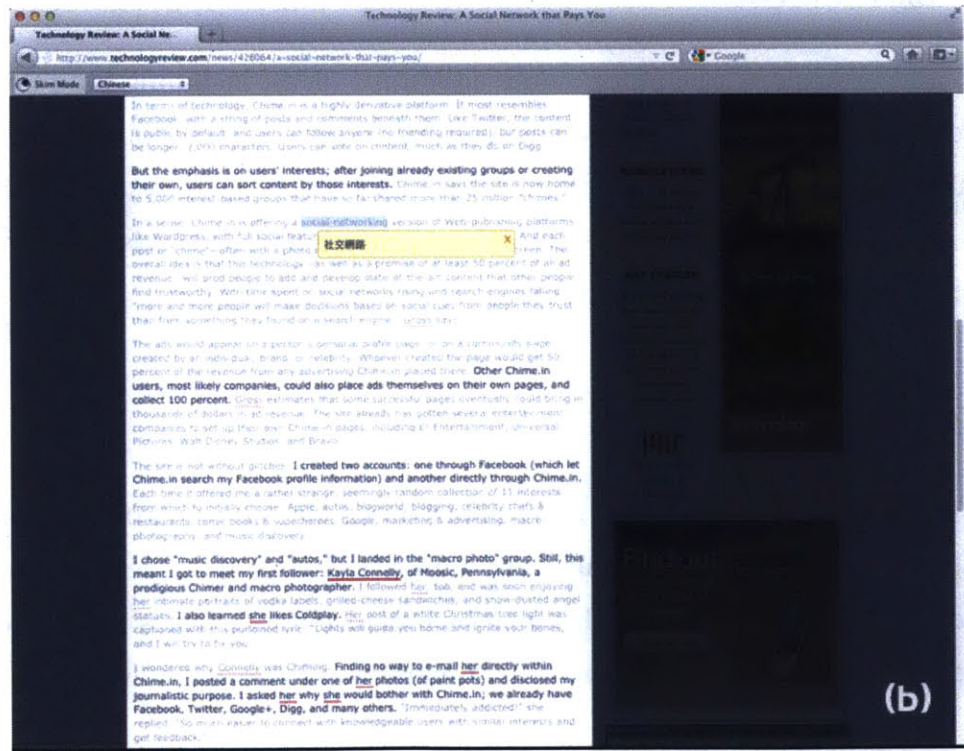
Although the web browser has become a standard interface for information access, mobile web reading remains a challenge because of the inherent limitations of mobility. One common challenge mobile users encounter is how to maintain reading fluency even when they switch activities, such as from sitting to walking or vice versa. This thesis investigates this issue and defines this scenario as continuous reading on a mobile device.

I detect mobile device position to provide automatic switching (or named auto-switching) between visual-reading and audio-listening to solve this issue. When the user is in a walking situation, he can listen to the content by using text-to-speech (TTS) technique and switch back to visual reading when the eyes are free, such as sitting or waiting at red lights. The corresponding reaction to the context switches is triggered automatically. To evaluate this approach to mobile continuous reading, I conducted a user study with 10 mobile users on four predefined conditions: visual-reading, audio-listening, manual-switching between visual and audio, and auto-switching between them. The results suggested that auto-switching not only provides the easiest reading experience, but it also results in significantly fewer missteps while walking, compared with visual-reading.

The Read4Me Browser [12] is a prototype system built to support the presented study, including manual mode switching and automatic mode switch-



(a)



(b)

Figure 1-2: A comparison of reading a web page in (a) original format; and (b) using Froggy GX.

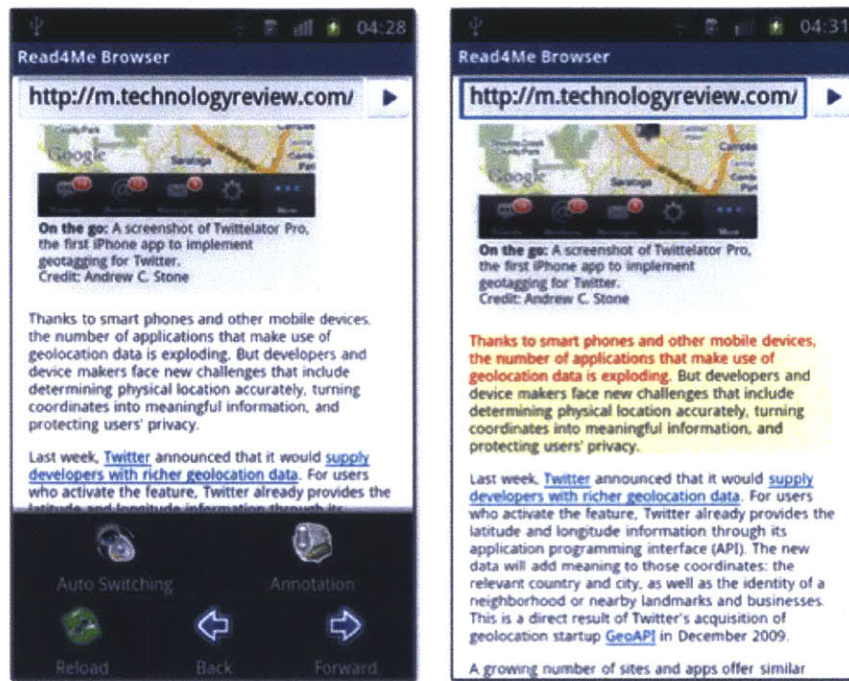


Figure 1-3: Left:Read4Me browser;Right: Reading web pages on the go.

ing, and extensions to support some additional ideas, including Line Control, Voice Annotation and Emoticon Highlighting. (Figure 1-3) Although a heuristic analysis-based algorithm is implemented to support automatic mode switching, a better solution with trained Support Vector Machine (SVM) classifiers was investigated and evaluation results are also presented in Chapter 5.

### 1.3 Contributions

This thesis hypothesizes that it is possible to enhance web pages on desktop and mobile browsers for two populations: non-native English readers and mobile readers. The thesis achieves this goal by enhancing web pages from three directions: readability enhancement, skimmability enhancement and continuous reading support on a mobile device.

This thesis supports the claim with three developed prototype systems and

evaluations: (1) Froggy: enhancing web page readability for non-native English readers with dynamic content transformation; (2) Froggy GX: enhancing web page skimmability for non-native English readers with content filtering and semantic data integration; and (3) Read4Me: providing continuous reading support on a mobile device for mobile readers with natural interactions. All of these three systems are evaluated with targeted users, and the results are presented and discussed in this thesis.

## 1.4 Outline

This thesis is organized as follows. Chapter 2 presents all literature studies related to this thesis, ranging from traditional reading, current web page reading, web page skimmability to reading on-the-go research. Chapter 3 introduces the research work of enhancing web page readability. Chapter 4 presents the research of enhancing web page skimmability and the *Froggy GX* system. Chapter 5 introduces a better way to support continuous reading on a mobile device and *Read4Me* mobile web browser. The discussion of conducted user studies on these three systems are organized in Chapter 6. Chapter 7 concludes this thesis with a few remarks and future work.

# Chapter 2

## Related Work

This thesis presents the ideas of web page enhancement on desktop and mobile browsers from three directions: readability, skimmability and continuous reading support on a mobile device. In this chapter, I will discuss the related work for each aspect respectively.

### 2.1 Web Page Readability

#### 2.1.1 Interaction Techniques

There has been much work in online reading focusing on new interaction techniques, such as navigation techniques for dual-display e-book readers [37], the Read's Helper reading environment [51] and active reading support [78]. These kinds of techniques are developed to support practices observed in fluent readers, such as annotation [22, 66], clipping [22, 61], skimming [42], fast navigation [66], and obtaining overviews [66].

Previous research has studied the effect of presentation changes and hyperlink appearance on reading. For example, Bernard et al. studied the effect of font type and size on the legibility and reading time [30], Boyarski et al. [34] and Dillon2006 [41] investigated the font type for screen reading and Gould et al. [50] tried to understand why reading was slow on CRT displays. In terms of hyperlink



appearance, De Ridder [40] found that the difference of using visible and invisible links for foreign language reading was only users' willingness to consult additional information. There was no difference in learning outcomes (vocabulary and comprehension). Zellweger et al. [91] tried to support hypertext browsing by adjusting typography to integrate additional information, but they found that users' preferences were complex and intense. The observation results could be used for the design of dynamic reading environment.

On the other hand, other work considers users with reading limitations, including children learning to read [63], users with visual impairments and/or motor impairments [23], users with dyslexia or other learning disabilities [81], and older adults with reduced eyesight [30]. For readability enhancement, I aim at a different population, i.e. non-native English readers.

### **2.1.2 Hypertext Reading**

In hypertext reading, there are some studies investigating factors related to web page reading. Protopsaltis et al. found that the reading goal did not influence reading times and comprehension score [71]. Bell's work [28] showed that if the subjects were exposed to extensive reading, i.e. exposed to regime of graded readers, which are books specially prepared for language learners [4], they could achieve a significantly faster reading speed and higher reading comprehension scores. On the other hand, Dyson et al. [46] studied the effectiveness of reading from screen. The results indicated that the overall comprehension will be reduced when reading fast, and a medium line length (55 characters per line) supports effective reading at normal or fast speed. In electronic documents, Hornbæk et al. studied the reading patterns and visualizations for reading [55]. The study indicates that different visualization user interfaces might be helpful in different conditions. For example, the fisheye interface is more appropriate for tasks where understanding the detail of the document is not the subjects' main purpose.

### **2.1.3 Paper Document Reading**

In paper document reading, Keshavarz et al.'s study of English-as-a-Foreign-Language (EFL) readers showed that there is a significant effect of content and EFL proficiency on reading comprehension and recall [58]. However, since O'Hara and Sellen's work [66] found that there is a difference between reading paper and on-line documents, more evidence is needed to verify if the effect still exists to on-line document reading. William's work provides another idea to enhance the comprehension [87]. Because textual cohesion is important to provide semantic relationships within a text, he proposed to recognize it by using arrow, rectangle, dot line and line such that the reader could interpret textual elements, which are tied. As William put it, "inter-element semantic cohesion is one of the major features that enables a fluent reader to distinguish text from a random string of discrete sentences." However, it takes time to annotate the content for reading. In readability enhancement project, one of my experienced transformations used in paper prototyping was inspired by William's work.

### **2.1.4 Tools for Readability Enhancement**

There are some tools for end-users to adjust web pages for readability enhancement, such as browser commands that change the font size, and browser extensions that remove or recolor sections of a page [11, 16]. Platypus [11] is a firefox extension that allows users to modify web pages and save those changes for future visit. Web Developer [16] is a browser extension for customizing web pages, such as disable JavaScript/CSS, hide images, outline frames/links/headlines, etc. Although manual actions are reasonable, such as pressing a hot key, on the specific content or region, too many options and complex design of the tool user interface will reduce the user's intention to use it when reading web pages. On the other hand, the Readability browser add-on [14] and iOS5 Safari Reader feature [6] provide an alternative solution to readability enhancement. Both of them offer one-click operation to remove distractions and show main text content ei-

ther in current viewing page or a popup window. However, the original web page layout is sacrificed for the simplicity and the readers cannot recognize where they are reading at in the original web page. Furthermore, the blocks of text are still difficult to read for some populations, such as non-native English readers and people with dyslexia.

Some studies investigate how to segment web pages on the semantic level [35, 83] or extract content structure from web pages [52], but none of them focus on readability enhancement on the user interface level. Richards et al. [73] proposed to have web content adaptations and transformations for specific populations. Different from other approaches, Walker et al. [86] used a visual-syntactic text formatting (VSTF) method to enhance online reading. VSTF is a new transformation method that transforms block-style text into cascading patterns to help identify grammatical structure. (Figure 2-1)

VSTF transformation uses two techniques: (1) computer-executed algorithms to analyze the content for syntactic structure, word difficulty and patterns of punctuation use, and specify formatting patterns; and (2) display text with indentation and different colors for easy reading. Basically, VSTF method breaks text into shorter rows (8 to 30 characters) and uses varied indentation to help the eyes read smoothly. A user study with 48 college students found that VSTF method increased reading comprehension and efficiency of reading online text. In addition, it also reduced eyestrain. Another long-term study with 100 ninth-grade students also found that VSTF method increased academic achievement and reading proficiency. Most of the students (73 out of 100) are native English speakers though. Jenga format is similar to VSTF, but Jenga format focuses on sentence separation and spacing in selected paragraph, which provides simpler implementation, better reading comprehension and better user satisfaction for reading web pages. (Please refer to Chapter 3 for the details)

**When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.**

**(a)**



**When in the Course  
of human events,  
it becomes necessary  
for one people  
to dissolve the political bands  
which have  
connected them with another,  
and to assume  
among the powers  
of the earth,  
the separate and equal station  
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and of Nature's God  
entitle them,  
a decent respect  
to the opinions  
of mankind  
requires  
that they  
should declare the causes  
which impel them  
to the separation.**

**(b)**

Figure 2-1: VSTF converts a block of text, such as the first sentence from the U.S. Declaration of Independence, to cascading patterns: (a) original format; and (b) VSTF format. [86]

## 2.2 Web Page Skimmability

### 2.2.1 Reading Strategies

People use different strategies in reading for different purposes. These strategies include *linear reading*, *speed reading*, *scanning* and *skim reading*. When reading important information, readers use *linear reading* to read content word-by-word, line-by-line and sentence-by-sentence. The normal *linear reading* speed of native readers is around 200-230 words/minute [20]. To increase reading speed without reducing reading comprehension significantly, *speed reading* (> 400 words/minute) is a technique some readers use, but it takes time to learn and master this skill.

When readers already have questions in mind and look for specific information in the content, they perform *scanning* on the content for this information, such as looking for a phone number from a phone book or finding a specific word in a dictionary. In contrast, *skim reading* is a process where readers do not have any particular information to look for and select parts of the text to read, but the selection strategies vary among readers. Some readers might choose first and last paragraphs, but some might read only the first few sentences of each paragraph. Masson's work indicated that when readers are required to skim read narratives and newspaper stories, the recognition of important and unimportant information declined equally [62].

### 2.2.2 Skim Reading on the Web

Because there is excessive information to read on the Web, more and more people skim-read web pages rather than read them in detail [42, 43]. Recently, researchers have investigated the behavior of skim reading on the Web, such as Nielsen's eye-tracking study with 232 users on thousands of web pages [65] and Duggan and Payne's analyses of readers' eye movements as they skimmed through expository text under time constraints [44].

Duggan and Payne's work not only confirmed Masson's study, but also con-

cluded that skim readers can successfully read the most important text by using a *satisficing* strategy, which means reading text and skipping to next section of text when the information gain drops below certain threshold. In addition, Duggan and Payne suggested a few possible strategies that skim readers can use, such as the F-shape viewing pattern found by Nielsen [65]. However, all of these results are learned from studies with native readers. It is not clear if non-native readers use similar strategies in skim reading or, to ask a more fundamental question, do non-native readers know how to skim read web pages at all?

## **2.3 Mobile Continuous Reading**

### **2.3.1 Visual Reading on Mobile Devices**

In digital era, reading is a common activity people perform on computers and mobile devices. Previous research showed that the difference between personal computers (PCs) and mobile devices affects users' performance in reading and navigation behaviors [25, 57]. Bao et al.'s work [25] found that the users' reading speed was slower on the phone than on the computers, and users performed more standard work on their computers than on smart phones, such as reading email, documents and calendar,

Roto and Kaikkonen's work [75] found that the users are delighted to read web pages on a mobile device, but a limited display was an issue. Compared with the full size display on a traditional computer screen, Sanchez's study showed that there is a deficit in reasoning performance when using a small display [77]. Although previous research has shown that people use web services while moving from place to place, mobile users have a short attention span on a mobile device due to frequent context switches [67], which makes reading articles, such as web pages or e-books, difficult on a mobile device.

### 2.3.2 Techniques for Audio Listening on Mobile Devices

Reading a document or a web page with audio listening on a mobile device is not new, but researchers are still investigating how to improve audio quality. Text-to-Speech (TTS) is the most common technique used to support audio listening, and its support on mobile devices is increasing. For example, since version 1.6, Android starts to provide a TTS feature which can be used in mobile applications for different purposes, such as translation, document and screen reading, etc. The iPhone SDK does not support TTS natively, but different third party APIs are available, such as iSpeech and Flite.

Vadas et al.'s work investigated mobile users' performance in text comprehension while mobile [84]. Four conditions were studied: audio-walking, audio-sitting, visual-walking and visual-sitting. The results of a user study with 20 participants found that participants' comprehension for audio-walking condition was comparable to the visual walking condition. In addition, audio interface allowed participants to navigate environment better, and were less demanding than visual reading while walking. However, there is no clear suggestion of how to combine the audio modality with visual presentations for general mobile users. My mobile continuous reading user study was modeled by Vadas et al.'s work, but there still existed many differences between my study and theirs. (Please refer to Chapter 5 for the details.)

Audio modality for reading on-the-go was suggested by Vadas et al. and text-to-speech (TTS) was a technique widely used nowadays. The design of screen readers mainly uses TTS to assist visually impaired people to access information on the Web, such as WebAnywhere [31], aiBrowser for Multimedia [57] and HearSay [72]. On mobile devices, a screen reader is a solution for sighted people to access information in a hands-free condition, such as cooking or driving. However, screen readers on mobile devices, such as Apple's accessibility tool - VoiceOver [1] and Code Factory's Mobile Speak [8], still encounter a challenge of having human quality expressive speech. My mobile continuous reading project

uses Android's TTS, which has the same challenge as well.

Although Odiogo [9] is a web service that transforms blog posts and sites into near human quality audio speech, it cannot be used in real time inside mobile applications. SeeReader [36] is a mobile document reader that combines TTS with automatic content recognition and presentation control to notify users of important visual content while listening to the content. However, it does not focus on supporting continuous mobile reading with frequent context switches, which happen frequently as people use mobile devices in their daily lives.

### **2.3.3 Mobile Interaction Techniques**

A number of interaction techniques have been explored to provide better reading experiences, such as tilt and flick for scrolling [48], physical orientation for exploring music [29], gesture recognition [56, 68], activity recognition [24, 56] and foot gestures [79]. Most of them use accelerometer to achieve the goal. For example, Fitchett et al.'s tilt scrolling method is controlled by using accelerometer [48], Bergman et al.'s Garvity Sphere continually read accelerometer output and filtered the data for exploring music [29] and Scott et al. used acceleration data with a machine learning approach to recognize gestures [79].

In addition to accelerometer, there are different kinds of sensors available in mobile devices nowadays, including gravity sensor, gyroscope sensor, light sensor, magnetic field sensor, Near Field Communication (NFC) sensor, orientation sensor, pressure sensor, proximity sensor and temperature sensor [59]. In my mobile continuous reading project, I detect the pose of a mobile device by using orientation sensor, which is simulated by combining magnetic and accelerometer sensors at the driver level by Android OS.



# Chapter 3

## Enhancing Web Page Readability

On today's primarily English-language Web, non-native readers (whose first language is not English) encounter problems, even if they have some fluency in English. Problems include unfamiliar vocabulary, complicated grammatical structure, and long, crowded, or otherwise intimidating content display. Distracting content, such as ads, animations, logos, videos, and photographs, is constantly competing for the user's attention. Poor color contrast, tiny fonts, and unreadable font faces interfere with comfortable reading [69]. All of these problems hinder non-native readers from reading the content fluently.

This thesis defines Web page readability as a combination of reading comprehension, reading speed and user satisfaction. In terms of reading comprehension, dictionary, thesaurus, and translation support were already provided by many existing online tools and browser add-ons. This research focuses instead on the presentation of content to enhance reading comprehension and user satisfaction for non-native readers. This is similar to the work of Walker et al. [86] who developed a visual-syntactic text formatting (VSTF) method to enhance online reading, but the transformation format this thesis proposes is easier to implement and can provide flexible interaction design for reading web pages. I conducted a user study with 30 Asian users to investigate the effect of these transformations on web page reading. The results of the user study indicated that the transformation enhanced reading comprehension for these users, as well as

making the web pages feel easier to read.

In the rest of this chapter, I explain the motivation and reasons of the proposed transformation. The detailed user study procedure and the results are also presented and discussed.

### **3.1 Transformations and Jenga Format**

I conducted an iterative paper prototype study to understand what kind of transformation of the content makes reading easier for native and non-native users. 28 users joined this study. In this study, I had a paper prototype to display the content in 7 different formats, including 1 standard format and 6 different transformation formats. Figure 3-1 illustrates 3 examples of paragraph transformations as paper prototypes.

The preliminary study suggested two important factors affecting reading speed and comprehension – sentence separation and sentence spacing. Sentence separation breaks blocks of text into sentences, whereas sentence spacing provides more spaces between sentences in presentation. This finding inspired this research to enhance web page readability by transforming web page content for the readers.

Conventionally, most web pages display the content in traditional paragraph format (Figure 3-2), which this research calls Standard Format (SF). Although this format is good at packing text content in limited space and readers are familiar with it, the standard format has some disadvantages. For example, readers may jump back to the wrong line when they finish reading a line and continue to the next line. Because the text is dense, it is easy to miss the main idea when reading a long article. It is especially difficult for non-native readers to read and understand lengthy paragraphs because they may need to identify syntactic structures [86] or mentally translate the content to their native language.

Researchers have proposed alternatives to the standard format. A notable method is visual-syntactic text formatting (VSTF) [86], which was proposed by



Cloud computing--the idea of relying on Web-based applications and storing data in the "cloud" of the Internet--has long been touted as a way to do business on the road. Now software companies are making entire Web-based operating systems. Built to work like a whole computer in the cloud and aimed at a wider audience, these browser-based services could help those who can't afford their own computer.

Having the look and feel of Microsoft Windows or other popular desktop programs, the Web-based operating systems bring together a selection of integrated Web-based applications that typically run with Flash or Java. Users can choose to save data locally or on the Internet. Joshua Rand, the CEO of Sapotek, which makes [Desktop Two](#), says that a major goal of an online desktop is to get the collection of applications working together: "It's not a Tower of Babel desktop. It's entirely fluent." Desktop Two uses a number of open-source applications, including Open Office as its productivity suite.

Once a useful group of applications are collected in a familiar format, cloud computing becomes more accessible to people who aren't comfortable tracking down a series of individual Web applications and combining them, Rand says. Desktop Two's service is free for individuals, although a small scroll bar of ads appears at the top of the screen. The company launched its Spanish-language version, [Computadora.de](#), in Mexico in 2003, three years before launching in the United States. Rand says that he and his business partner, Oscar Mondragon, who lives in Mexico, had observed while traveling that in spite of socioeconomic differences that determine whether individuals own computers and how much bandwidth they have, people were using the Internet everywhere, including in Internet cafes and libraries. With

Figure 3-2: Standard Format (SF)

Walker et al. to replace the block-shaped text of the standard format with a cascading pattern to help readers identify grammatical structure and increase reading comprehension. VSTF transformation uses two techniques: (1) computer-executed algorithms to analyze the content for syntactic structure, word difficulty and patterns of punctuation use, and specify formatting patterns; and (2) display text with indentation and different colors for easy reading.

VSTF transformation breaks text into shorter rows (8 to 30 characters) and uses varied indentation to help the eyes' movement. Walker et al. conducted two studies on VSTF method. The first user study with 48 college students found that VSTF format increased reading comprehension and efficiency of reading on-line text, and it also reduced eyestrain. Another long-term user study with 100 ninth-grade students found that VSTF format increased academic achievement and reading proficiency. However, we found that if you apply this method to web pages, it expands the length of the page enormously. Also, users need to be familiar with the cascading pattern to know how to interpret the sentence. Figure 3-3 shows an example of using Clip Read software to read content in VSTF format.

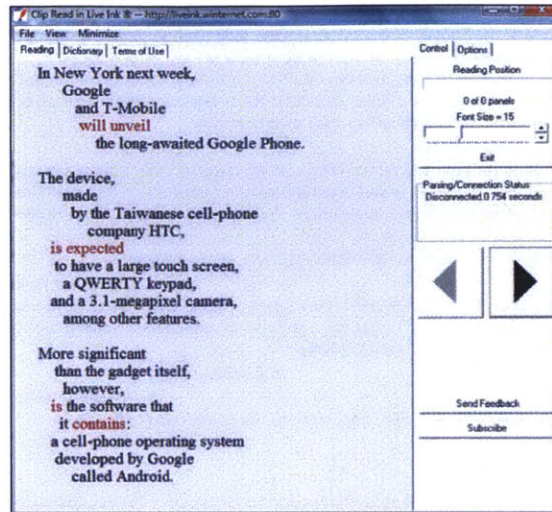


Figure 3-3: Using Clip Read software to read content in visual-syntactic text formatting (VSTF) format [86]

Jenga format is similar to VSTF, but Jenga format focuses on sentence separation and spacing in selected paragraph, which provides simpler implementation, better reading comprehension and better user satisfaction for reading web pages.

### 3.1.1 Jenga Format

Based on the two factors found from the paper prototypes, this research designed a new transformation approach, which divides a paragraph into sentences and inserts whitespace between them, using the ideas of sentence separation and sentence spacing found above. When the user clicks on a specific paragraph of a web page, the indicated paragraph is converted into separated sentences, starting in the same place horizontally, but these sentences have more space in between. The expanded paragraph turns back to the original format if a user clicks it again. The format is named Jenga because the gaps between interlocking sentences are reminiscent of the Jenga puzzle game (Figure 3-4).

One advantage of this transformation is that it highlights the paragraph in yellow, helping the reader focus on it even if they are reading a long and crowded

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Figure 3-4: Jenga Format (JF) transformation

article. In addition, because sentences start in the same place horizontally and are separated with space in between, the reader can read one sentence at a time without breaking the continuity of the reading.

The final design of keeping the start of each sentence where it is was motivated by the observation to my primitive design, which separated all sentences and aligned them to the left automatically. Although aligning all sentences to the left makes the presentation clean and organized, it forces the reader to move their eyes to the left margin every time when they finish reading a sentence, which interrupts the continuity of reading in the paragraph. To solve this problem, the final design of Jenga format inserts space between sentences without changing their shape.

## **3.2 User Study**

To understand the effect of content presentation transformation, this research designed and conducted a formal user study to investigate the effect on non-native users. The study was conducted from April 2008 to February 2009.

### **3.2.1 Hypotheses**

I have following hypotheses and hope to find the answers from this user study.

1. I expect the transformation of content presentation to slow down reading speed, because it might not be the format readers are familiar with.
2. For non-native readers, the transformation of content presentation will provide greater personal satisfaction when reading web pages.
3. Compared with standard content presentation, the transformation will enhance web page reading comprehension.

### **3.2.2 Procedure**

The study has three conditions, the different transformation methods: Standard Format (SF), Visual-Syntactic Text Formatting (VSTF) and Jenga Format (JF).

In order to have a sampling from the population of Asians living in the Boston area, the subject recruitment was based on posting flyers and sending emails to different schools in Boston Area to look for Asian users, who have been lived in U.S. less than 5 years and whose first language is not English. I looked for users who are able to read English web pages, defined as those whose TOEFL score is higher than 500 out of 677. The user study was a within-subject study, conducted one participant at a time. The laboratory setting was a quiet environment with a single laptop and a mouse, which is fairly similar to reading at home or in an office environment.


The content of the study are six web pages. Three of them were selected from a technical web site (Technology Review) and the other three were selected from a business web site (Economist). On average, there were 935 words (SD=66.7) per web page. The study procedure was automated by using a Chickenfoot script [33] and it works as follows. The user spent 2 to 3 hours to read six web pages sequentially, and there was a 5 minute break after reading two web pages. The user study included not only reading web pages, but also obtaining informed consent, describing the procedure, answering questionnaires, and having an after-study interview. Users spent an average of 10.81 minutes reading each web page, and there was 21.63 minutes of reading between breaks on average.

The users were informed that they did not have any time limit to read the web pages, but we recorded the reading time for the analysis. Each web page had a corresponding questionnaire page, which showed up when user clicked “Done Reading” button at the end of the page. When the user jumped to the questionnaire page to answer questions, he or she could not go back to the original web page to look for answers. When reading web pages under transformation conditions, users click on a paragraph to read it in transformed format. (Figure 3-5) For comparison in the user study, the background color was also added to the VSTF transformation. (Figure 3-6)

After reading each web page, two kinds of questions in the questionnaire were asked. The first part contains questions testing comprehension of each web page and the second part contains questions related to readers’ subjective feeling (Figure 3-7).

The comprehension part of the questionnaire had 5 single selection questions. Each question had 5 options and the types of questions were similar to Dyson and Haselgrove’s [46, 45], including Main Idea, Structure, Main Factual and Incidental. In addition, I added a new type of question, Reasoning, to increase the difficulty. However, in the questionnaire, I didn’t add type information, such as main idea, structure, main factual, incidental and reasoning, before each question. (Figure 3-7(a)) Please refer to appendix for the details.





**Gabby gadgets:** SILVIA is a new platform designed to let computers, cell phones, toys, and other gadgets carry on realistic conversations with people. Cognitive Code, the company that created SILVIA, is initially targeting toy manufacturers. Here, the interface for SILVIA is represented by a woman's face on a laptop screen. Credit: Cognitive Code

**MULTIMEDIA**

- Click here to see an early version of SILVIA interact with Cognitive Code.

A new company called [Cognitive Code](#) has built software that it believes will let everyday gadgets talk with humans. At the Techcrunch40 conference in San Francisco on Monday, the startup unveiled a developer's studio with a set of algorithms that convert strings of words into concepts and formulate a wordy response. The developer's studio could let businesses, such as cell-phone manufacturers and toy makers, use the technology to add conversational abilities to a product.

Instead of composing an e-mail on a PDA, says [Leslie Spring](#), the company's chief technology officer, imagine instructing a handheld to "send an e-mail to Tom and tell him 'I'll be there in 10 minutes.'" Spring says that such a feature could be possible with the algorithms--based on 15 patents--that Cognitive Code has developed.

The problem that the company is tackling is called natural-language processing, and it's been the subject of intense research at world-renowned research labs for decades.

Some computer programs are already able to parse basic information from inputs that don't match exact commands.

Well-known examples are chatbots such as [Alice](#) and [Jabberwacky](#), programs that simulate a conversation via text input.

Spring claims that Cognitive Code's product, SILVIA (which stands for symbolically isolated, linguistically variable intelligence algorithm), is more advanced than chatbots for a couple of reasons. First, SILVIA

Figure 3-5: User clicks on a paragraph and read it in JF transformation

Cloud computing-- the idea of relying on Web-based applications and storing data in the "cloud" of the Internet-- has long been touted as a way to do business on the road. Now software companies are making entire Web-based operating systems. Built to work like a whole computer in the cloud and aimed at a wider audience, these browser-based services could help those who can't afford their own computer.

Having the look  
and feel  
of Microsoft Windows  
or other popular desktop programs,  
the Web-based operating systems  
bring  
together a selection of integrated  
Web-based applications that typically run  
with Flash or Java.

Users  
can choose  
to save  
data locally  
or  
on the Internet.

Joshua Rand,  
the CEO  
of Sapotek,  
which makes Desktop Two,  
says that a major  
goal of an online desktop  
is to get  
the collection of applications  
working together:

Figure 3-6: Visual-Syntactic Text Formatting (VSTF) transformation

The subjective part of the questionnaire had 2 questions (Figure 3-7(b)), which were similar to Walker et al.'s [86] survey on VSTF, but we used 7-point Likert-scale degrees from very difficult (scale 1) to very easy (scale 7) instead of using Walker's scale degrees, i.e. disagree, uncertain, agree, to each defined question.

The first part was graded based on the number of correct answers, and the second part used the satisfaction score users selected (ranging from 1 to 7). In each test round, the web pages were presented in a random order, and two consequent pages used the same transformation method, which was also selected in a random order. The transformation methods selected in a random order are used to eliminate the concern that fatigue might affect the performance of reading.

In order to observe the user's reading behavior and ask questions related to the observation, the study was not conducted on the Web. The study was observed by an experimenter sitting beside the user, but the experimenter only ob-

**(a)**

**Part 1:**

1. What's the main purpose of this article?
  - Introduce a company's product which can let human talk to the gadgets.
  - Explain why natural language cannot be used to control device.
  - Discuss why vision can be used in a computer.
  - Show the latest technique in the health care system.
2. Which one of the following is true?
  - The problem that Cognitive Code is tackling is called natural information process.
  - Chatbot programs, such as Alice and Jabberwacky, can simulate a conversation via text input.
  - Chatbot is more advanced than SILVIA.
  - None of the above
3. Why people suspect Cognitive Code's claim about SILVIA's portability?
  - It's still unclear how easy it will be to plug SILVIA into any system.
  - It only takes few hours to put SILVIA into each platform.
  - SILVIA is not as good as a chatbot.
  - SILVIA is too large to be put into any system.
4. Initially, what market does Cognitive Code target on?
  - Toy market
  - Health market
  - Business market
  - Personal device market
5. Which one is false about SILVIA?
  - It is built by Cognitive Code to let everyday gadgets talk with human.
  - It can remember and understand the context of a conversation.
  - You cannot speak to SILVIA using whatever phrase you want.
  - The company claims that SILVIA's core algorithms can be implemented into different devices.

**(b)**

**Part 2:**

A1: How easy was it to read this web page?

Very Difficult			Normal			Very Easy
1	2	3	4	5	6	7
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

A2: How well did you understand this web page?

Very Difficult			Normal			Very Easy
1	2	3	4	5	6	7
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 3-7: Questions from the user study: (a) example questions of the comprehension part; and (b) the complete set of questions for the subjective part.

served and took notes without answering questions related to the content. After the whole test, a face-to-face interview was conducted to collect additional feedback from the users.

### 3.2.3 Users

There were 30 users joining our study: 14 males and 16 females. All the users were Asians whose first languages are not English. On average, the users were 25.2 years old and spent 3.2 years in the U.S.

On average, users spent 13.1 years to learn English, and more than 85% of the users have moderate English fluency. (We use ETS TOEFL score comparison table to do the comparison.) [15] The users were moderately fluent in English and had learned English for more than ten years. Table 3.2.3 to 3.2.3 are the analyses of all users' English language background, education, nationality and major.

English background	Number of users	Percentage
TOEFL 600-677	4	13%
TOEFL 550-599	15	50%
TOEFL 500-549	2	7%
SAT CR 700-750	1	3%
SAT CR 550-600	4	13%
Unknown	4	13%

Table 3.1: Analysis of all users' language background

Education	Number of users	Percentage
Ph.D.	1	3%
Master	11	37%
Bachelor	12	40%
High School	6	20%

Table 3.2: Analysis of all users' education

Nationality	Number of users	Percentage
Taiwan	9	30%
China	8	27%
South Korean	6	20%
Hong Kong	2	7%
Vietnam	2	7%
Philippines	1	3%
U.S.A. <sup>1</sup>	1	3%
Japan	1	3%

Table 3.3: Analysis of all users' nationality.

### 3.2.4 Results

The results of the user study are illustrated in Figure 3-8 to Figure 3-12. Figure 3-8 shows the average reading speed of all users and Figure 3-9 illustrates the average comprehension score on the web pages. Because a higher comprehension score might come from spending a longer reading time, to lower a concern in reading time and understand the performance of information learning for each reading method, I analyze the average comprehension score per unit time and show it in Figure 3-10. Figure 3-11 and 3-12 are the results of subjective questions rated by all the users.

<sup>1</sup>This user was born in the U.S. and moved to another country in early age. His first language is not English.

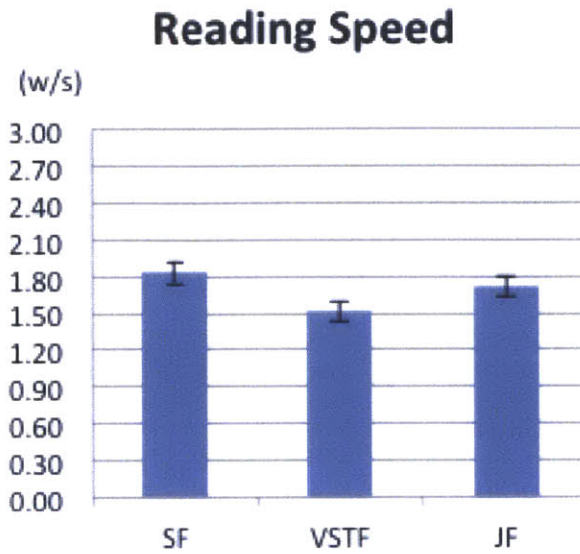


Figure 3-8: Reading speed for each condition, in words per second. Error bars show standard error

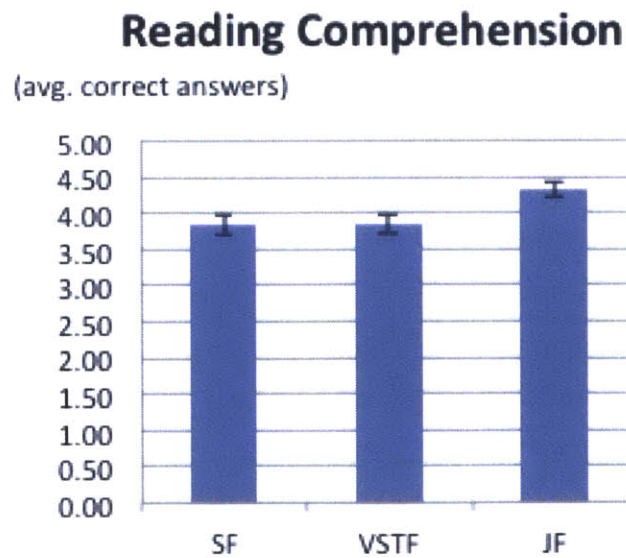


Figure 3-9: Comprehension for each condition (measured by number of correct answers to a 5-question quiz about the article)

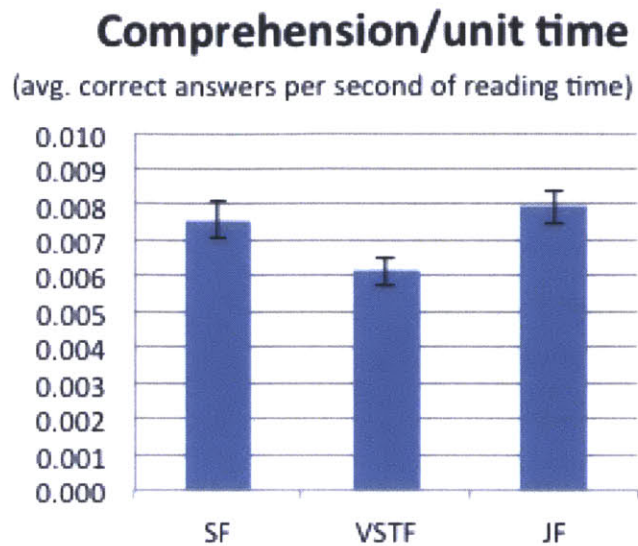


Figure 3-10: Comprehension per unit time (measured by number of correct answers per second of reading time)

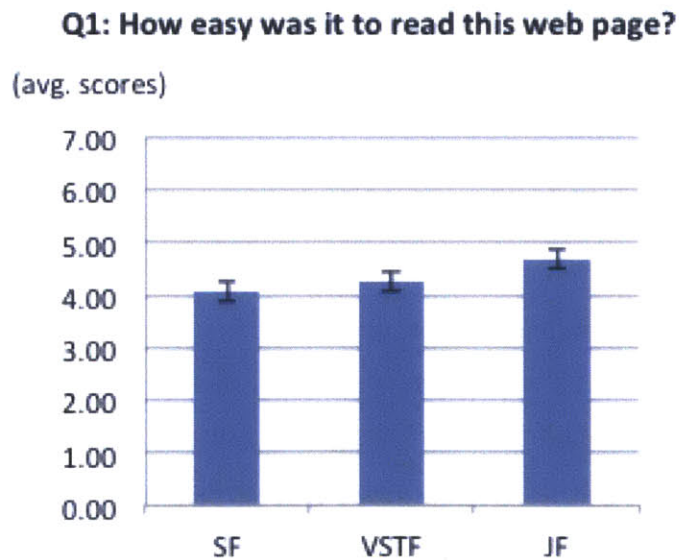


Figure 3-11: Ease of reading (rated on a scale from 1=very difficult to 7=very easy)

Major	Number of users	Percentage
Business	8	27%
Engineering/Science	7	23%
Medical/Health/Nursing	4	13%
Literature (Language)	3	10%
Psychology	2	7%
Economy/Finance	2	7%
Accounting	1	3%
Laws	1	3%
International Relations	1	3%
Unknown	1	3%

Table 3.4: Analysis of all users' educational background

The one-way analysis of variance (ANOVA) is used to analyze the data. The results indicate that there is a significant difference between SF, VSTF and JF on reading speed ( $F_{2,177} = 3.35$ ,  $p < 0.05$ ) and comprehension ( $F_{2,177} = 4.62$ ,  $p < 0.05$ ). A post-hoc Tukey analysis shows that reading with SF is significantly faster than reading with VSTF ( $p < 0.05$ ). In addition, a post-hoc Tukey also shows that reading with JF provides significantly better reading comprehension than reading with SF or with VSTF ( $p < 0.05$ ). It means reading web pages with JF, which divides a paragraph into sentences and inserts space between them, provides the best reading comprehension among all conditions.

There is also a significant difference on the first subjective question, i.e. How easy was it to read this web page? ( $F_{2,171} = 3.13$ ,  $p < 0.05$ ) A post-hoc Tukey analysis shows that reading with JF is significantly easier than reading with SF ( $p < 0.05$ ) and reading with VSTF is also significantly easier than reading with SF ( $p < 0.05$ ). This result indicates that reading web pages with SF is not as easy as reading with JF or with VSTF. However, I don't see any significant difference on the second subjective question: How well did you understand the web page?



## Q2: How well did you understand this web page?

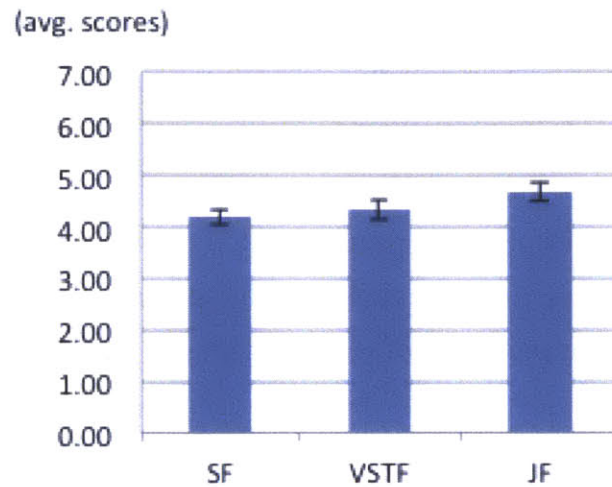


Figure 3-12: User's self-evaluation of understanding (measured on a scale from 1=very difficult to 7=very easy)

There is also a significant difference between SF, VSTF and JF on comprehension per unit time ( $F_{2,177} = 4.33, p < 0.05$ ). A post-hoc Tukey test gives an honest significant difference of JF over VSTF and of SF over VSTF on comprehension per unit time ( $p < 0.05$ ). There are two interpretations to this result. First, it means VSTF has the lowest performance of information learning among all conditions. Second, although JF provides the best reading comprehension, this performance does not come from spending a longer reading time. On the other hand, there is no honest significant difference of JF over SF on comprehension per unit time. Part of the reason may be that the increase of the reading time of using JF balances the comprehension score.

When observing the user study, I also noticed some interesting behaviors many users did for their reading. For example, some users always move the mouse cursor to the position of the sentence that they were reading. Some users used the mouse to highlight the whole paragraph when reading in original format (SF). The most repeated behavior observed is that many users read lengthy paragraphs

repeatedly.

There were many interesting comments from the users when I interviewed them after the study. For example, many users mentioned that SF format is too crowded and hard to read, especially on a lengthy page. In addition, the SF format felt very uncomfortable to their eyes and brain. However, for the VSTF format, there were conflicting opinions. Some users liked its segmentation of the sentences and the color scheme applied to the subject and verb, but others complained about its frequent segmentation of the sentence. In the observation, although I noticed that repeat reading on paragraphs or the whole article was a common behavior, it was not specifically happening more on any transformation.

For JF format, there are more positive comments. For example, one subject said “I think it would be helpful for readers to understand the meaning of the article. Also, readers can easily find what the article emphasizes.” Another subject said “When I see a sentence, I can roughly know the meaning. Then, when I read each word, I can know it more what it wants to explain. I can see each sentence clearly.” However, one subject said “It helps to separate the content. But I don’t like the format because it seems like to make the sentence longer,” and another subject said “[It is] hard to connect the previous sentence. Maybe that is because I get used to the normal format.”

Based on the results of the user study, I can answer questions proposed in Hypotheses section.

1. The transformation of content presentation enhances web page readability to Asian readers.
2. The transformation matters. JF transformation is better than SF and VSTF transformations in reading comprehension.
3. Compared with SF format, reading JF transformation content does not negatively affect the reading speed of Asian users, but reading with VSTF transformation make the reading speed slower.

4. In general, JF transformation makes web page reading easier than SF format.

### 3.2.5 Post-study Interview

In addition to the quantitative study presented in the previous section, I also conducted a post-study interview with these 30 non-native readers to have their feedbacks.

There were 20 users (67%) that ranked Jenga Format as the best way to read web pages, 7 users (23%) that voted for VSTF Format and 3 users (10%) that voted for Standard Format. A common issue reported by users is that Standard Format is not always easy to read, and VSTF Format has a lengthy presentation.

*"[Standard Format] English is not my native language, so I need more space line by line. Because space makes me feel more comfortable."*

*"[Standard Format] As a foreigner, I feel much more burden to read the long story compared with [VSTF Format] and [Jenga Format]"*

*"[Standard Format] Whole paragraph makes me [feel] complicated. So I should read the whole paragraph one time and re-read the same paragraph again"*

*"[VSTF Format] Too many separations. My ideas will be blocked sometimes"*

*"[VSTF Format] I felt very distracted by reading the shortened width of the sentence. But, it seems like bring my attention to the key points of each blob."*

Users also commented on the experience of using Jenga Format to read web pages:

*"It [Jenga Format] is easier to read than the block format (Standard Format)."*

*“Overall, the way that [Jenga Format] offers is the most comfortable arrangement.”*

*“From my point, I find it [Jenga Format] is a better way to read. It [Jenga Format] can speed up the reading to some extent and I can get more information.”*

*“[By using Jenga Format] I can focus on the article more compared to [VSTF Format] and [Standard Format]. (I like it [Jenga Format] most)”*

However, not all users are satisfied with Jenga Format.

*“To some paragraph, it is segmented well and I can read faster. However, to some paragraph, it is not segmented well and hard to read.”*

*“There are some difficulties in this method to read through and to understand it.”*

*“It [Jenga Format] makes the article longer [than Standard Format].”*

*“... since there are no highlights (sentences are separated), it is not easy to find some specific information after reading.”*

There are a few enhancement ideas suggested from the users, including:

1. highlight/bold the main ideas (5 users)
2. highlight or underline particular vocabularies or important keywords (5 users)
3. make markings or write reminders (4 users)
4. have a dictionary of vocabulary and terminology definitions (4 users)
5. attach some related pictures aside or at the end of the paragraph (3 users)
6. make the font bigger when reading the paragraph (2 users)
7. transform a paragraph to note list

8. provide story highlights
9. provide history flowchart
10. provide a summary of scientific concepts
11. have a lighter contrast (yellow color is good)

Jenga format is designed to provide web page readability enhancement, but it has some limitations. First, if the web site contains a lot of multimedia content, such as audio, video and animation, this kind of content can not be transformed into a better reading or watching format. However, this is an interesting research topic for future work. Second, Jenga format is helpful for reading web pages with dense content, such as narrative or lengthy web pages, but if each paragraph only has one sentence, Jenga format might not be helpful. In fact, a paragraph with only one sentence might not be a problem to non-native readers.

Although the user study with 30 Asian users showed that Jenga format can enhance web page readability for non-native readers, one important issue was that non-native readers' reading speed was slow. Compared with 200-230 words/minute for native readers [20], my study found that non-native readers' reading speed is about 108 words/minute, i.e. the non-native readers' reading speed is only half of native readers'. However, information overload on the Web and limited reading time force users to skim-read web pages, rather than read them sentence by sentence. It is still challenging for non-native readers to understand first-hand information written in English under time constraints, but it is necessary for today's web.

### **3.3 Conclusion**

In this research, I found that when users try to read information on the Web, they suffer from unnecessary distractions and web page readability issues. For non-native users, a lengthy web page makes reading more difficult. In this chapter,

I tried to solve these problems from two directions: distraction elimination and content transformation. Based on the paper prototype studies, two important factors were found affecting reading: sentence separation and sentence spacing.

In the user studies, this research focused on investigating the effect of transformations to web pages for web page readability enhancement. I designed a user study to verify the assumption: the transformation of the web page content can enhance the reading comprehension to the users, especially to Asian non-native users. There were 30 Asian users participating in the user study, and the study showed promising results that JF transformation proposed in this research can enhance the web page reading comprehension to Asian users. Another advantage of the transformations proposed is that the reading speed does not have a significant difference compared with the original reading, i.e. SF format.

## Chapter 4

# Enhancing Web Page Skimmability

While there are about 328 million people in the world speaking English as their native language, there are up to 1.4 billion people speaking English as their second language [58]. Although the Web offers an enormous set of reading materials, UNESCO's report in 2009 showed that more than 41% of web pages were written in English [70]. People speaking English as their second language (*non-native readers*) often need to read English web pages. For example, they might need to read first-hand information from English-speaking countries, such as the United States, or may have jobs that require them to understand English on the Web. In the past, reading English web pages has been identified as a difficult task for non-native readers, and researchers have tried to enhance web page readability for this group of users [87, 89]. However, since there is excessive information to read on the Web, more and more people skim-read rather than read web pages in detail [42, 43]. Unfortunately, skim reading of English web pages is not a common skill among non-native readers.

This thesis defines skimmability as a combination of reading comprehension and user satisfaction under time constraints. To understand the difference in skimming performance between native and non-native readers under time constraints, we conducted a preliminary study. The results showed that native readers are 20% better than non-native readers in reading comprehension under time constraints, as explained below.

In this chapter, I focus on investigating useful techniques to enhance web page skimmability for non-native readers. I propose four techniques to enhance web page skimmability: (1) content spotlight; (2) salient sentence selection; (3) contextual referencing; and (4) in-place translation. Both content spotlight and salient sentence selection help non-native readers focus on reading filtered content. Contextual referencing integrates semantic data to provides quick inferring. In-place translation supports readers to check unknown words or phrases in their native language easily.

Froggy GX (Figure 4-1) [3] is a prototype system that implements these four proposed techniques. The system design has gone through five iterations with six non-native readers. Since salient sentence selection is an important feature of Froggy GX, the quality of sentence selection is also analyzed and reported in this chapter. The user study with 20 non-native Asian users showed that Froggy GX not only enhanced reading comprehension under time constraints, but also provided higher user satisfaction.

## **4.1 Preliminary Study of Skim Reading**

There is limited work studying the difference between native and non-native readers in skim reading. I conducted a small preliminary study to understand this issue. Six users (three native speakers and three non-native speakers) were recruited (average age 26). The three non-natives had learned English for 13.6 years on average and spent 2.83 years living in the United States, and all participants had at least a bachelor's degree. Each participant was given two articles to read (one from the TOEFL test and the other from the GRE), with a 30-second time limit per article. On average, each article has 414 words ( $SD = 66$ ). After reading each article, the study asked each user to answer five multiple-choice questions, to measure reading comprehension. At the end of the reading, I also interviewed each user about his reading experience under time constraints.

The results, measured by the number of correct answers in the quiz, indi-



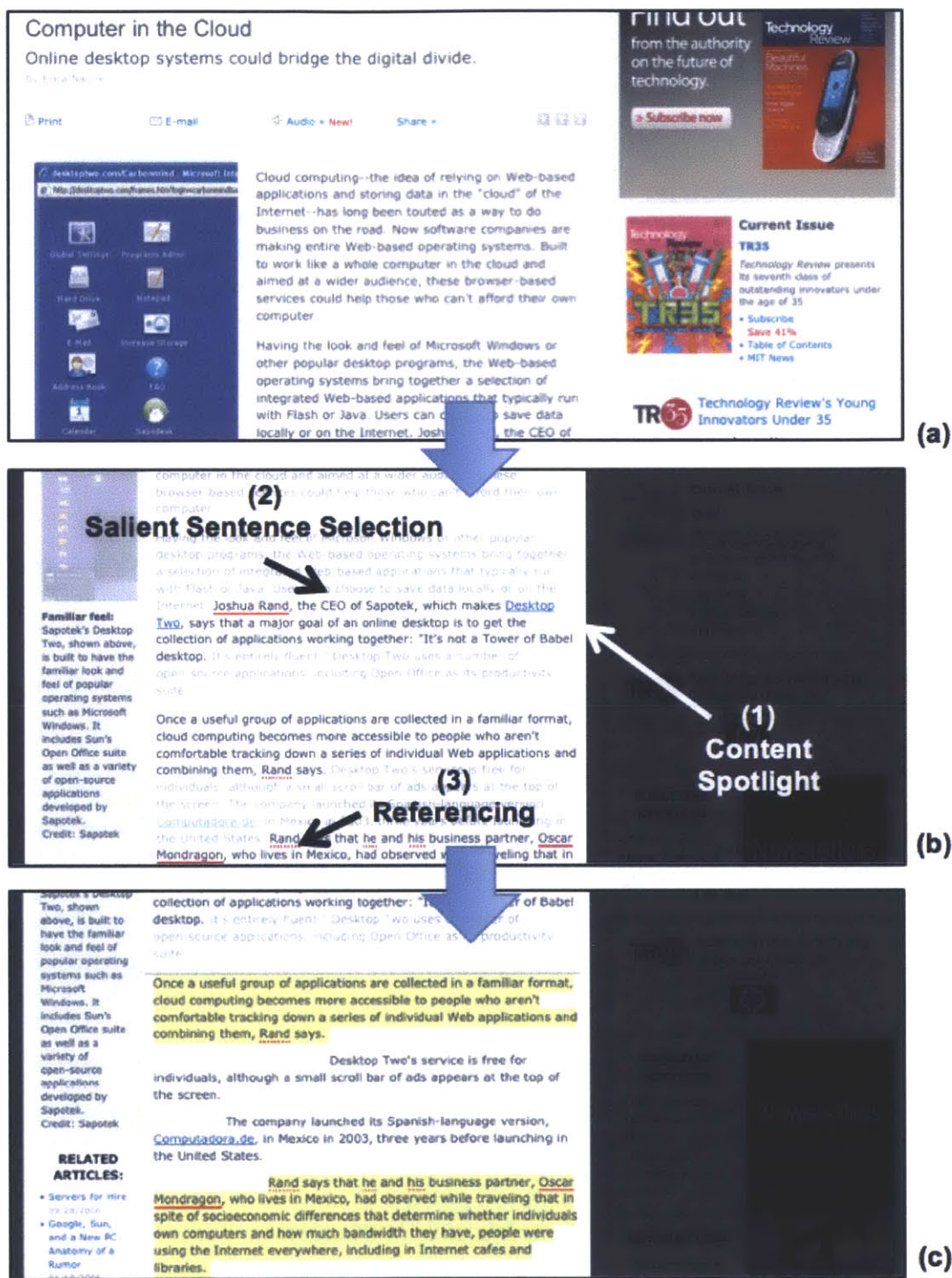


Figure 4-1: Skim reading environment for non-native readers. (a) Original web page; (b) transformed page for skim reading; and (c) reading in Jenga format (Please refer to Chapter 3 for Jenga format).

## Reading Comprehension

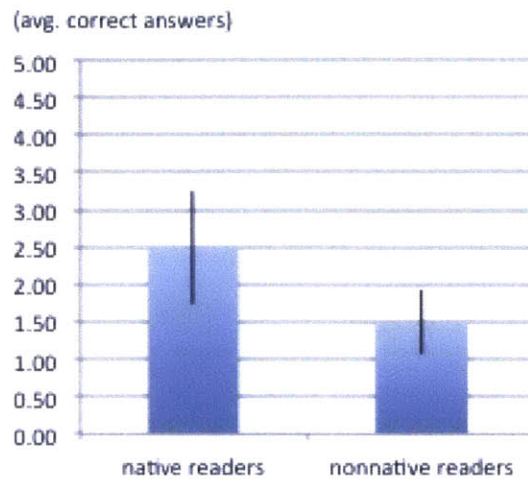


Figure 4-2: Reading comprehension is measured by number of correct answer to a 5-question quiz.

cated that native readers' reading comprehension is roughly 20% better on average than non-native readers' under a 30-second time constraint. (Figure 4-2) One question is that if the 20% difference comes from non-native readers' individual and linguistic differences. According to the analysis of non-native readers' language fluency and background from the study, it indicated that the 20% difference comes from skim reading skills rather than English fluency and the study can conclude that non-native readers do not have good reading strategies under time constraints.

Non-native participants consistently gave feedback that there was too much information on the page, and they did not know what to focus on while under time constraint. Comments from the nonnative participants included:

*"It is difficult to read the whole article in 30 seconds. Too much information to read."*

*"I can only finish reading the first few sentences."*

## **4.2 System Design**

Based on the results and feedback from the preliminary study, I believe that it is important to enhance web page skimmability for non-native readers. Froggy GX is a prototype system developed to enhance web page skimmability for non-native readers.

### **4.2.1 Paper Prototype**

After the preliminary study, I also presented four new content transformations on paper to the participants for their feedback. The four presented formats were: (1) key sentence highlighting, (2) key sentences shown as bullet points in a popup window, (3) key sentences translated into a reader's native language, and (4) presenting translated key sentences at the beginning of the article. (Figure 4-3)

The lessons learned from the paper prototype are that non-native readers prefer to read filtered information, such as key sentences, and feel comfortable to read this information written in their native language. Non-native readers also reported that they sometimes search for a certain keyword on the content and read the enclosing sentence.

### **4.2.2 Design Principles**

There are several design principles behind the system. First, the tool needs to provide a good reading strategy for non-native readers. Because non-native readers' reading speed is slow in general [89], it is necessary to help them finish reading within time constraints, by providing filtered information.

Second, simple interaction is key. Users do not have enough time to control widgets for reading, such as buttons, sliders and textboxes. Therefore, the design of such a tool must be simple. Moreover, because non-native readers feel more comfortable reading content written in their native language, we provide translations of the content on demand. However, state-of-the-art machine translation

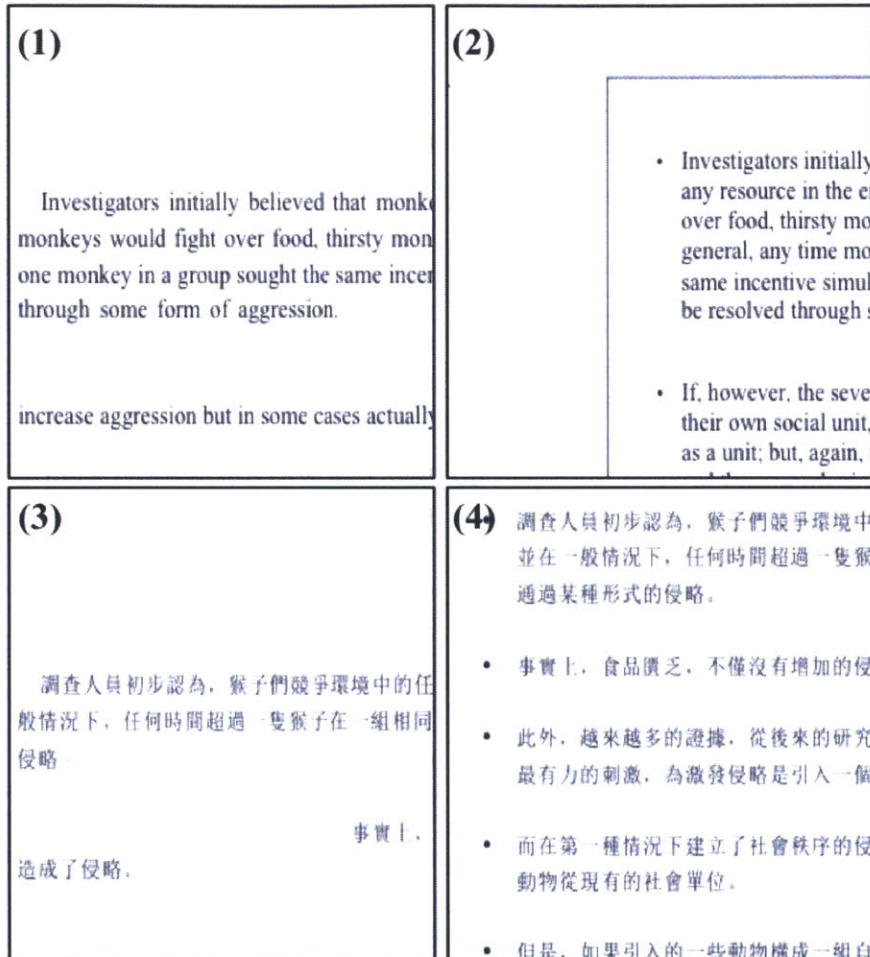


Figure 4-3: Examples of transformations used in paper prototype. (1) key sentence highlighting; (2) key sentences shown as bullet points in a popup window; (3) key sentences translated into a reader's native language, and (4) presenting translated key sentences at the beginning of the article.

technology is only good enough for translating individual words and phrases, but not entire articles, so this feature should be used sparingly.

Third, readers who simply read dispersed key sentences might miss the connection between key sentences and the meaning of pronoun references, such as “he”, “she” and “it”. Techniques like named-entity recognition (NER) [18] or anaphora resolution [76] might help to address the referencing issue.

Lastly, reducing distractions is requested. I conducted a face-to-face interview with 14 users on web behavior survey. One of the questions was: “What actions do you want to perform to the web sites you visit frequently?” Delete Content and Shrink Content were two desired actions. The content means unnecessary distractions, including static, embedded, animated and popup advertisements. However, some users preferred to minimize unnecessary distractions or make them less salient rather than to remove them because users mentioned that the web sites have financial incentives to display them.

### **4.2.3 User Interface Design**

Based on these principles, I developed a prototype system, Froggy GX, using an iterative design process with six non-native users. Froggy GX is a Firefox extension with several features: (1) content spotlight; (2) salient sentence selection; (3) contextual referencing; and (4) in-place translation.

The design of Froggy GX includes only one button for the skim mode trigger and one drop down menu for a user to select his native language or preferred language for in-place translation (Figure 4-4). In terms of translation, Froggy GX supports Chinese, Korean, Japanese, Vietnamese, Thai and Indonesian languages now.

#### **Content Spotlight and Presentation**

There are a few actions executed when the Skim Mode button is clicked, including web page cleaning, unimportant content masking and main reading area

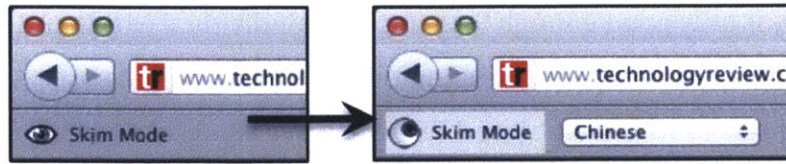


Figure 4-4: Froggy GX - an extension of Firefox browser. (Left: Default state; Right: Skim mode is triggered)

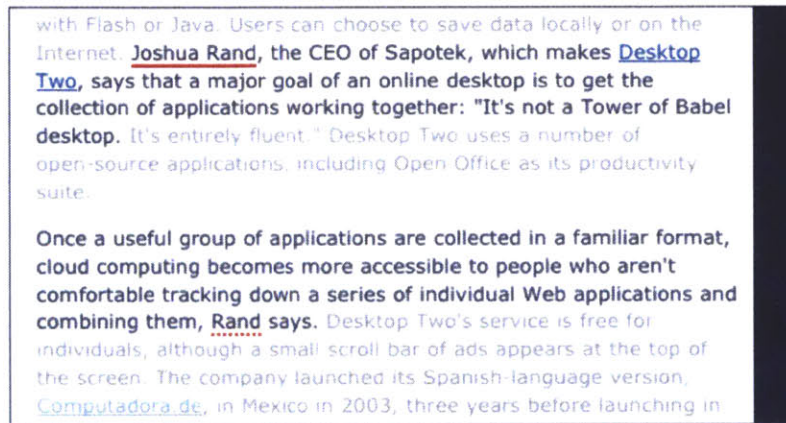


Figure 4-5: Important sentences remain readable and unimportant sentences are made less visible.

spotlighting. Web page cleaning reduces distractions in size and dims them out. The distraction contains large images, animations and Flash. Froggy GX spotlights main reading area and masks surrounding content.

In spotlighted reading area, Froggy GX dims out unimportant sentences and makes important sentences stand out (Figure 4-5). The important (or named salient) sentences are the top 20% of the ranked sentences calculated by LexRank algorithm, as explained in the implementation section.

If the reader wants to read a whole paragraph in a more comfortable way, using the Jenga format proposed in Chapter 3, he can double click on the paragraph to animate an expansion of the whole paragraph to Jenga format [89]. (Figure 4-6) When a paragraph is expanded, the system not only restores the unimportant sentences to original readable level, but it also highlights salient sentences with

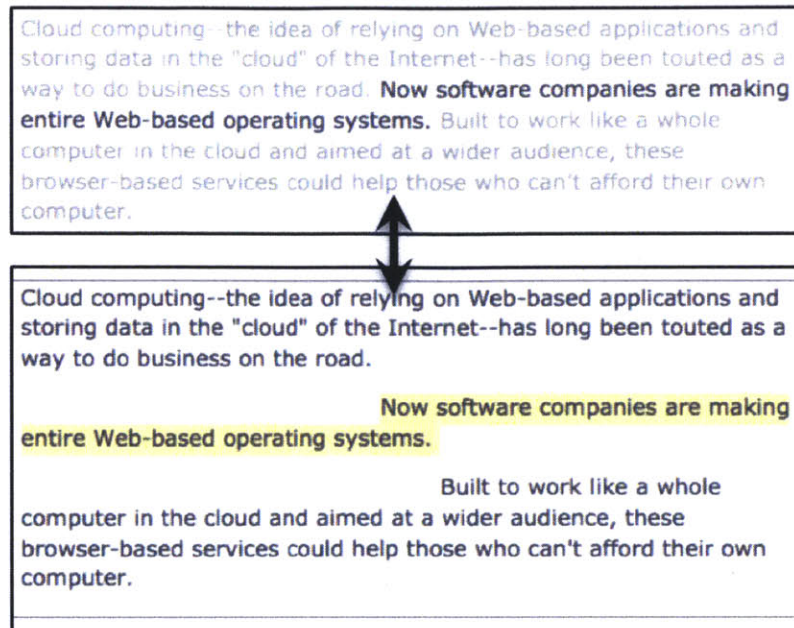


Figure 4-6: Paragraph transformation. (Top) Original paragraph; and (Bottom) Double click to expand a paragraph to Jenga format animatedly. Salient sentences are highlighted and a gray separation line is added to the top and bottom of the selected paragraph.

yellow color. When the paragraph is expanded, a gray separation line is added to the top and bottom of the selected paragraph, and the space between the selected paragraph and the following paragraph are also enlarged.

However, in pilot study with eight users, there was no significant enhancement in reading comprehension under time constraints. After analyzing users' comments, I found that users reported that unimportant sentences were too dim to read. Although users can double click a paragraph to read sentences in Jenga format, which makes unimportant sentences readable, they either didn't have enough time to double click on a paragraph or were too lazy to expand a paragraph. A few quotes from the users:

*"[I] read through the highlighted sentences sequentially. Not enough time to expand paragraph [to make invisible sentences visible]."*

*“[I was too] lazy to [double] click a paragraph to read invisible sentences.”*

This finding inspires me to make unimportant sentences slightly dim but still readable in the user interface, and the results of the user study indicated that this change matters. I think making important sentences visible and unimportant sentences less visible could help non-native to focus on important sentences first and read unimportant sentences to support important ones without an effort.

### **Contextual Referencing**

The text context of the web page is extracted and analyzed for named entities using OpenCalais [10]. There are more than 39 categories of entities offered by OpenCalais, but Froggy GX only uses the Person category name entities because design iterations suggested that Person information is important for understanding narrative content, such as news, technology and business web pages. Froggy GX marks named entities with bold red underlines, and pronoun references (such as he, she, or his) with dotted red underlines. When the user hovers a mouse over an entity or pronoun, a popup shows the name of the entity. If the user clicks on the popup, it expands to show the first sentence on the page that referred to it, which typically gives the full name of the person and their relationship to the article. (Figure 4-7)

### **In-place Translation**

When the reader does not understand the meaning of a word or a phrase, he can select it to have it translated in place. It is not necessary to select a word or a phrase precisely, and the Froggy GX can expand the selection automatically to find the proper boundary. (Figure 4-8)



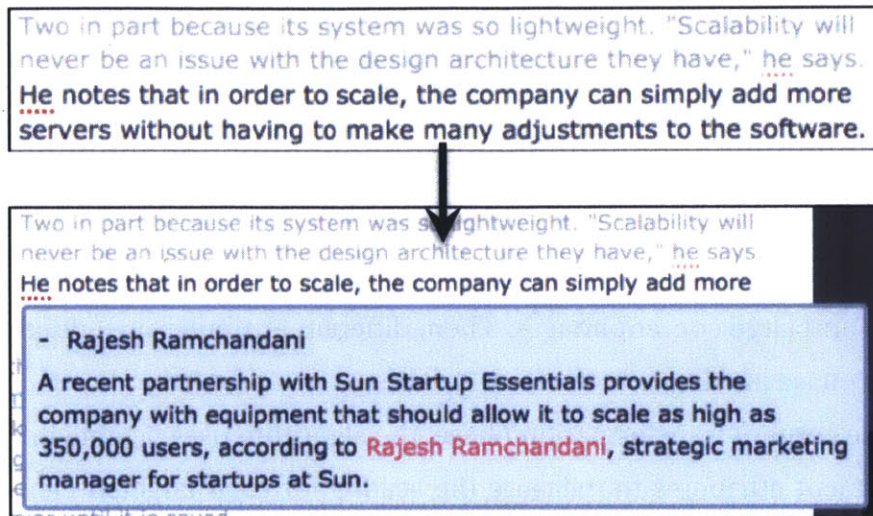


Figure 4-7: Semantic data integration for referencing. (Top: Name entity instance is marked with dotted underline; Bottom: Mouse hover the instance and show the definition sentence of the name entity in this article.)

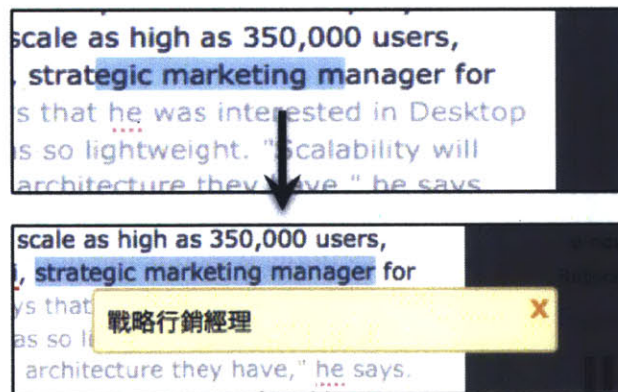


Figure 4-8: In-place translation support. (Top: A partial selection; Bottom: A popup with the translation.)

## **4.3 Implementation**

### **4.3.1 Clean Page**

The Clean Page algorithm of Froggy GX operates in two phases: content classification and content transformation. In content classification phase, the algorithm uses rule-based methods to parse the Document Object Model (DOM) tree and identifies possible distracting page components, such as static ads, animated content and large content images. Then, different attributes are added to nodes for next phase parsing.

In the content transformation phase, the algorithm uses tagging information and element attributes to measure the scaling for each targeted element, and deploys corresponding transparency and resizing effect to the target elements.

### **4.3.2 Jenga Spacing**

When user clicks on any paragraph, Froggy GX transforms it into JF format. The key technique is the use of inline CSS property, `top`, to adjust the space between sentences. If I only add `top` property to sentences without doing any adjustment, the shifted sentences will overlap to next paragraph. To solve this problem, I calculate the total shift distance of a paragraph and append a new `<div>` node with CSS property, `line-height`, to embed this information at the end of the paragraph. When expansion animation happens, I not only change `top` property value of sentences, but also dynamically recalculate the total shift distance and apply it to `line-height` property of the `<div>` node, which is the node added to keep the layout correctly.

### **4.3.3 Content Spotlight**

As mentioned in the previous section, when the web page is loaded, Froggy GX starts a sequence of actions in the background to prepare a skim reading environment, including parsing the content, tagging all paragraphs and sentences,

and calculating an absolute position and dimension of each paragraph. Based on this information, Froggy GX can find a container node for spotlight purposes. The container node covers the dimensions of all paragraph nodes and is the closest node to all paragraph nodes in the DOM tree. Similarly, Froggy GX masks the content by adding a <div> node to the DOM tree and sets a certain value to its opacity attribute in CSS property. In order to have a spotlight effect, Froggy GX increases the z-order of the container node and sets its background color to white. Container node is above the masking node.

To have a clean reading environment, Froggy GX uses a technique similar to existing systems (e.g. Safari 5 Reader, Firefox Readability and Froggy [89] extensions) to detect possible annoying content (such as advertisements or less relevant content on the page) and make them proportionally smaller and transparent.

#### 4.3.4 Salient Sentences Selection

For salient sentences selection, Froggy GX implements the *Lexical PageRank (LexRank)* algorithm [47] in JavaScript at the client side. As Erkan and Radev explained [47], “. . . , LexRank, for computing the sentence importance based on the concept of eigenvector centrality in a graph representation of sentences.” Given  $n$  sentences, we can have an  $n \times n$  cosine similarity matrix. The intra-sentence cosine similarity is defined as the formula 4.1.

$$idf - modified - cosine(x, y) = \frac{\sum_{w \in x, y} t_{f_w, x} t_{f_w, y} (idf_w)^2}{\sqrt{\sum_{x_i \in x} (t_{f_{x_i, x}} idf_{x_i})^2} \sqrt{\sum_{y_i \in y} (t_{f_{y_i, y}} idf_{y_i})^2}} \quad (4.1)$$

The term frequency,  $t_{f_{a,b}}$  means the number of occurrences of the word  $a$  in the sentence  $b$ . The inverse document frequency, i.e.  $idf$ , is defined by the formula 4.2.

$$idf_i = \log \left( \frac{N}{n_i} \right) \quad (4.2)$$

where  $N$  is the total number of documents in a collection and  $n_i$  is the number of documents that contain the word  $i$ . Since the user may view an arbitrary page, and there is no corpus of documents defined in our case, Froggy GX uses all paragraphs of the web page as a collection of documents to compute inverse document frequency (*idf*) for all words. In my implementation, before calculating cosine similarity matrix of all sentences, I preprocess the content with stop words elimination [2] and stemming [13] for term frequency (*tf*) calculation.

Although Froggy GX computes LexRank scores for all sentences, it only chooses the top 20% of ranked sentences as salient sentences. This threshold was determined as follows. Given a 1000-word document and an average reading speed of non-native speakers is around 100 words/minute [89], most non-native readers would be able to read at most 20% of the content in two minutes.

#### **4.3.5 In-Place Translation**

When the user selects a word or a phrase on the viewing page, Froggy GX uses the Microsoft Translator API [7] to perform data translation, which uses the preferred language selected in the drop down menu.

To make selection easier, Froggy GX allows users to roughly select a word or a phrase and expands the selection automatically to find the proper boundary. This feature can save the users time and make the meaning checking faster. (Figure 4-8)

#### **4.3.6 Contextual Referencing**

After Froggy GX spotlights the web page, it also extracts data from this spotlighted area and submits this data as a document to the OpenCalais web service [10] for semantic data extraction. Currently, OpenCalais provides a feature to annotate a given content and returns semantic data, such as entities (e.g., Company, Country and Person), events or facts (e.g., Acquisition, Alliance and Bankruptcy). Although the data is presented in JavaScript Object Notation (JSON) format, a local

customization process is needed. Froggy GX groups all semantic data, including entities, events and facts, by using their categories. In addition to the entities and their inferring implied nouns, such as Joshua Rand, Rand, he and his in Figure 4-1, OpenCalais also provides prefix, suffix and offset information of these inferring implied nouns.

## 4.4 Quality of Sentence Selection Evaluation

One concern of using an automatic text summarization algorithm for skim reading support is whether the algorithm would choose the same salient sentences that a human would. To understand the difference, we recruited five native English readers to highlight salient sentences on six web pages, half from a technical website, and half from a business website. The six articles contained 270 sentences in total, and, on average, 45 (SD = 7.6) sentences in each page.

In this evaluation, we investigated two conditions:

1.  $C_1$ : Native readers highlight key sentences for non-native readers to skim read
2.  $C_2$ : Froggy GX LexRank highlights key sentences for non-native readers to skim read

I use a 20% selection rate in the Froggy GX LexRank implementation for the comparison. There were total of 272 highlights from five native English readers in condition  $C_1$ . The summary of  $C_1$  vs.  $C_2$  is listed. (Table 4.4). As Table 4.4 illustrates, on average, there is a 27% (SD = 6%) selection rate in key sentence selection from total sentences. Based on these selected sentences, Froggy GX LexRank reaches 46% (SD = 9%) in precision, which means 46% of salient sentences selected by Froggy GX overlap with key sentences selected by human.

Although 46% precision is still far away from perfect matching (100% matching), this number simply indicates that there exists a huge gap in salient sentence selection between human and Froggy GX, and it also means researchers still have

a chance to improve selection algorithm. Note that salient sentences selected by human majority voting still does not reach highly agreement among raters. (Fleiss' Kappa analysis,  $K=0.174$ ) The results of the user study (presented in next section) indicate that this kind of precision with suitable user interface design is good enough to enhance users' reading comprehension under time constraints.

	# of total sentences	$C_1$					$C_2$		
		# of selected sentences	selection rate	total votes	avg votes	SD	# of selected selection	# of overlapped sentences	precision
A1	38	10	26%	34	6.8	2.9	10	4	40%
A2	48	13	27%	51	10	5.8	11	4	36%
A3	35	12	34%	43	8.6	5.0	8	4	50%
A4	52	18	35%	58	11.6	6.6	12	7	58%
A5	43	8	19%	32	6.4	3.4	10	5	50%
A6	54	12	22%	54	10.8	4.9	13	5	38%
AVG	45	12.2	27%	45	9.1		10.7	4.8	46%
SD	7.6	3.4	6%	11	2.2		1.8	1.2	9%

Table 4.1: The comparison of the important sentences selected by native readers and Froggy GX.  $C_1$ : Important sentences selected by native readers; and  $C_2$ : Important sentences selected by Froggy GX.

## 4.5 User Study

To understand the effectiveness of Froggy GX in skimming reading support for non-native English readers, I conducted a formal user study with 20 non-native Asian users. The study was conducted from August 2012 to September 2012.

### 4.5.1 Hypotheses

This research has following hypotheses for the user study.

1. Reading comprehension under time constraints is better with Froggy GX than without.
2. User satisfaction with reading under time constraints is higher with Froggy GX than without.

### **4.5.2 Users**

The subject recruitment was based on posting flyers in Boston area, sending emails and posting messages to student associations' pages on Facebook. The study mainly focused on recruiting Asian users who had been living in the U.S. for less than five years and whose first languages were not English. We looked for users who were able to read general English web pages without difficulty. For each user study, the compensation was ten dollars per hour and the study lasted for at most two hours.

20 users participated in the study: 6 males and 14 females. All users were Asians whose first languages were not English. On average, the users were 26.1 years old and had spent 1.3 years in the U.S. On average, the users had spent 15.7 years (SD = 3.9) learning English and their English performance in TOEFL exam was 96.3 (SD=10.3) in Internet-based Test (iBT). Specifically, 10 users (50% of the users) had higher English fluency (iBT score was higher than 100 and less than 120) and another 10 users had moderate English fluency (iBT score was higher than 70 and less than 100). The majority of the users took the TOEFL exam in 2011 (8 out of 20). 14 users (70%) reported that they had improved their English skills recently since they took TOEFL exams.

In terms of education background, 11 users had a Bachelor degree and 9 users had a Master degree. However, the users' major or jobs were quite diverse. Although the majority of the users' major or job was in engineering/science (30%) and business/marketing (25%), the study also had users with medical/health/nursing (15%), literature/language (10%), media (5%), economy/finance (5%), laws (5%) and music (5%). As for the nationality reported by the users, 11 users were from Taiwan (55%), 5 from China (25%), 3 from South Korea (15%) and 1 from Japan (5%). In terms of the native languages the users spoke, 16 users spoke Mandarin Chinese (80%), 3 spoke Korean (15%) and 1 spoke Japanese (5%).

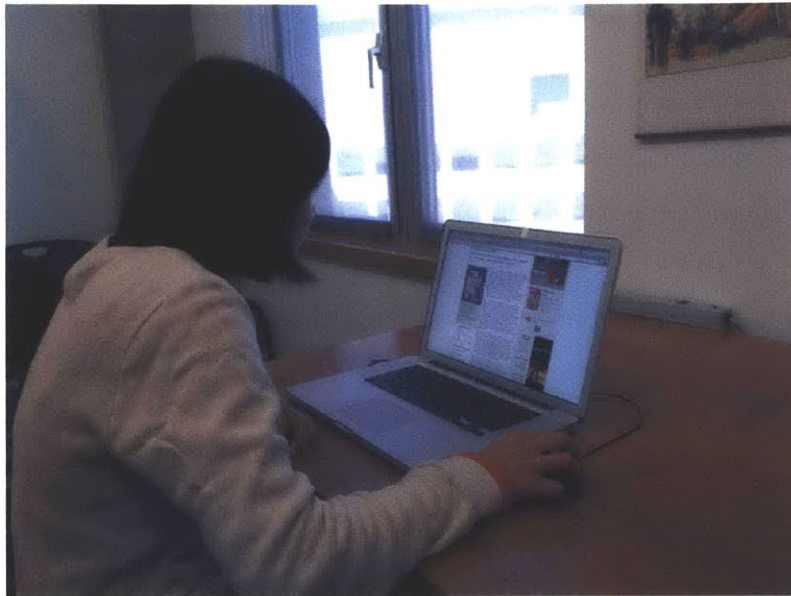


Figure 4-9: The environment setting of skim-reading user study.

### 4.5.3 Procedure

The study has two conditions: (1) reading a web page with Froggy GX under time constraint; and (2) reading a web page without Froggy GX under time constraint.

It was a laboratory setting and within subjects study. The environment setting was similar to reading at home or in an office, i.e. using a laptop computer with a mouse. (Figure 4-9)

On average, each study took 112 minutes ( $SD = 18$ ). In the study, all participants read the same four web pages. The order of web pages and reading unaided or with Froggy GX were all randomized and counterbalanced in advance. The first round reading had a 2-minute time constraint, followed by a second round reading which did not have any time constraint. After each round of the reading, we gave a questionnaire to each user to record his subjective feedback and reading comprehension. There was a five-minute break after reading two web pages.

The design of two rounds of reading of each web page is to understand if the users have a consistent reading capability among all web pages. Specifically, the



second round of reading is used to understand whether the users performance in the first round either comes from reading unaided or with Froggy GX under time constraints or the difficulty of web pages.

In addition to have the users' demographic information at the beginning of the study, we also had a pre-study questionnaire, which contained eight questions to understand the users' reading habit on the Web. The experimenter gave a Froggy GX tutorial to the users and let them play with the tool on two example web pages until they felt comfortable to use the tool.

To understand the users' performance in understanding web pages, we gave the users a questionnaire after they finished each round of a web page reading. The questionnaire had three parts: (1) 7-level Likert-scale questions about the ease of reading, degree of understanding, and enjoyability; (2) a reading comprehension test with five multiple-choice questions [89]; and (3) a test of memory for meaning with five sentences [44]. The test questions are described in more detail in the next section. Since each web page had two rounds of reading, we gave the same questionnaire to the user in these two rounds of reading. The example of part 2 and part 3 of the questionnaire presented in the tutorial session is illustrated as Figure 4-10.

Before the end of the study, we also had a post-study interview with all users to understand their reading pattern with and without time constraints, and the suggestions to the tool they used in the skim reading study.

#### **4.5.4 Material**

The study selected four out of six articles that were used in the quality of sentence selection evaluation, which was presented in the previous section. On average, there were 929 words (SD = 74.7) and 46 sentences (SD=8.8) in each web page.

Each questionnaire has three parts: (1) a three 7-point Likert-scale user satisfaction questions (ease of reading, degree of understanding, and enjoyability); (2) five single selection reading comprehension questions; and (3) five true/false

## Questionnaire:

### Part 2:

1. What's the main purpose of this article?
  - Show why technology sector is successful now
  - Explain why health companies are changing
  - Discuss how to improve the accuracy of technology development
  - Describe technology sector has facing a challenge

### Part 3:

Are the following sentences consistent with the web page you just read?

1. Technology companies have a lot of money to spend.
  - Consistent
  - Inconsistent

Figure 4-10: Example reading comprehension question (part 2 of the questionnaire) and example memory-for-meaning question (part 3).

questions about the test of memory for meaning. The design of the questionnaire is a combination of traditional reading comprehension questions from readability studies and memory for meaning questions from skim-reading studies.

For Part 2 (reading comprehension questions), I re-used reading comprehension questions from Chapter 3 (please refer to the appendix for these comprehension questions), which were similar to Dyson and Haselgrove's work [46, 45], including questions about the main idea, structure, main factual, incidentals and reasoning. The type information of the reasoning question is not added in front of each question. For Part 3 (the test of memory for meaning), the questions followed the evaluation method used by Duggan and Payne [44, 43] and Masson's work [62]. Each question is a sentence, which might be either an original sentence from the web page or have its meaning changed to be semantically incongruent with the original statement. Users need to answer true or false questions about whether or not the given sentence is consistent with the web page they just read. There were a total of 50 sentences selected by 5 native English readers by using majority voting. Another native reader was recruited to transform all 50 sentences into semantically incongruent statements. In order to select questions for the test of memory for meaning test, another native reader was recruited to

choose five questions from these 100 sentences, either original or semantically incongruent sentence. I combined the results of Part 2 and Part 3 and named it reading comprehension here.

#### **4.5.5 Results**

There are two results reported in this section: (1) The result of the pre-study questionnaire; and (2) Non-native readers' performance in web page skim reading with and without Froggy GX.

##### **The Pre-study Questionnaire Result**

The pre-study questionnaire was designed to understand the users' reading habits on the Web. On average, the users spent 1.2 hours (SD=0.9) daily on reading English web pages. 16 users (80%) skim-read most web pages written in their native languages and 4 users (20%) skim-read some web pages written in their native languages. In terms of the frequency, 16 users (80%) skim-read web pages written in their native languages daily and 4 users (20%) did it in every few days.

On the other hand, 13 users (65%) skim-read English web pages everyday or every few days and 7 users (35%) reported that they did it from a few times a week to seldom doing it. The average time spent in skim-reading English web pages was 0.8 hours (SD=0.4). Although the frequency of the need to skim-read English web pages was 4 (SD=1.0) in 1-7 Likert scale (1: Never, 4: Neutral and 7: Very frequent), the users reported that the importance to read English web pages quickly was 5.6 (SD=1.0), which was 1.5 points higher than the neutral score (1: Totally unimportant, 4: Neutral and 7: Extremely important). 18 users (90%) answered that if there was a way to understand web pages quickly, they would like to use it, and only 2 users (10%) reported that it depended on the context. 12 users (60%) agreed with the statement that reading English web pages quickly was a challenge to them, which statement had an average 4.3 score (SD=1.6) in 1-7 Likert scale (1: Totally disagree, 4: Neutral and 7: Totally agree).

## Performance in Skim Reading

In the study, each user was asked to read each of four web pages twice. The first round reading was always under 2-minute time constraint and the second round of reading had no time constraint. For the figures in this section, we simplify the naming for presentation: (Second round reading does not involve a time constraint or using Froggy GX tool.)

1. Tool: First round reading with a time constraint and the tool
2. Second reading that first round with the tool
3. NoTool: First round reading with a time constraint, but without using the tool
4. Second reading that first round without the tool

Figure 4-11 illustrates the average comprehension score under time constraints with and without the Froggy GX tool (left), and the average comprehension score of the second round reading without the tool (right). The number of correct answers to a 10-question quiz measured the score. The quiz had ten single selection questions: five questions each had five options and another five questions each had two (consistent/inconsistent) options.

Two-tailed paired t-test is used to analyze reading comprehension under a time constraint with and without the tool. The result indicated that there was a significant difference in this measurement ( $t(39) = 3.046, p < .005$ ). Figure 4-11 (Left) illustrated that the users' reading comprehension was enhanced 12% (Tool: 6.4 (SD=0.17) vs. NoTool: 5.7 (SD=0.22)) when they used Froggy GX to skim read web pages. However, there was no significant difference in reading comprehension without a time constraint in the second round reading, i.e. Tool\*\* vs. NoTool\*\* (Figure 4-11).

I measured the reading time of all second round readings. Although there is a 6% improvement in reading time of the second round reading when its first

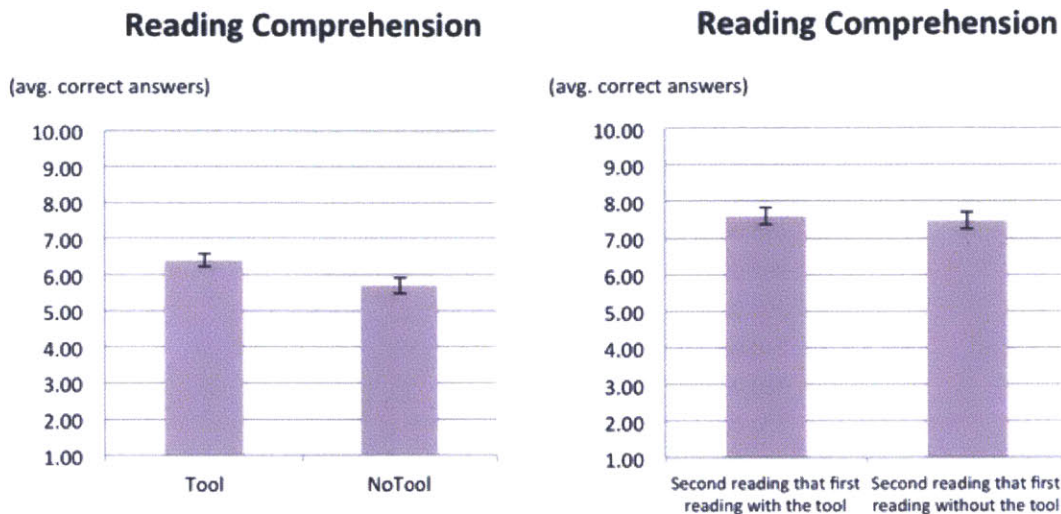


Figure 4-11: The graph on the left shows reading comprehension between using and not using the tool under a time constraint. The graph on the right shows second round reading without using the tool and a time constraint.

round reading uses the tool, the two-tailed paired t-test analysis does not show a significant difference in reading time measurement between Tool\*\* and NoTool\*\* (Tool\*\*: 352.3 (SD=16.87) vs. NoTool\*\*: 374.5(SD=21.22)) (Figure 4-12) It means users maintain a consistent reading speed when they read web pages without a time constraint, no matter if web pages are read with or without the tool in advance.

The study asked three subjective questions to the users after they finished the reading of each round. The results are illustrated as Figure 4-13 to Figure 4-15.

The two-tailed paired t-test analysis shows that there is a significant improvement in ease of reading when using the tool under a time constraint. ( $t(39) = 2.906, p < 0.01$ ) However, there is no significant difference in ease of reading in the second round of reading without time constraints (Figure 4-13). This result indicates that reading web pages under a time constraint with the tool is easier than without using the tool.

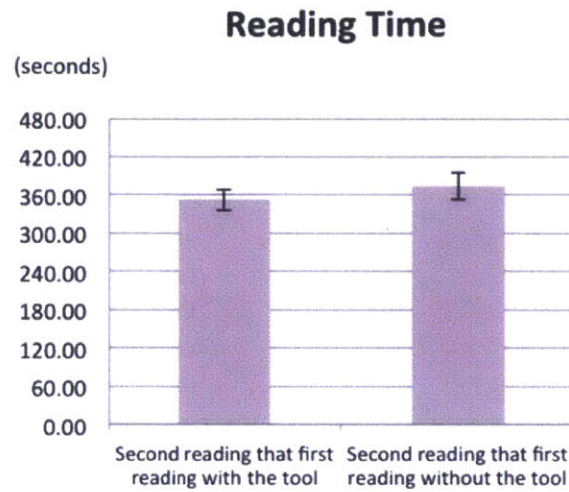


Figure 4-12: The reading time of the second round reading.

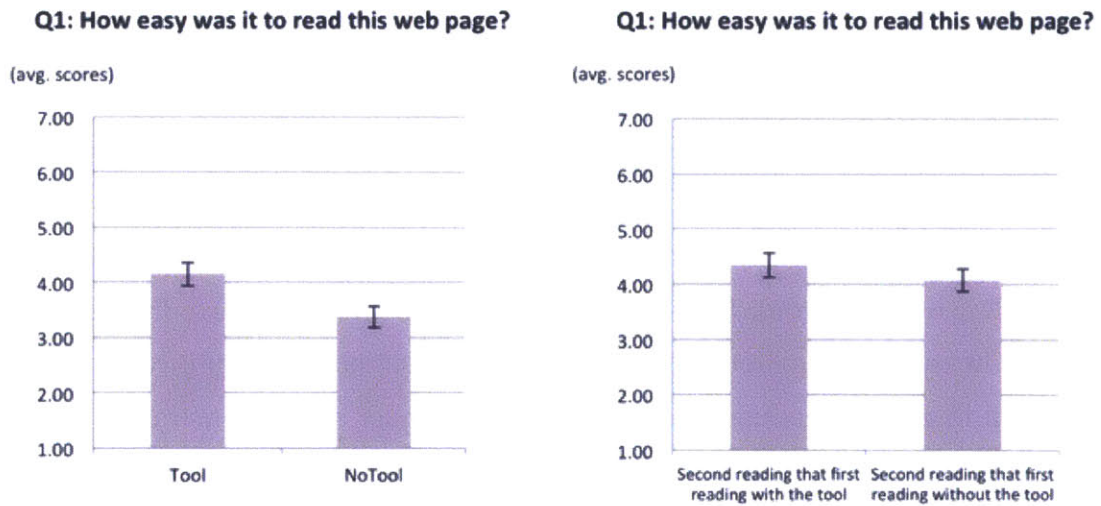


Figure 4-13: Ease of reading (rated on a scale from 1 = very difficult to 7 = very easy).

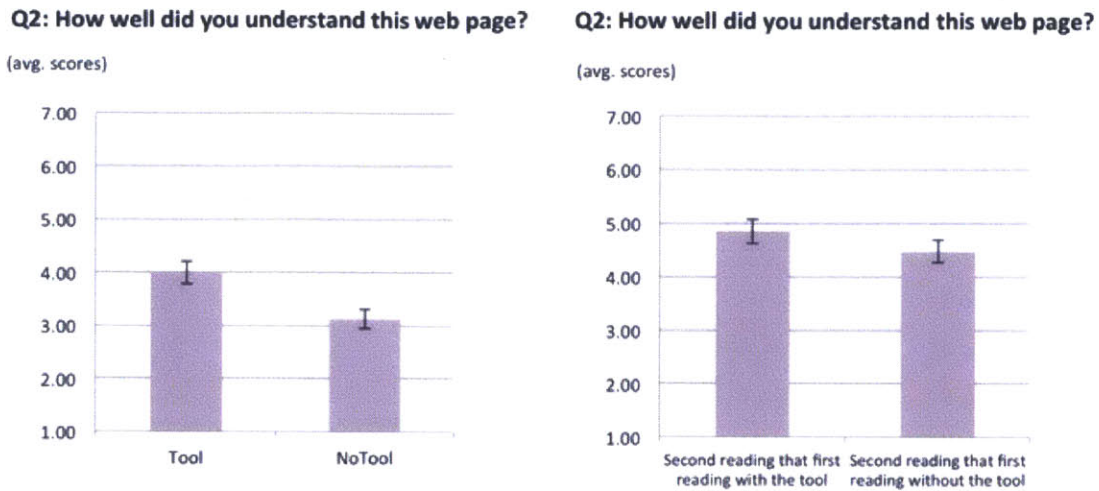


Figure 4-14: Self-evaluation of understanding (rated on a scale from 1 = very difficult to 7 = very easy).

The two-tailed paired t-test analysis shows that there is a significant improvement in users' self-evaluation of understanding when they used the tool under a time constraint. ( $t(39) = 3.26, p < .005$ ) However, there is no significant difference in the self-evaluation of understanding in the second round of reading (Figure 4-14). This result suggests that reading web pages under a time constraint with the tool subjectively gives users a better understanding of web pages than without using the tool.

The two-tailed paired t-test analysis shows that there is a significant improvement in enjoyability of reading when using the tool under a time constraint. ( $t(39) = 3.536, p < .005$ ) However, there is no significant difference in enjoyability of reading in the second round of the reading without a time constraint. (Figure 4-15) This result shows that reading web pages under a time constraint with the tool provides a better enjoyability than without using the tool.

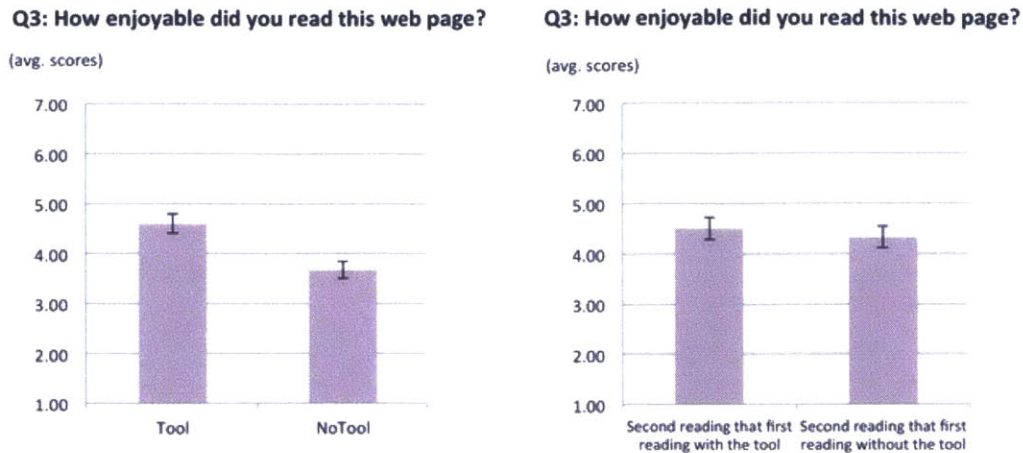


Figure 4-15: Enjoyability of reading (rated on a scale from 1 = very unenjoyable to 7 = very enjoyable).

#### 4.5.6 Post-study Interview

After the quantitative study with 20 non-native users, I also conducted a post-study interview with them to have their feedback. Generally speaking, most of the participants liked the idea of showing filtered content on the current viewing page, including separating important sentences from unimportant sentences, and in-place translation support. Some comments from the interview support this point:

*“I prefer [that you] show key sentences [on the page]”*

*“Two level highlight[ing] mechanism (differentiating important & unimportant sentences) helps me grasp more information than just reading topic sentences.”*

For the reading strategy part, Froggy GX (1) takes non-native readers’ reading speed into consideration, (2) shows only 20% of the ranked sentences as key sentences for users to focus on first, and (3) makes unimportant sentences less visible to differentiate the content. Froggy GX suggests the readers read key sentences first and extends the reading to sentences surrounding key sentences to



support the understanding and transition between key sentences.

A post-study interview with the users showed that they are satisfied with the current design of Froggy GX. Specifically, highlighting key sentences and making unimportant sentences less visible are helpful to them. A few quotes from the users:

*“I think the tool is cool to use when I read the articles. It’s really helpful for understanding the content and faster.”*

*“With the help of the tool, I am less stressful. I can finish reading all the highlights within the timeframe . . .”*

*“When I have the tool, I feel like I was reading only the black out sentences and few sentences around. It makes me feel less stressful . . .”*

*“Generally, I like this tool pretty much, especially the translation function. And I think it really help me to skim and understand the article efficiently.”*

However, some users also commented that filtering content might cause them miss some details:

*“The way it shows the highlighted sentences makes me ignore most of other sentences, which might not be always good because it seems I will lost important information.”*

*“With tool: more easily to read the important sentences in the paragraph, but it may lose some important information, which will be hidden by the tool.”*

In addition to key sentence highlighting, the design of in-place translation and semantic data integration for referencing are also helpful to the users, but the design of in-place translation needs some enhancement in the future:

*“I think the word translation part is useful and the underlined pronouns and names [contextual referencing] too.”*

*“For the translation, maybe it can provide multiple meanings of each word for the reader.”*

*“Maybe it would be more convenient if the translation can appear whenever the mouse points at the word [rather than selects it].”*

The feature of expanding a paragraph to Jenga format was not heavily used in the study. Users commented that they are not familiar with this presentation format and hesitated to use this feature in reading under a time constraint. A long-term study can allow the users become familiar with this format and use it in practice more:

*“Because I just have 2mins so the expansion of the paragraph isn’t useful for me.”*

*“I don’t like the sentence which is separated when I double click on the paragraph. Because they are not start from the left, and the space will let me feel there are more content I have to read.”*

This post-study interview with 20 non-native readers revealed some interesting reading patterns. For example, when the readers skim-read web pages without Froggy GX, most of them shared the following reading patterns.

1. read the first sentence and last sentence of each paragraph
2. read sentence by sentence serially
3. read first few paragraphs only
4. read one to two sentences of each paragraph and skip the rest

When non-native readers skim-read web pages with Froggy GX, most of them share the following reading strategies.

1. only read the highlighted text
2. read highlighted sentences, then when needed, go into details
3. check highlighted sentences, then read surrounding text

Most users reported that they like to read web pages under time constraints with Froggy GX, but two users mentioned that the tool might cause them to miss some details in reading. In fact, there exists a trade-off between reading time and the amount of information presentation. The more information presented, the longer reading time users need. That also means it would be difficult to finish reading under time constraints. The filtering rate used by skim reading tool might affect the readers' performance. In the study, Froggy GX takes non-native readers' reading speed into consideration and only highlights 20% of ranked sentences, which can be finished in 2 minutes, but, as readers commented, some detail information might be skipped.

There are a few enhancement ideas suggested from the users (not all suggestions are suitable for skim reading situation though), including:

1. add photos to translation for understanding vocabularies
2. link translation to dictionary or thesaurus
3. provide a feature for annotation or memo
4. move over a word to show translation (no need to select)
5. start separated sentences at the same position
6. a better way to highlight important sentences
  - (a) move over a sentence to let it become stronger font, such as bold font
  - (b) highlight key sentences in different color
  - (c) don't make unimportant sentences transparent
  - (d) don't gray out quotations

## 4.6 Conclusion

Reading web pages under time constraints is a common task, but research into skim reading behavior for non-native readers on the Web is still in its infancy. Although Duggan et al.'s work [44] has presented possible strategies used by native readers, it is still unknown whether these practices are also useful for non-native readers. To verify the assumption that there exists a difference between native readers and non-native readers in reading under time constraints, this research conducted a preliminary study with six readers (three native readers and three non-native readers) and the results indicated that native readers' reading comprehension is 20% better than non-native readers' under a 30 second time constraint in reading.

This research investigated the possible solutions for non-native readers to use when reading web pages, including: (1) content spotlight; (2) salient sentence selection; (3) contextual referencing; and (4) in-place translation. After conducting five design iterations with six non-native readers, Froggy GX was built to support skim reading for non-native readers.

The user study with 20 non-native Asian users showed that Froggy GX not only provides a good filtered content for skim reading, i.e. showing key sentences, but it also enhances the non-native readers' satisfaction in ease of reading, self-evaluation of understanding, and enjoyability of reading.

Because not all salient sentences are easy to read for non-native readers, the future work of this research is to investigate a way of combining LexRank algorithm with other readability equations, such as the Flesch formulas and the Gunning Fog formula, to improve the quality of salient sentence selection.

## Chapter 5

# Mobile Continuous Reading Support

According to Pew Internet Mobile Access 2010 [82], eight in ten American adults (82%) own a cellphone of some kind and 32% of American adults use their cellphone to access the Internet, an increase from 25% in 2009. Although mobile phone penetration has been increased in recent years, reading web pages on a mobile device is still not as easy and comfortable as doing the same activity on a desktop computer.

Since reading on-the-go has become relatively common and focusing on the display of a mobile phone is difficult while walking, previous work has suggested that audio is an acceptable modality for mobile comprehension of text [84]. Although audio has been used in screen readers for blind or visually impaired people [31, 36, 49], there has been no clear understanding how to combine the audio modality with visual presentation for sighted people on mobile devices. In general, the mobile device is used with a short attention span and users are likely to switch activities while using the device [67].

Context switches happen in reading on-the-go situation, but this scenario was not adequately addressed in previous studies, such as from walking to sitting, static standing, driving or other hands-free situations. This raises another challenge: how do we help mobile users have a continuous reading experience while reading on-the-go with frequent context switches? Different contexts impose different constraints. For example, driving may prevent the user from holding the

device.

In this chapter, I present a user study with 10 mobile users designed to understand the differences between reading web pages under four different conditions: visual-reading, audio-listening, manual-switching between visual and audio, and auto-switching between them. The web pages are read with frequent context switching, i.e. from sitting to walking or from walking to sitting. The results showed that auto-switching not only provides significantly fewer dangerous encounters than visual-reading, but it also provides the best reading experience.

Read4Me browser [12] is a prototype system built to support the presented study, including the four tested conditions, and extended to support a few additional ideas, partly inspired by the study. These new ideas include: adding voice annotation in visual-reading and on-the-go conditions; speaking a simple phrase to mark sentences with emoticons; and supporting line control for fast backward, forward, play and pause in audio-listening condition. Read4Me browser supports auto-switching by using the pose of the mobile device. The results show that this approach can predict five predefined conditions (left-ear listening, right-ear listening, in docking, in pocket and static reading) with 93.2% accuracy, while also predicting two predefined states (Look&Point and Hear&Say) with 99.6% accuracy.

There are two contributions in the research presented in this chapter. First, this research studied the scenario of continuous reading on a mobile device under four defined conditions. Second, this research designed a new mobile web browser, Read4Me, to support the study and extended its features with new ideas partly inspired from the study. In the rest of this chapter, I present the results of the user study. Lessons learned from the study are also organized in the discussion section. This chapter introduces Read4Me browser in detail, moving from design principles and implementation to experiments with trained Support Vector Machine (SVM) classifiers for phone pose detection [21]. Conclusions from this research are presented at the end of this chapter.

## **5.1 User Study of Mobile Reading**

The goal of the presented study is to understand the differences between different approaches to reading on a mobile device. The approaches studied include visual reading, audio listening and the combination of both, all while reading content on a mobile device. This research uses web pages on a mobile web browser in particular, but the notion of the study could be extended to content reading in general on a mobile device.

### **5.1.1 Subjects**

Ten participants volunteered to join the study, 8 males and 2 females, on average 26.6 years old ( $SD = 2.37$ ). Study advertisements were sent out by email and posted as flyers on campus. Seven participants had not listened to audio books in the past, but all of them had used mobile phones and mobile web browsers. All participants are graduate students and all are fluent in English, although the first language of 7 out of 10 participants is not English.

### **5.1.2 Experiment Design**

The design of the user study came from existing literature [26, 27, 84] that focused on measuring human performance in mobile reading situations. Specifically, the study is modeled after the study by Vadas et al. [84] that examined overall performance and perceived workload for four conditions: audio-walking, audio-sitting, visual-walking, and visual-sitting. However, there are several differences between this study and theirs. First, this study examined four different conditions: visual-reading, audio-listening, manual-switching between visual and audio, and auto-switching between them. (Figure 5-1) In all conditions, participants needed to switch periodically between sitting and walking, which is the second difference: this study adds interruptions to participants' reading. Third, this study uses web pages as reading material, which are dense, and need more of a user's attention

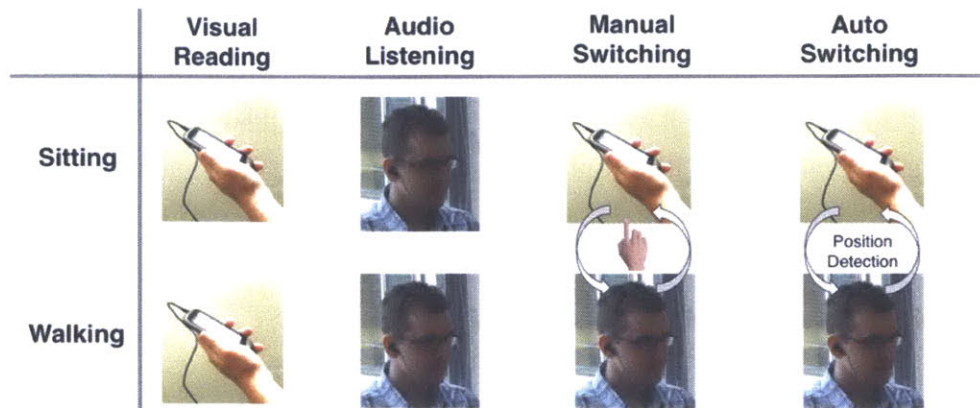


Figure 5-1: Four investigated conditions

to read, whereas the Vadas et al. study uses a short passage containing only one to three paragraphs.

### 5.1.3 Procedure

The user study setting is illustrated in Figure 5-2. A path is taped on the ground and is 30 cm wide and 42.5 meters long. All participants are instructed to walk inside the taped path, and an experimenter recorded the number of out-of-path steps during the study.

Four web pages were used in the user study: two articles selected from technology websites and another two from business websites. On average, there are 922.5 words per web page (SD = 82.5) and the study web pages are a subset of study materials from [89]. The web pages are formatted using mobile templates from the original web sites. The order of web pages presented is randomly selected, as well as the condition applied to those pages.

At the beginning of the study, the experimenter presented one sample web page and allowed the participant to get used to reading it in the four tested conditions. During the study, the experimenter raised a big sign and rang a bell to inform participants when to switch activities, e.g., from walking to sitting or vice versa. The switch happened once a minute to simulate frequent context switches



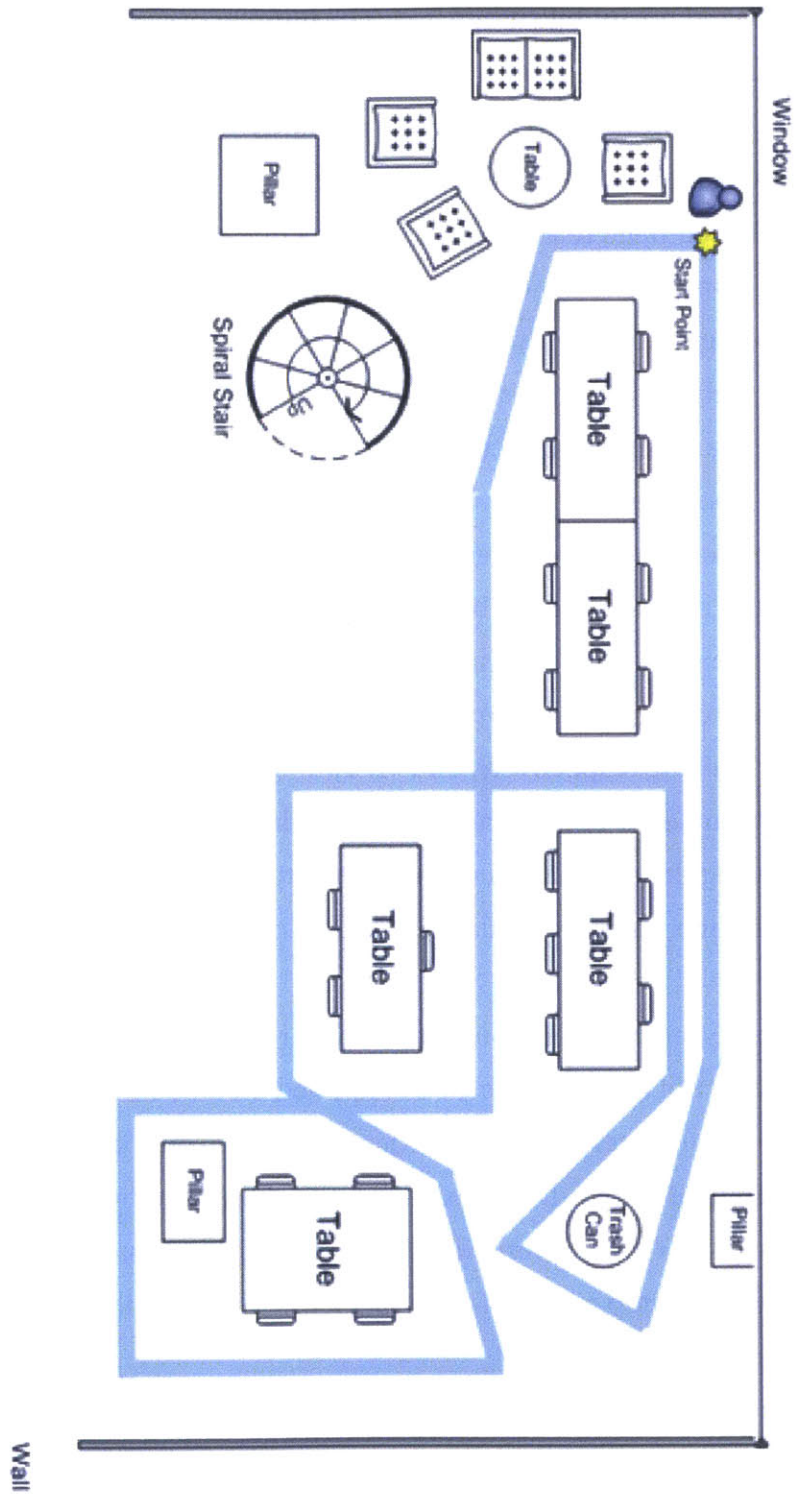


Figure 5-2: The floor plan of user study experiment. The blue line is the path that participants had to follow.

happening on today's mobile usage [67]. The number of switches varied depending on the participant's reading time. For all conditions, all participants wore a wired headset and were asked to hold the phone as they walked through the path. (Figure 5-3) On average, each study lasted for 70 minutes (SD = 12.71).

After each web page reading, I presented a questionnaire containing 5 multiple choice comprehension questions about the article and 2 subjective questions about ease of reading the web page and self-evaluation of understanding. The studied web pages and reading comprehension questions are reused from readability enhancement project. (Please refer to appendix for these questions.) I conducted a post-test interview to solicit participants' subjective feedback.

There are four conditions investigated in the study: (1) visual-reading: participant reads the content visually both while sitting and while walking; (2) audio-listening: participant listens to the content in both the sitting and walking states; (3) manual-switching: user manually switches to visual-reading or audio-listening for sitting or walking respectively; and (4) auto-switching: the mobile device automatically switches to visual-reading or audio-listening for sitting or walking respectively, using the orientation of the device to determine whether the user is carrying it in their hand for visual reading, or carrying it in a pocket for audio listening.

Each user experienced all four conditions, reading one article in each condition. The order of reading articles and applied methods were randomized. Although the experimenter informed participants to step only inside the taped path at the beginning of the study, the experimenter didn't remind participants again during the study. The experimenter kept track of this value as the participant walked, counting a step as out-of-path if at least half of the foot area was outside the blue taped path.

In the audio-listening, manual-switching and auto-switching conditions, the mobile browser highlights the current listening sentence in red and the current listening paragraph with a yellow background (Figure 5-4). The listening paragraph is always scrolled automatically to the beginning of the screen. The main

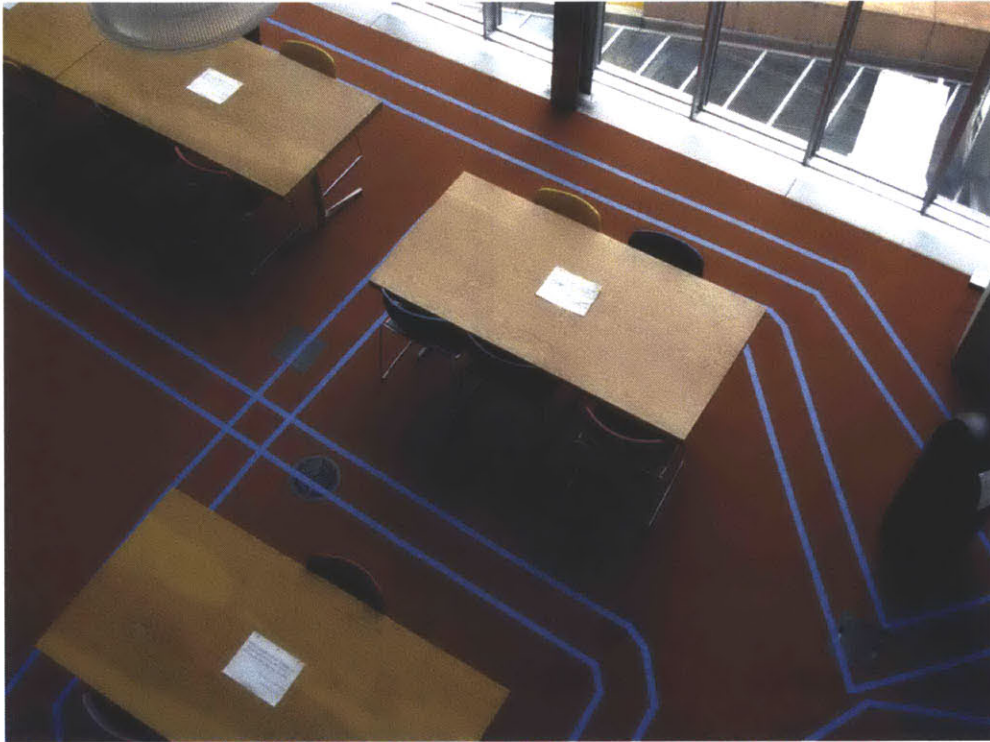


Figure 5-3: The floor plan of user study experiment. The blue line is the path that participants had to follow.

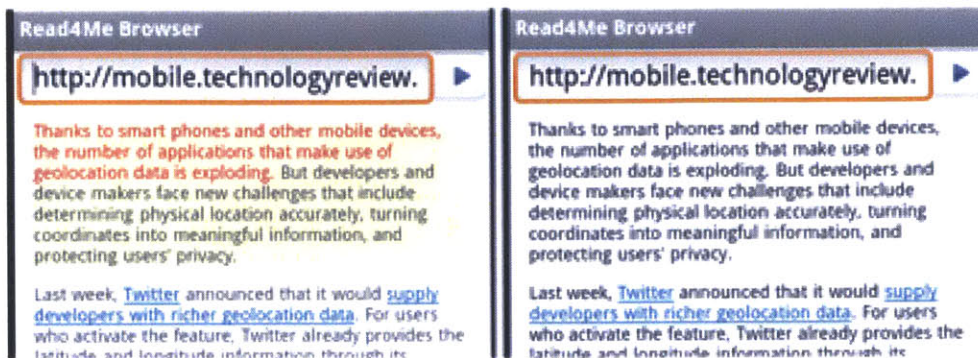


Figure 5-4: The difference between marked sentences and paragraphs (left) with plain ones (right).

difference between manual-switching and auto-switching is whether one needs to manually press a button to start or stop listening to the web page.

This user study measures: (1) reading speed; (2) reading comprehension; (3) number of out of path steps; (4) user satisfaction in ease of reading; and (5) self-evaluation of understanding. Reading speed means the number of words a participant reads per second, and reading comprehension is measured by the number of correct answers to the 5-question quiz. The user ratings of two subjective questions are used to measure user satisfaction in ease of reading and self-evaluation of understanding.

### 5.1.4 Hypotheses

In this user study, I had the following hypotheses to evaluate:

1. Visual-reading provides the best reading comprehension, but it also has the highest out-of-path rate.
2. Audio-listening provides the best user satisfaction because it allows users to pay attention to surrounding environment and does not require extra burden for reading, such as visual attention.
3. Auto-switching has lower reading comprehension than visual-reading, but

more user satisfaction than visual-reading and less user satisfaction than audio-listening.

4. Manual-switching provides a similar reading comprehension as auto-switching, but it has a lower user satisfaction compared with auto-switching.

If I group four hypotheses by using reading comprehension and user satisfaction, the hypotheses can be stated as follows:

1. Reading Comprehension

audio-listening < manual-switching  $\approx$  auto-switching < visual-reading

2. User Satisfaction

visual-reading < manual-switching < auto-switching < audio-listening

### 5.1.5 Results

This research measured five variables in the study: reading speed, reading comprehension, number of out-of-path steps, user satisfaction of ease of reading and user's self-evaluation of understanding. It is a within-subject study and we analyzed the results using a one-way ANOVA. For easy explanation, we use  $V$ ,  $A$ ,  $MS$  and  $AS$  to represent visual-reading, audio-listening, manual-switching and auto-switching.

Figure 5-5 presents the average reading speed for each of the four conditions, measured in words per second. Although there is no clear overlap between the  $V$  and  $A$  error bars, statistically there is no significant difference across all 4 conditions. ( $F_{3,36} = 1.67, p = 0.19$ ) The reason for the tiny variance in  $A$ , audio-listening, is because participants listened to spoken sentences generated using Text-to-Speech (TTS) at a constant speed that couldn't be changed during the study by participants.

Figure 5-6 shows the results of the reading comprehension measurement, which is defined as the number of correct answers out of 5 comprehension questions. There is no significant difference found in this measurement. ( $F_{3,36} = 0.54$ )

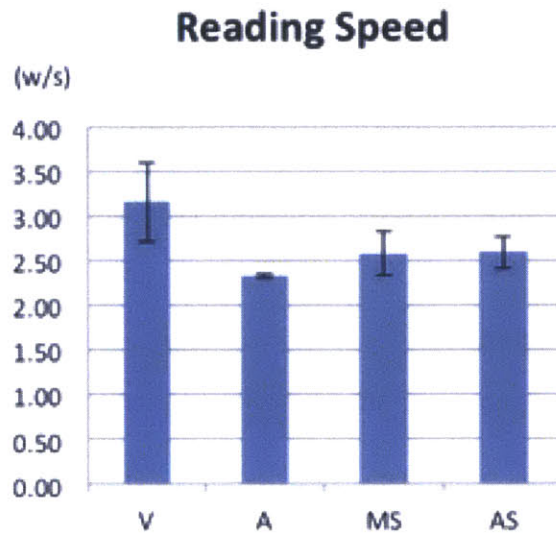


Figure 5-5: Reading speed for each condition, in words per second. Error bars show standard error.

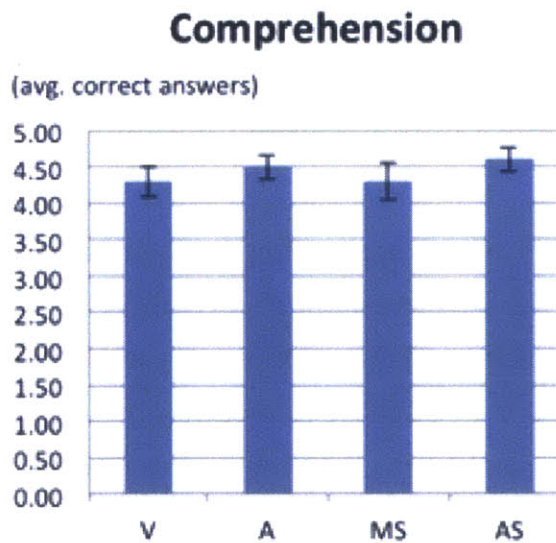


Figure 5-6: Comprehension for each condition (measured by number of correct answers to a 5-question quiz).

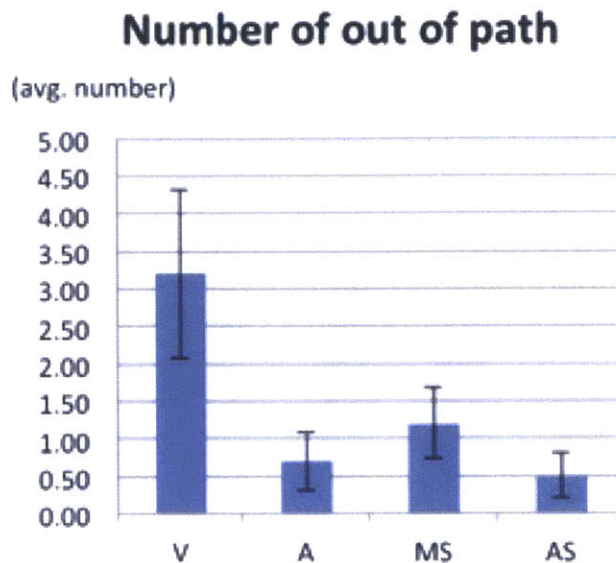


Figure 5-7: The number of out of path steps for each condition.

Figure 5-7 presents the number of participants' steps out of the taped path in each condition. The measurement of the number of steps out of path is an indicator to understand participants' awareness of the surrounding environment.

There is a significant difference in this measurement. ( $F_{3,36} = 3.53, p < 0.05$ ) A post-hoc Tukey test reports an honest significant difference between *V* and *AS* on the number of out-of-path steps ( $q = 4.10, p < 0.05$ ) and also gives an honest significant difference between *V* and *A* ( $q = 3.80, p < 0.05$ ).

Figure 5-8 shows subjective reading ease of the web page, on a Likert-type scale (1 = very difficult, 7 = very easy). There is a significant difference in subjective reading ease ( $F_{3,36} = 8.88, p < 0.001$ ). A post-hoc Tukey test gives an honest significant difference between *V* and *AS* ( $q = 7.26, p < 0.01$ ), *A* and *AS* ( $q = 4.24, p < 0.05$ ), and *MS* and *AS* ( $q = 3.93, p < 0.05$ ). The result indicates that auto-switching provides the best reading ease of the web page among all four conditions.

Figure 5-9 reports on the second subjective question, self-evaluation of understanding, which is also a Likert-type scale question. There is no significant

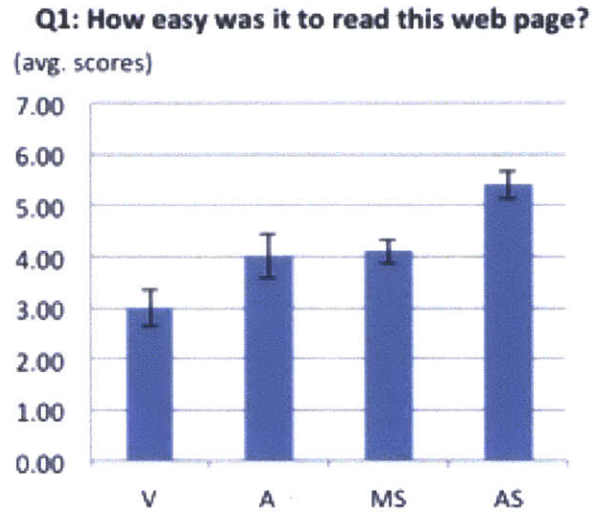


Figure 5-8: Ease of reading (rated on a scale from 1=very difficult to 7=very easy).

difference in self-evaluation of understanding. ( $F_{3,36} = 1.67, p = 0.19$ )

This research also uses a corresponding nonparametric method, Kruskal-Wallis one-way analysis, to analyze the data that have a significant difference in one-way ANOVA analysis, i.e., the number of out of path steps and ease of reading. Kruskal-Wallis test shows that there exists a significant difference in ease of reading measurement among four conditions (chi-squared = 18.0364,  $df = 3$ ,  $p$ -value = 0.0004323). The post hoc paired comparison test shows significant differences between *V* and *A* ( $K = 13.3, p < 0.01$ ), *V* and *MS* ( $K = 17.8, p < 0.01$ ), *V* and *AS* ( $K = 28.5, p < 0.01$ ), *A* and *AS* ( $K = 21.6, p < 0.01$ ) and *MS* and *AS* ( $K = 23.1, p < 0.01$ ). The results indicate that auto-switching provides the best reading ease of the web page among four conditions that matches to the analysis done with parametric method, i.e. one-way ANOVA. However, Kruskal-Wallis test does not show a significant difference in the number of out of path steps measurement.

Based on the results from the user study, we can address the hypotheses presented:



### Q2: How well did you understand this web page?

(avg. scores)

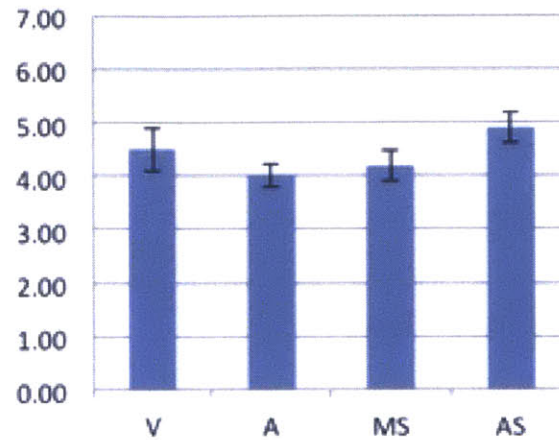


Figure 5-9: User's self-evaluation of understanding (1=very difficult, 7=very easy).

1. Visual-reading has a similar reading comprehension as audio-listening, manual-switching in between and auto-switching in between. However, visual-reading has the highest rate of stepping out of path, which is an indicator showing that participants might be more likely to encounter dangers when using visual-reading as a reading practice on a mobile device.
2. Audio-listening does not provide the best user satisfaction. Instead, auto-switching, i.e. automatically switching between audio listening and visual reading on a mobile browser, provides the best user satisfaction.
3. Auto-switching not only offers a similar reading comprehension as visual-reading, but it also provides the best user satisfaction among all four conditions. In fact, there are significant differences between using auto-switching and visual-reading in both number of steps out of path and the subjective ease of reading measurements. (Figure 5-8 & 5-9)
4. Manual-switching provides a similar reading comprehension as auto-switching, but there is no significant difference in user satisfaction between them.

If the results are interpreted by using reading comprehension and user satisfaction, this research can conclude the followings:

1. Reading Comprehension

audio-listening  $\approx$  manual-switching  $\approx$  auto-switching  $\approx$  visual-reading

2. User Satisfaction

visual-reading  $<$  manual-switching  $\approx$  audio-listening  $<$  auto-switching

### 5.1.6 Post-study Interview

There are many useful comments we received from the participants during the post-study interview. I classify them into five categories:

#### Visual reading is not always good

Reading on-the-go is hard, but many people still do it and suffer from this condition. Some comments support this point:

*“[It was] very difficult when walking, because I couldn’t balance well and my eyes hurt.”*

*“[I] can quickly scan [the] document and automatically adjust pace [for] document locations that require more thorough understanding.”*

*“... it could be dangerous if not inside a room.”*

However, several users responded that they had better reading comprehension in visual reading than listening.

*“Comprehension is better with [visual] reading compared to pure listening.”*

*“I can read much more quickly than something can be read [with audio]. I can also skim over portions I know things about ...”*

### **Listening isn't simply listening**

Users also responded that they prefer listening on-the-go over reading on-the-go, which matches the findings in Vadas's work [84]. A common suggestion I heard from the users is that they need more control in the audio listening condition. Because of the potentially distracting background environment, such as surrounding people or distracting objects, it is easy for a mobile user to lose their focus on listening and be unable catch up in their understanding. As one user noted, "I prefer having control while listening (reading-like experience while listening, such as repeat, jump ahead, change speed, etc.)." Another added, "The inability to go back while listening seems to be a fundamental problem with listening because it might be very hard for the system to guess exactly what I want to listen to again." The preferred way to trigger actions might be "voice command" or "line/headset control". As another user commented, "... providing both remote and voice control would be best because sometimes my hands are not free (imagine holding grocery bags on both hands, or driving)." Providing improved quality audio over TTS and support for quickly glancing at content while listening, e.g. to key sentences, are two other requests.

### **Mobile Web browser should be smarter**

One issue that comes out from the user study concerning the system is that when switching from visual reading to audio listening, the browser is not smart enough to know where the user stopped reading. Instead, it normally reads from the beginning of the first visible paragraph. One user mentioned, "Sometimes when I stopped reading in the middle of A, but the speaker [browser] start[ed] from B directly, and I lost some part of A (this causes me sometimes to go back and re-read something.)."

### **Manual-switching and auto-switching are useful**

While 8 out of 10 users explicitly mentioned that auto-switching in mobile reading is their most-preferred method, 3 out of 10 preferred manual-switching. (2 users voted for two methods as their most-preferred method and 1 user responded “It depends.”) As one user noted, “It [Manual-switching] is closer to the natural way that I tend to do.” Another added, “I prefer listening while walking and reading while sitting . . . manual-switching gives more freedom when to listen and when to read.” It would be helpful to provide both of these two options in the mobile web browser design to help mobile reading, but the design needs to lower users’ burden to enable manual-switching, which was mentioned by three users. One suggestion from users is that we should also provide manual-switching with the same visual cues used in auto-switching, so that they can easily understand where they stop listening as they switch to visual reading.

### **Challenges of using audio and TTS**

There are two challenges in using TTS to support audio listening in the study. First, content filtering is necessary to enhance the listening comprehension. There are three types of information that might be distractions:

1. Abbreviations: for example, in the visual-reading condition, reading TX or CO in context can be interpreted as Texas or Colorado intuitively. But, in the audio-listening condition, speaking TX or CO does not carry the same meaning as speaking Texas or Colorado. Transforming abbreviations into appropriate terms can enhance listening comprehension for users.
2. Punctuation: filtering punctuation is also necessary. Without transforming the content, simply putting “- -” symbols into TTS will return “hyphen hyphen” in audio. This can disrupt and annoy the reader. One acceptable solution is to have a short pause instead.
3. Foreign names or place names: uncommon foreign names or location names

might be fine in visual reading, but they might cause difficulty for listeners, such as Bhattacharjee, Chvez, etc.

All of these three issues were found in a pilot study and fixed later for the formal study presented in this chapter. However, we still received some comments from study participants. For example, one user said, “ it reads 'e-mail' as separate words, and the breaking of sentence[s] is sometimes weird and annoying,” and another commented, “The text-to-speech software will stop a sentence in the place it shouldn't stop and make it more difficult to understand.”

### **5.1.7 Limitations**

There were limitations of the study. For example, this study did not examine user performance during the context switch itself, such as from walking to sitting and from sitting to walking for each condition. Users might get lost during the transition and the performance might change accordingly, but the data presented only shows the user's performance for the entire period of reading process. A further study should be conducted to understand this part. The comments from the users presented are helpful to extend current understanding in mobile reading research. For example, as suggested in [84], “having an audio output option would be a beneficial and useful feature for mobile devices that involve the presentation of text passages,” but synthesizing speech from text by using a state-of-the-art TTS engine still has room to improve according to the study.

## **5.2 Read4Me Browser**

In this section, I introduce a new mobile web browser, Read4Me browser, to demonstrate ideas for enhancing mobile reading.

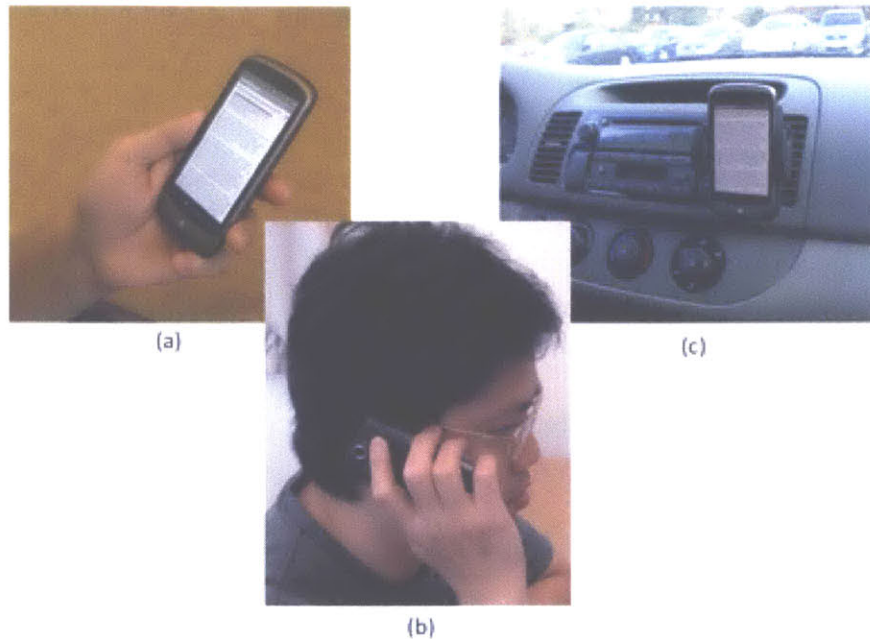


Figure 5-10: The phone is in (a) viewing position (b) listening position and (c) in docking position.

### 5.2.1 Design Principles and Users Interface Design

Read4Me browser is a prototype system developed to support the presented user study and then extended to implement additional ideas and suggestions from the study participants. In order to support auto-switching, we investigated different approaches and decided to use orientation sensor information to satisfy the goal. This research didn't adopt similar approaches as in [54] to integrate multiple sensors, but instead used a single sensor to make the design simple and easy to extend.

Read4Me browser uses the orientation of the mobile device to detect certain conditions and react accordingly. For example, when the user places the phone in a viewing position to read visually, the browser will not speak any sentences. (Figure 5-10(a)) When the phone is placed in docking or listening position, the browser uses TTS to read web pages aloud sentence by sentence. (Figure 5-10 (b) and (c))

Read4Me browser defines two operational states, Look&Point and Hear&Say, and uses orientation information to transition between these conditions seamlessly. While the first state represents the condition of looking and pointing on a screen, the second state supports hands-free conditions, such as walking or driving. In the Look&Point state, the user can read web pages as usual and use their finger to touch the screen for scrolling, clicking, panning, zooming, etc. When switching to the Hear&Say state, the user can listen to web page content, parsed by Read4Me browser and read using TTS. In the Hear&Say state, Read4Me browser reads one sentence at a time and highlights the current sentence in red so that the user can easily identify it when switching back to the Look&Point state.

In addition to supporting auto-switching, Read4Me browser also implemented manual mode switching to support manual-switching in the user study. One touch on screen toggles between the Look&Point and the Hear&Say states.

## **5.2.2 System Overview and Implementation**

Read4Me browser runs on the Android 2.3 platform using the WebKit engine and WebView widget. Read4Me browser supports portrait mode at this moment, but landscape mode will be implemented in the future. Although we hope to develop a general mobile browser to be used on different platforms, cross-platform compatibility has not been a priority at the current stage.

### **User Interface Design**

Read4Me browser has a similar user interface as other mobile web browsers. It has a URL bar, Go button, content area and menu. There are five options in the menu: Auto Switching, Annotation, Reload, Back and Forward. (Figure 5-11)

### **Auto-Switching**

While Reload, Back and Forward mean reloading the current page, going back to the previous page and going forward to the next page, “Auto Switching” is de-

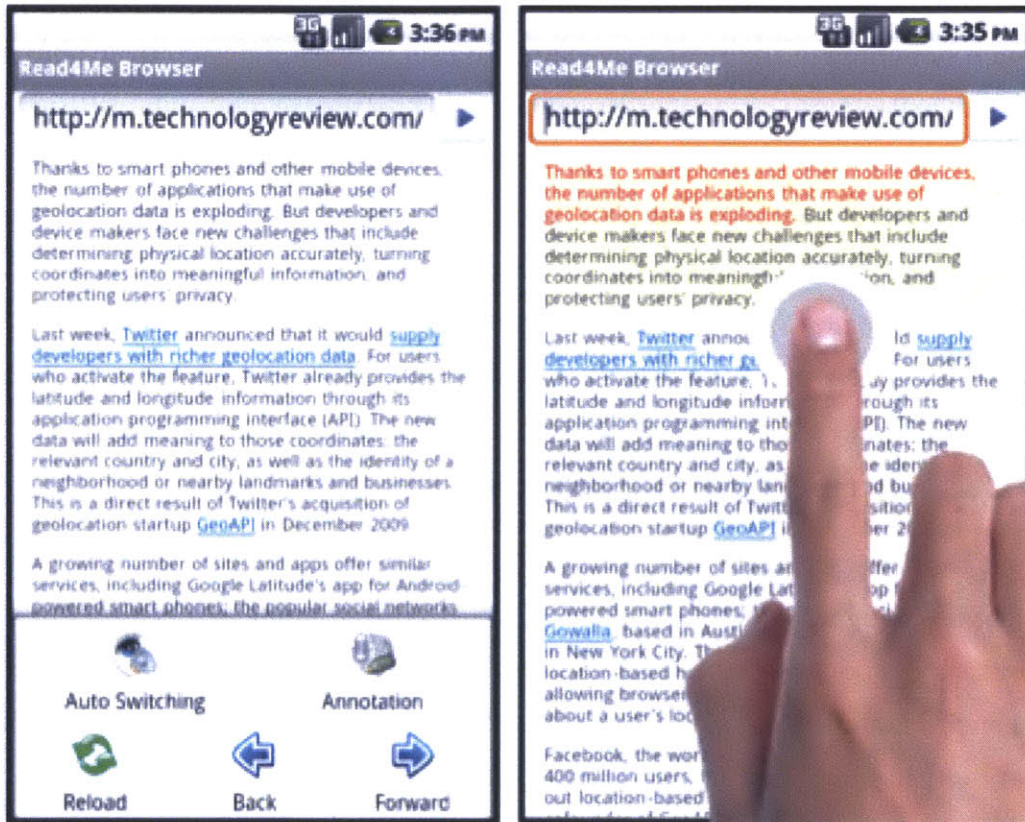


Figure 5-11: The Read4Me browser interface: (left) menu options (right) when using a figure to touch on the screen, manual-switching can be enabled or disabled.



signed to support the scenario of automatically switching between visual reading and audio listening using the phones orientation information. Specifically, when the phone is in docking or hearing position, the browser will enter Hear&Say state and start reading content aloud. When the phone is in visual reading position, the browser stops reading aloud.

There are four conditions defined in Read4Me browser: (1) left-ear listening, (2) right-ear listening, (3) in docking, and (4) static reading. The first three conditions trigger the Hear&Say state, whereas the fourth condition triggers the Look&Point state. In order to detect the switches between conditions, Read4Me browser uses the orientation sensor. Because the research is concerned more with the position of the device than the rate of rotation about an axis, the system design chose the orientation sensor rather than gyroscope sensor for this purpose. In fact, there is no hardware orientation sensor in Android phones, but instead Android OS combines magnetic field and accelerometer sensors at the driver level to provide orientation values as if there were an orientation sensor [59].

The coordinate system of the phone has three axes: the X-axis is horizontal and points to right of the phone, the Y-axis is vertical in the plane of the phones screen, and the Z-axis points directly out of the screen. The orientation sensor data is a set of (azimuth, pitch, roll) values defined follows:

- Azimuth: the angle between the Y-axis and the magnetic north direction around the Z-axis (0 ~ 359 degrees)
- Pitch: the angle around X-axis (-180 ~ 180 degrees)
- Roll: the angle around Y-axis (-90 ~ 90 degrees)

Currently, the algorithm implemented in Read4Me browser is a heuristic analysis-based approach. I investigated the value ranges of each condition and set these values as criteria in advance. When Read4Me detects the situation of conditions change, it responds accordingly. Since orientation values update in milliseconds,

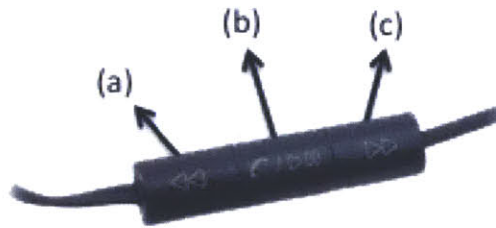


Figure 5-12: Stereo headset remote controller for Voice Annotation, Emoticon Highlighting and Line Control.

to provide a better switching detection, the system uses a timer (500 milliseconds) to detect whether the phone is under a specific condition. Let  $R_i$  be the region defined for each condition and  $i$  be left-ear, right-ear, in-dock and static-reading. The value ranges of each  $R_i$  are:


- $R_{left-ear} | R_{right-ear} : (-100 \leq Pitch \leq -70) \& \& (-10 \leq Roll \leq 10)$
- $R_{in-dock} : (-90 \leq Roll \leq -30) | (30 \leq Roll \leq 90)$
- $R_{static-reading} : otherwise$

### Line Control - Fast Backward and Forward

Line control is a newly-added feature that was requested by the study participants. As one user mentioned, “I prefer having control while listening (reading-like experience while listening, such as repeat, jump ahead, change speed, etc.)” Read4Me browser uses Figure 5-12 (a), (b) and (c) buttons to provide fast backward, play and pause, and forward in Hear&Say state. By using this feature, the user can quickly skim through sentences at a fast speed without any interruptions.

### Voice Annotation and Emoticon Highlighting

Voice Annotation and Emoticon Highlighting are features designed to demonstrate how to annotate and highlight without the user visually reading the con-

 Last week, [Twitter](#) announced that it would [supply developers with richer geolocation data](#). For users who activate the feature, Twitter already provides the latitude and longitude information through its application programming interface (API). The new data will add meaning to those coordinates: the relevant country and city, as well as the identity of a neighborhood or nearby landmarks and businesses.


 This is a direct result of Twitter's acquisition of geolocation startup [GeoAPI](#) in December 2009.

Figure 5-13: Adding voice memos to sentences on-the-go.

tent, to support annotating and highlighting for the on-the-go situation. For example, when the user is walking, i.e. in Hear&Say state, and the browser reads a certain sentence aloud, the user can double-click the button in Figure 5-12 (b) to add a voice memo to the sentence. A small audio icon is added as a visual cue at the left top of the sentence. When the user revisits the same page later, all voice memos show up again for review. (Figure 5-13) If the browser is in Look&Point state and the user can visually read the content, he can also add a voice memo by simply long-pressing a sentence.

However, similar to reading on paper, it is not always necessary to add annotations. Instead, marking or highlighting sentences for later review may be good enough. Emoticon Highlighting is the feature designed for this purpose. It allows users to highlight sentences with emoticons. When listening to content in Hear&Say state, the user can single click the Figure 5-12 (b) button and say “[cool | awesome | great]” to add a positive emoticon or say “[not good | bad | sad]” to add a negative emoticon (Figure 5-14). Read4Me browser uses Android speech recognizer to do speech recognition and then does simple keyword spotting for emotion extraction.

SimpleGEO currently offers a service for application and Web developers that turns latitude and longitude information into addresses, but that's only the beginning. 😊 founder Stump says he is in talks with a number of providers of geo-data to make their libraries of data available to developers, and ultimately users. "If you had an interesting location data set, you could feed into our system and resell it," says Stump. "We're creating iTunes for geo-data."

😬 Perhaps the biggest remaining issue is protecting users' privacy. Laraki believes that the best way to solve this problem is through simplicity--instead of giving the user a maze of settings, they need to be able to easily decide whether to transmit their location or not.

Figure 5-14: Adding Emoticon Highlighting on-the-go.

### 5.2.3 Auto-Switching with SVM Classifier

Although this research has designed and implemented a heuristic analysis-based algorithm for automatic mode switching in Read4Me browser, this research also conducted an experiment to investigate another solution to extend Read4Me browser's capabilities to support additional conditions. One common condition, for instance, is that people like to put their cellphone into a pocket while walking and listening to music, then use a headset remote controller to control the audio.

Based on the same idea, I want to add one condition, in pocket, to the existing design and investigates a solution using a machine learning approach. Now, there are five conditions defined: (1) left-ear listening (2) right-ear listening (3) in docking (4) in pocket and (5) static reading. The first four conditions are defined in Hear&Say state and the fifth condition is defined in Look&Point state. The fourth condition is the new addition.

This experiment collected 250 samples from each of these five conditions, 1250 samples in total. The samples were collected in a laboratory setting, with

samples recorded every few seconds in each condition. Each sample contains azimuth, pitch, and roll values for a given posture label. The whole dataset is separated into a training dataset (1000 samples, 200 for each condition) and a testing dataset (250 samples, 50 for each condition) for the evaluation.

### Training SVM Classifiers and Evaluation

This experiment uses the azimuth, pitch, and roll data from the orientation sensor to identify the condition which mobile browser should switch to.

I trained SVM classifiers [21], using One-Against-All classification with a Radial Basis Kernel, to predict the five defined conditions. To make each dimension have the same dynamic range, it divided the azimuth value by 200, the pitch value by 100, and the roll value by 50. In addition, it set the slack penalty to 10 and maximum number of iterations of quadratic programming to 100,000 during the SVM training phase.

To evaluate the five trained SVM classifiers for five conditions, the experiment used the testing dataset. The experiment evaluated the performance of the classifiers in two ways. First, it looked at the accuracy of predicting the five conditions, i.e. given a set value of (azimuth, pitch, roll), which classifier has a highest score when evaluating it. Second, it looked at prediction accuracy for the two states, where Look&Point State corresponds to the static reading condition, and Hear&Say State corresponds to the other four conditions. The results of the evaluation on the testing dataset are shown in Table 5.2.3.

Prediction	# of samples	# of errors	Success Rate
2 States	250	1	99.6%
5 Conditions	250	17	93.2%

Table 5.1: Evaluating the testing dataset (250 samples) on five trained SVMs.

The results suggest that one-against-all SVM classifiers can predict the posi-

tion of mobile phone more accurately with respect to states than in conditions. Although the results are promising, more studies are required to provide a robust support in real usage, such as collecting training and testing data from different people in a laboratory setting and obtaining data from real on-the-go conditions. This approach is not part of Read4Me browser at this moment and I reserve it as future work.

### 5.3 Conclusion

Mobile reading and browsing have many limitations originating from physical constraints. Although Vadas et al. [84] has studied reading on-the-go situation with different modalities, I think reading on-the-go with frequent context switches, such as switching from walking to sitting, to standing statically or hands-free situations, is important and not yet addressed. In this chapter, I address this problem and present the results of a user study modeled after the study by Vadas et al. [84] Results from this user study include:

1. All of four evaluated conditions, visual-reading, audio-listening, manual-switching and auto-switching, share a similar reading comprehension. However, visual-reading is more likely to expose readers to dangers than other conditions.
2. Auto-switching not only has the lowest incidence of stepping out of path, which is safer for mobile reading, but it also has the best subjective ease of reading in the study, which means it provides the best reading experience when reading content on a mobile web browser under frequent context switching situations.
3. Manual-switching provides a similar reading comprehension as auto-switching, and some study participants expressed the necessity of having this feature for certain conditions, such as listening to content while sitting in an office.

Read4Me browser is a prototype system built on top of the Android 2.3 platform to support the presented user study. In addition to having auto-switching and manual-switching support, Read4Me also implements three new ideas, including Line Control, Voice Annotation and Emoticon Highlighting.

In summary, there are two contributions presented in this chapter. First, I studied continuous reading on a mobile device with four defined conditions. Second, I designed and implemented a new mobile Web browser, Read4Me browser, to support continuous reading to the situation of reading on-the-go with frequent context switches.

# Chapter 6

## Discussion

This thesis has presented three issues that arise when users use today's Web on desktop and mobile browsers, including web page readability, web page skimmability and mobile continuous reading. I have presented the results of my investigation on these issues and ideas to improve each of them. In this chapter, I want to discuss the lessons learned from my research and generalize these findings into a few design principles. In addition, I also want to lay out the design space of enhancement for readability and discuss the coverage of my research in this space.

### 6.1 Design Principles

I have derived five design principles from my research. Each of them might be learned from a specific research project or several of them. Reducing distractions provide a clean reading environment. Content transformation enhances web page readability. Content filtering improves web page reading under time constraints. In-place translation gives users an instant support to reading. Lastly, continuous reading support makes mobile reading easier and safer than without having it. Each of them is discussed as follows.



### **6.1.1 Reducing Distractions**

Users prefer to have a comfortable reading environment. A face-to-face interview with 14 users on web behavior survey suggested that some users preferred to minimize unnecessary distractions, including static, embedded, animated and popup advertisements, or make them less salient rather than to remove them. This finding motivated me to investigate this issue. Reducing distractions is one of the design principles to enhance web page reading.

The skimmability enhancement project not only detected potential distractions, shrank them proportionally and made them less visible, but also spotlighted the main reading content and masked out the rest.

Although the skimmability enhancement project didn't investigate the relationship between distractions reduction and all the measurements, but the user study indicated that Froggy GX, which contains distractions reduction, i.e. the features of cleaning page, spotlighting and masking, can enhance reading comprehension and user satisfaction (ease of reading, self-evaluation of understanding and enjoyability of reading). According to the results, I believe reducing distractions can help for reading.

Similarly, the Readability browser add-on [14] and iOS5 Safari Reader feature [6] have taken this idea into design, but both of them remove distractions and only show main text content either in current viewing page or a popup window. Both of them sacrifice web page layout for the simplicity and it gives users less understanding about where they are reading in the original web page. In contrast, my approach tries to reduce distractions and keep users in original web page layout.

### **6.1.2 Content Transformation**

Content transformation enhances reading comprehension. As defined in Wikipedia [19], "Readability is the ease in which text can be read and understood." Research on readability has been conducted since L. A. Sherman [80] in 1880. A hundred

years of research on readability has helped people understand how to make reading easier and comfortable. However, the advent of the Web in the 1990s changed the environment again. Although there are different ways to investigate the web page readability issues, my research takes user satisfaction into consideration because I think reading should be comfortable, without too much pressure. However, for non-native English readers, it is not easy. Similar to Walker's VSTF format [86], I proposed a new content transformation method, Jenga format, to address web page readability issues.

The design philosophy behind the Jenga format involved two important factors learned from iterative paper prototype study with 28 users: sentence separation and sentence spacing. (Please refer to Chapter 3 for the details.) As I learned from the iterative paper prototype study, the traditional block format of text is not always easy to read for non-native English readers, but content transformation can improve their reading comprehension and satisfaction. Although the Jenga format has been proved to enhance web page readability for non-native English readers, I believe there might still exist other kinds of innovative content presentation that have not yet been explored but could also help to enhance web page reading in general.

### **6.1.3 Content Filtering**

When we move from readability to skimmability, the challenge becomes more difficult. In the readability enhancement project, although I could enhance web page readability for non-native English readers, their reading speed remained comparatively slow. Previous research [28] indicated that extensive reading can significantly improve readers' reading speed and reading comprehension, but the practice of extensive reading requires time and skim-reading skills are not common among non-native readers. Therefore, I think content filtering, which provides limited and important information to read, is a way to help non-native readers to skim-read. Froggy GX customizes the LexRank algorithm [47] to iden-

tify salient sentences and differentiate them from other sentences to provide content filtering.

However, another lesson learned from the Froggy GX in a pilot study with 10 users was that non-salient sentences are also important. I failed to notice this and tried to make non-salient sentences almost invisible. To correct this oversight, I made non-salient sentences less visible such that non-native readers can differentiate salient and non-salient sentences, yet still read non-salient sentences without great effort. The result of the user study indicated that this finding was helpful to enhance web page skimmability. Although non-native readers' comprehension strategies were not investigated in the project, I believe non-salient sentences, specifically the ones that surround salient sentences, help to connect disparate salient sentences.

Since the original LexRank algorithm only uses intra-sentence similarity to find salient sentences, it might not choose the easiest sentences to read for non-native readers. One interesting direction of future work is to investigate a way of combining the LexRank algorithm with readability equations to improve the quality of salient sentence selection. In general, readability metrics are used to measure the ease of the text to read and there are several formulas designed for this purpose, such as the Flesch formulas, the Gunning Fog formula, etc.

#### **6.1.4 In-place Translation Support**

As discussed in the skimmability enhancement project, some study participants mentioned that in-place translation was helpful to their reading under time constraints. A few enhancement ideas from the study participants were related to in-place translation, such as adding photos to translation for understanding vocabularies, making in-place translation easy to use, linking translation to a dictionary, etc. However, one lesson I learned was that the design of in-place translation of Froggy GX still has room to improve. For example, to trigger the translation feature, Froggy GX requires users to select a target, either a word, a phrase or

a sentence (precisely or roughly), to have a translation. Many participants found it tedious to create a selection. Instead, some participants' comments suggested to make it easier to trigger translation, such as mouse hover over the target. In addition to triggering translation, some participants also wanted to have multiple translations for better understanding the content. Because it is so often requested, I believe in-place translation is important to enhance reading for non-native readers.

### **6.1.5 Continuous Reading Support**

Reading on a mobile device is not easy, but reading on-the-go on a mobile device with frequent context switches is more difficult. Although e-readers are common nowadays, people still like to use their mobile phone to read information because they carry their phone all the time. For reading on a mobile device under frequent context switches, my research found that automatic mode switching provides the best continuous reading experience to mobile users. It not only allows mobile readers to enjoy reading under different conditions, but it also provide higher user satisfaction, compared with using simply one modality. However, there are still many challenges, such as the challenge of using audio and TTS, the lack of a smart way to detect where to start audio when switching from visual reading to audio listening, etc. Personally, I think the way to ease the reading on a mobile device is important and my research indicated that continuous reading support is one of them.

## **6.2 Design Space**

In this section, I want to lay out the design space of web page enhancement for reading and discuss the choices made for my thesis work. As Figure 6-1 illustrates, the design space of web page enhancement for reading can be interpreted from different aspects, including reader population, language, content type, sit-

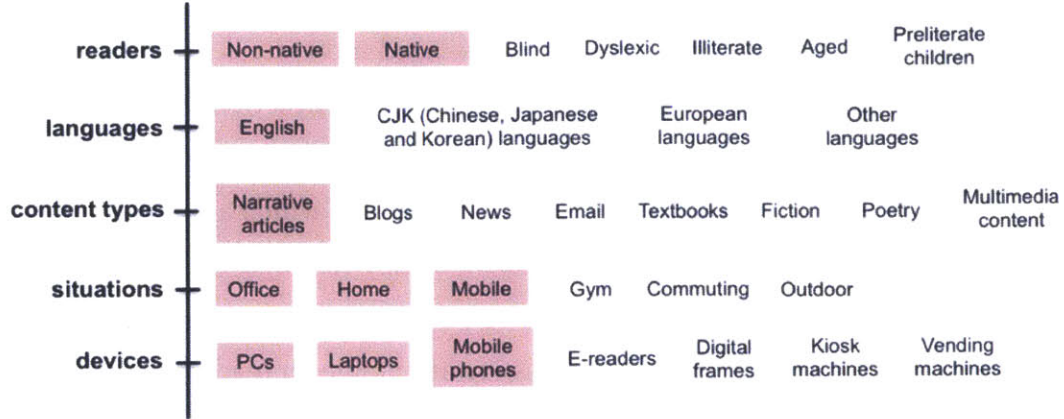


Figure 6-1: The design space of web page enhancement. The choices covered in this thesis are highlighted with pink colors.

uation, purpose and device.

Reader population categories include native or non-native readers, elderly populations, illiterate groups and preliterate children, as well as disabled individuals suffering from blindness and dyslexia. The content is written in languages such as English, CJK (Chinese, Japanese, Korean), European languages and other languages. Content types vary from narrative articles (such as technical, business, educational and reviews articles), blogs, news, email, textbooks, fiction, poetry to multimedia content (such as audio, video and animation). Reading situations range from office, home, mobile, gym, commuting to outdoor situations. Since the hardware design has improved a lot, web pages can be read on different kinds of devices, ranging from PCs, laptops, mobile devices, e-readers, digital frames, kiosk machines to vending machines.

The scope of my thesis focuses on English web pages for two specific populations: non-native English readers and mobile users. However, the design principles proposed might also help other populations, such as dyslexic groups and the elderly. For example, Vellutino et al. [85] pointed out that dyslexic children, who have inadequate facility in reading comprehension, have been found to have inadequate facility in word identification and word-level skills. Fundamentally,

content transformation and in-place translation-like support might help simplify content and recognize words. Furthermore, aged individuals often experience difficulty reading complex content. Hence, reducing distractions and content filtering could provide a more comfortable reading environment for such groups.

My research emphasizes narrative style web pages, which are text-heavy and information oriented articles. Blogs, email and textbooks also have similar properties. Personally, I believe content transformation can also help users read blogs, email and textbooks, but content filtering is not suitable for reading content which is important, such as important email. As for extremely long content, such as fiction and textbooks, which are normally organized into chapters, content filtering could be applied at the chapter level, and content transformation may be useful if users seek to understand further details. Related to this, my summer internship at IBM Research focused on extending readability enhancement techniques to blogs for enterprise social software. The result indicated that reducing distractions and content transformation were helpful to non-native employees in a corporation.

In terms of reading context, my research covers not only static situations (office and home), but also mobile situations, such as walking, sitting and context switches between them. However, there are many interesting situations not yet explored in my thesis, such as gym, commuting and outdoor environment. Although people normally use mobile phones or e-readers in these situations, reading sometimes happens on special devices, such as digital frames, kiosk machines or vending machines. For example, users read instructions and grade exams on vending machines [53]; visitors read tourist information on kiosk machines. In many of these cases, content filtering and in-place translation support could be helpful. The coverage of my thesis is highlighted with pink colors in Figure 6-1.

Although my research in readability and skimmability enhancement focuses on non-native English readers, I had several opportunities to demonstrate my systems to the public (and targeted populations) and get feedback. While some

audiences commented that the proposed solutions (Jenga format and content filtering) might be useful to native readers as well, other audiences also responded that Jenga format might also be useful to people with dyslexia and other reading disorders. Another interesting suggestion from the readers was how to make Jenga format and content filtering available to other applications, such as email clients and PDF readers for academic paper reading. Such comments would be interesting to explore further and potentially helpful for creating another tool to benefit broader populations.

# Chapter 7

## Conclusion and Future Work

In this thesis, I proposed three solutions for three identified issues: Froggy for Web Page Readability Enhancement, Froggy GX for Web Page Skimmability Enhancement and Read4Me Browser for continuous reading support on a mobile device. During my investigation, I also found some interesting research topics and would like to list them as future work. In this chapter, I discuss these topics and share my opinions on them.

### 7.1 Enhancing Blog Readability for Non-native English Readers in the Enterprise

Blogs are an important platform for people to access and share information, particularly in corporate settings where users rely on these systems for their work. However, because a global enterprise is multilingual, not all employees can understand the shared information in these systems easily if the content is written in a user's non-native language. I had a summer internship at IBM Research working on enhancing the readability of blogs in enterprise social software for this group of users [90]. A pilot user study of Japanese and Chinese bloggers suggest there are two main challenges: finding an interesting blog post to read and encountering difficulties in reading blog posts as currently rendered. Based on



these findings, I designed and implemented a Firefox extension, Clearly, which uses web customization techniques to improve these two levels of readability issues. However, the user study was not fully conducted and it is still unclear how to personalize the customization for an individual and a group of users with the same interest.

## **7.2 The Influence of Cognitive Style on Skim Reading**

Previous studies on cognitive styles and cultural exposure have shown that there exists a difference between Asian and Western people in perceiving web pages [32, 88]. The results suggested that Asian people are more field dependent, or holistic, and Western people are more field independent, i.e., analytic. In terms of skim reading, different reading strategies were found in eye-tracking studies of native English readers [44, 65]. However, the relationship between web page perception and reading strategy remains unknown. Moreover, no studies so far have focused on investigating non-native English readers' reading strategies used in skim reading. I think this research direction can help to understand the cognitive styles and skim reading strategies between Asian and European people when they read web pages under time constraints. The results can provide a fundamental understanding in this field and can be used for developing a better skim reading tools.

## **7.3 Enhancing Web Pages for Nonliterate Users**

Although the Web provides many useful resources, these resources are not accessible to nonliterate users, such as preschool age children, who do not know how to read and write but need parents to teach and play with them. The previous study showed that there is a need for family members to maintain intimacy, especially between children and parents [38], but one or both parents normally work outside the home and can't teach or play with kids to keep intimacy when (s)he

is in the office. Helping parents in distance settings utilize existing web resources and keep intimacy with their preschool age children is challenging. Previous research studies have tried to investigate how to keep intimacy for family members and different systems were proposed, such as eKISS [38], CASY [92], ASTRA [74], Digital Family Portrait [64] and Virtual Box [39]. However, none of them focused on preschool age children, who cannot type, read, or express themselves well.

It is challenging to utilize useful resources on the Web for nonliterate users, such as preschool age children. The idea I propose is to allow a parent at work to customize existing web resources, such as the International Childrens Digital Library (ICDL) [17, 5], to educate and play with their preschoolers at home. Parents at work can use their computer or mobile device to deliver customized web content for storytelling and preschool kids at home can interact with the content on a touch screen.

## **7.4 Summary**

This thesis hypothesizes that it is possible to enhance web pages on desktop and mobile browsers for two populations: non-native English readers and mobile readers. I have investigated this research issue and propose solutions from three directions to enhance web pages: (1) Enhancing web page readability for non-native English readers with Jenga format; (2) Froggy GX: enhancing web page skimmability for non-native English readers with content filtering and semantic data integration; and (3) Read4Me: providing continuous reading support on a mobile device for mobile readers with natural interactions.

# Appendix A

## User Study Materials

In this thesis, there were six web pages used in the user studies. In this appendix, I present the information of these web pages and the corresponding questions generated for the evaluation.

### A.1 Content Web Pages

There were two kinds of web pages selected for the user studies: technology and business web pages. In original web sites, some web pages were presented with multiple pages, i.e. users need to click on a link to read more content, and some web pages were presented in one page. To have a consistent presentation for the user studies, I made all six web pages to one page presentation.

- Web Page 1
  - Title: Computer in the Cloud - Online desktop systems could bridge the digital divide.
  - Author: Erica Naone
  - Type: Technology
  - URL: <http://www.technologyreview.com/news/408689/computer-in-the-cloud/>

- Web Page 2
  - Title: Changing how Japan works - Yasuyuki Nambu of Pasona is on a mission to make Japan's labour market more flexible.
  - Author: From *The Economist* print edition
  - Type: Business
  - URL: <http://www.economist.com/node/9861540>
  
- Web Page 3
  - Title: Intelligent, Chatty Machines - A startup hopes to help computers have meaningful conversations with people.
  - Author: Kate Greene
  - Type: Technology
  - URL: <http://www.technologyreview.com/news/408699/intelligent-chatty-machines/>
  
- Web Page 4
  - Title: The transcendental crusader - Can Taddy Blecher's combination of cheap business education and meditation transform South Africa?
  - Author: From *The Economist* print edition
  - Type: Business
  - URL: <http://www.economist.com/node/9723263>
  
- Web Page 5
  - Title: E-Paper Comes Alive - E Ink is making color and video versions of its e-paper, but commercial products are a few years off.
  - Author: David Talbot
  - Type: Technology

- URL: <http://www.technologyreview.com/news/409074/e-paper-comes-alive/>
- Web Page 6
  - Title: The capitalist communist - How a poetic Marxist has transformed business prospects in West Bengal.
  - Author: From *The Economist* print edition
  - Type: Business
  - URL: <http://www.economist.com/node/10171275>

## **A.2 Questions for Readability Enhancement Project**

In readability enhancement project, the questionnaire of each web page reading contains two parts: (1) Part 1 - reading comprehension questions; and (2) Part 2 - user's satisfaction questions. These questions are listed as the following. (Answers are marked with “\*”.)

### **A.2.1 Web Page 1**

- Part 1:
  - Q1. The passage answers which of the following questions?
    - A What is the beneficial feature of online desktop systems?
    - B Why did the first online desktop system fail?
    - C Is there more than one available online desktop system now?
    - D \* All of above
  - Q2. According to the article, what is “cloud computing”?
    - A Saving data in the form of a cloud into a computer
    - B Relying on Web-based applications to communicate with the user

C Retrieving personal data from the Internet is as slow as a cloud moving through the sky

D \* Relying on Web-based applications and storing data in the “cloud” of the Internet

– Q3. Which one of the following systems is not an online desktop system?

A Desktop Two

B Zimdesk

C Tarantella

D \* Facebook

– Q4. Which of the following is true about the Desktop Two?

A It is the first online desktop system.

B It can't serve more than 8000 users concurrently.

C \* Desktop Two's service is free for individuals.

D None of the above

– Q5. Which generation of users would most likely adopt the computer-in-the-cloud idea?

A \* The younger generation

B The middle-aged generation

C The older generation

D None of the above

• Part 2:

– Q1. How easy was it to read this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)

– Q2. How well did you understand this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)

## A.2.2 Web Page 2

- Part 1:

- Q1. What's the main purpose of this article?
  - A Explain why Japan's workplace does injustice to its workers.
  - B Discuss why Japan's labor market has been shrinking in recent years.
  - C \* Introduce a company which helps to put non-regular employees into the mainstream.
  - D Explain why non-regular employees can not be the mainstream in Japan.
- Q2. What did Mr. Nambu's father suggest for him to turn the job-placement scheme into?
  - A An organization for educational purpose
  - B A new investment strategy
  - C \* A commercial venture
  - D A non-profit organization
- Q3. Before Pasona, which one of the following is false in Japan?
  - A Regular workers were expected to remain loyal to their employers.
  - B Job placements were handled by a government agency.
  - C Temporary employees were not given corporate welfare.
  - D \* Temporary employees had the same rights as regular workers in the corporation.
- Q4. What does "freesters" mean?
  - A The young people who do not have a job.
  - B \* A new group of young people who drift from job to job.
  - C A group of young people who work for a new company.
  - D The older people who were retired.

- Q5. Which one is false about Pasona?
  - A It helps to introduce temporary employees into Japan's labor market.
  - B It empowers workers by giving them more choice and flexibility.
  - C \* It only provides temporary employee services.
  - D It has expanded into other areas of workforce services, such as out-placement support.

- Part 2:

- Q1. How easy was it to read this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)
- Q2. How well did you understand this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)

### **A.2.3 Web Page 3**

- Part 1:

- Q1. What's the main purpose of this article?
  - A \* Introduce a company's product which can let human talk to the gadgets.
  - B Explain why natural language cannot be used to control device.
  - C Discuss why vision can be used in a computer.
  - D Show the latest technique in the health care system.
- Q2. Which one of the following is true?
  - A The problem that Cognitive Code is tackling is called natural information process.
  - B \* Chatbot programs, such as Alice and Jabberwacky, can simulate a conversation via text input.



- C Chatbot is more advanced than SILVIA.
- D None of the above
- Q3. Why people suspect Cognitive Code's claim about SILVIA's portability?
  - A \* It's still unclear how easy it will be to plug SILVIA into any system.
  - B It only takes few hours to put SILVIA into each platform.
  - C SILVIA is not as good as a chatbot.
  - D SILVIA is too large to be put into any system.
- Q4. Initially, what market does Cognitive Code target on?
  - A \* Toy market
  - B Health market
  - C Business market
  - D Personal device market
- Q5. Which one is false about SILVIA?
  - A It is built by Cognitive Code to let everyday gadgets talk with human.
  - B It can remember and understand the context of a conversation.
  - C \* You cannot speak to SILVIA using whatever phrase you want.
  - D The company claims that SILVIA's core algorithms can be implemented into different devices.

- Part 2:

- Q1. How easy was it to read this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)
- Q2. How well did you understand this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)

#### A.2.4 Web Page 4

- Part 1:
  - Q1. What's the main purpose of this passage?
    - A Introduce a new business model to help a company reduce costs
    - B Investigate current employment issues in South Africa
    - C \* Describe a person who started a free university for poor people in South Africa
    - D Discuss the effect of deploying "black economic empowerment" in South Africa
  - Q2. According to the article, what is "CIDA"?
    - A \* An almost-free business university for students who cannot afford mainstream higher education
    - B An almost-free book store for poor students
    - C An agency to help poor people resolve family and racial conflicts
    - D A new company to sell training services to the government
  - Q3. Who helped Mr. Blecher to start "CIDA"?
    - A Banks
    - B Sponsors
    - C Students and Teachers
    - D \* All of above
  - Q4. Which of the following is incorrect about "CIDA"?
    - A The founder describes CIDA as "a whole ecosystem created to support kids."
    - B Many students come from very poor rural backgrounds and have extreme financial hardship.
    - C Some students start with a residential one-year foundation course before enrolling in the BBA degree.

D \* None of the above

– Q5. There are some doubts about “CIDA.” Which of the following is not mentioned in the passage?

A CIDA's fast growth has overwhelmed its administrative systems.

B Employers are said to have been disappointed by the general BBA graduates they have hired.

C \* CIDA doesn't have good connections to outside companies.

D The quality of education in CIDA needs to improve compared with that of mainstream universities.

• Part 2:

– Q1. How easy was it to read this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)

– Q2. How well did you understand this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)

### **A.2.5 Web Page 5**

• Part 1:

– Q1. What's the main purpose of this article?

A Explain why Amazon kindle e-reader is so popular

B Discuss how to make the display brighter and cheaper

C \* Describe how E Ink makes color and video versions of e-paper

D Explain why so many companies failed to develop color and video versions of e-paper

– Q2. According to the passage, which device does not use E Ink's technology?

A Sony Reader

- B Amazon kindle e-reader
- C Samsung's 14.3-inch screen
- D \* Qualcomm e-paper

– Q3. Which one of the following statements does not describe E Ink's basic technology?

- A Using a layer of microcapsules filled with flecks of submicrometer black and white pigment chips in a clear liquid.
- B The white chips can be positively charged, and the black chips are negatively charged.
- C A positive charge on the bottom electrode pushes the white chips to the surface, making the screen white.
- D \* E Ink put lasers inside the e-paper to reflect the content.

– Q4. According to the passage, which statement is true?

- A The video version of e-paper will be ready for market soon.
- B E Ink's technology can not make the color version e-paper possible now.
- C \* E Ink is refining the electronics and mechanics of e-paper to have higher reflectivity.
- D Compared with E Ink, Qualcomm's e-paper looks more like real paper.

– Q5. How many e-paper related prototypes are shown in E Ink's Cambridge headquarters?

- A One
- B \* Two
- C Three
- D Four

● Part 2:

- Q1. How easy was it to read this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)
- Q2. How well did you understand this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)

### **A.2.6 Web Page 6**

- Part 1:

- Q1. What's the main purpose of this article?
  - A Show why West Bengal has refused to embrace capitalism
  - B Explain why West Bengal can not have a stable political environment
  - C Discuss how to improve the agriculture techniques in West Bengal
  - D \* Describe how a person transformed business prospects in West Bengal
- Q2. After Mr. Bhattacharjee's invitation, foreign companies joined an influx of India firms in certain fields. Which one of these fields is not mentioned in the article?
  - A Computer services
  - B \* Entertainment
  - C Manufacturing
  - D Steelmaking
- Q3. According to the passage, which one of the following is not Buddhadeb Bhattacharjee's role?
  - A A poet and playwright
  - B The state's chief minister
  - C A life-long communist
  - D \* A musician

- Q4. Compared to a Chinese model, why the creation of special economic zones (SEZs) has gone badly awry in West Bengal?
  - A The taxes in special economic zones (SEZs) are too low.
  - B There are not many job opportunities for the local people.
  - C The total investment money is not enough to support the development.
  - D \* Acquiring land for development is difficult.
- Q5. Which one of the statements is not true?
  - A Some Indian commentators have likened Mr. Bhattacharjee to China's great moderniser, Deng Xiaoping.
  - B Mr. Bhattacharjee is not the first leader to preach socialism while practicing capitalism.
  - C \* Building petrochemical plants in two special economic zones (SEZs) has been successful.
  - D The creation of special economic zones (SEZs) is not Mr. Bhattacharjee's key policy.

- Part 2:

- Q1. How easy was it to read this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)
- Q2. How well did you understand this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)

### **A.3 Questions for Skimmability Enhancement Project**

In skimmability enhancement project, the questionnaire of each web page reading contains three parts: (1) Part 1 - reading comprehension questions; (2) Part 2 - test of memory for meaning; and (3) Part 3 - user's satisfaction questions. For the questions in Part 1, I reuse reading comprehension questions from the previous

section, i.e. Questions for Readability Enhancement Project. For the questions in Part 3, I have following questions for each questionnaire.

- Part 3:
  - Q1. How easy was it to read this web page? (1: Very Difficult, 4: Neutral, 7: Very Easy)
  - Q2. How well did you understand this web page? (1: Very Difficult, 4: Normal, 7: Very Easy)
  - Q3. How enjoyable did you read this web page? (1: Very Unenjoyable, 4: Neutral, 7: Very Enjoyable)

In the following, I present materials used in the test of memory for meaning (Part 2). Specifically, I list all salient sentences selected by five native English readers with majority voting and the corresponding semantically incongruent statements, which were rewritten by another native English reader. I selected four out of six web pages and used them in the user study: web page 3, 4, 5, and 6. Following annotations are used to describe these data.

- PX<sub>SY</sub>: the Y<sup>th</sup> sentence of the X<sup>th</sup> paragraph in the reading web page.
- In each PX<sub>SY</sub>, the first sentence is the original statement and the second sentence is a semantically incongruent statement.
- \*: the original statement was used in the study.
- \*\*: a semantically incongruent statement was used in the study.

### **A.3.1 Web Page 1 (10 sentences)**

- P0\_S0
  - Cloud computing—the idea of relying on Web-based applications and storing data in the “cloud” of the Internet—has long been touted as a way to do business on the road.

- Cloud computing—the idea of relying on Web-based applications and storing data in the “cloud” of the Internet—has long been considered problematic for doing business on the road.
- P0\_S1
  - Now software companies are making entire Web-based operating systems.
  - Now software companies are afraid to make entire Web-based operating systems.
- P0\_S2
  - Built to work like a whole computer in the cloud and aimed at a wider audience, these browser-based services could help those who can't afford their own computer.
  - Built to work like a whole computer in the cloud but aimed at a narrower audience, these browser-based services could help those who are already familiar with traditional computers.
- P1\_S0
  - Having the look and feel of Microsoft Windows or other popular desktop programs, the Web-based operating systems bring together a selection of integrated Web-based applications that typically run with Flash or Java.
  - Having the look and feel of popular web destinations, news sites, or search engines, the Web-based operating systems bring together a selection of integrated Web-based applications that typically run with Flash or Java.
- P1\_S1
  - Users can choose to save data locally or on the Internet.



- Users cannot save data locally, but instead save it on the Internet.
- P2\_S0
  - “Once a useful group of applications are collected in a familiar format, cloud computing becomes more accessible to people who aren’t comfortable tracking down a series of individual Web applications and combining them,” Rand says.
  - “Groups of applications can certainly be collected in a familiar format, but cloud computing is already accessible because people are comfortable tracking down individual Web applications and combining them,” Rand says.
- P2\_S5
  - The result is a system that he says can be used by the large population of computer users worldwide—including students—who may not own a home computer.
  - The result is a system that he says is unlikely to be used by the large population of computer users worldwide—including students—who may not own a home computer.
- P4\_S1
  - Desktop Two now has around 175,000 users worldwide, and Rand says that the system can support about 8,000 to 10,000 of them concurrently.
  - Desktop Two now has around 175,000 users worldwide, and Rand says that the system can support all of them concurrently.
- P4\_S4
  - “Scalability will never be an issue with the design architecture they have,” he says.

- “Scalability has always been an issue with the design architecture they have,” he says.

- P8\_S0

- Michels says that he expects the younger generation to be more willing to adopt the computer-in-the-cloud idea than people were 10 years ago because of young people’s familiarity and comfort with Web-mail systems and other forms of cloud computing currently in use.
- Michels says that he expects the older generation to be more willing to adopt the computer-in-the-cloud idea than they were 10 years ago because of growing familiarity and comfort with Web-mail systems and other forms of cloud computing currently in use. ?

### **A.3.2 Web Page 2 (13 sentences)**

- P0\_S1

- Men were far more likely to be hired than women and were paid much more for the same work.
- Men were far more likely to be fired than women but were paid much more for the same work.

- P0\_S3

- Mr Nambu had the idea of creating a non-profit organisation to place women in flexible, part-time jobs.
- Mr Nambu had the idea of creating a non-profit organisation to place women in full-time jobs.

- P0\_S5

- The result was Pasona, a firm that now has annual revenues of around \$2 billion and which sends around a quarter of a million people off to a job every day.
- The result was Pasona, a firm that now has annual revenues of around \$2 billion and which has around a quarter of a million unfilled job positions every day, on average.
- P1.S0
  - Before Pasona, job placements were handled by a government agency and offered little more than empty, make-work employment.
  - Before Pasona, job placements were handled by private agencies and offered little more than empty, make-work employment.
- P1.S1
  - Moreover, part-time and temporary employees were treated as outcasts from Japan's corporate-welfare model, founded on the principles of lifetime employment and seniority-based wages that depend on length of service, not performance.
  - Moreover, part-time and temporary employees were treated as outcasts from Japan's corporate-welfare model, founded on the principles of lifetime employment and performance-based wages that depend on workers staying at the same company.
- P2.S0
  - In the 30 years since Mr Nambu set up shop, non-regular employees have gone from the periphery of the Japanese labour force to the mainstream.
  - In the 30 years before Mr Nambu set up shop, non-regular employees had gone from the mainstream of the Japanese labour force to the periphery.

- P2\_S2
  - And a generational backlash against the stereotypical “salaryman”, or white-collar worker, created a new group of young people, known as “freeters” (a combination of “free” and Arbeiter, the German word for worker), who drifted from job to job.
  - And a generational backlash against the stereotypical “freeters” (a combination of “free” and Arbeiter, the German word for worker), who drift from job to job, may lead a new group of young people to become “salarymen”, or white-collar workers.
- P3\_S0
  - The result is a two-tier labour market, with huge differences in pay and benefits between regular and non-regular workers, even if they are doing the same jobs.
  - The result is a single-tier labour market, with very little differences in pay and benefits between workers who are doing the same jobs.
- P3\_S3
  - As for concerns about growing inequality, the best way to address them is to extend some of the benefits offered to regular workers to freeters, too.
  - There are also concerns about growing inequality, because extending the benefits offered to regular workers to freeters, too, cannot address the problem.
- P4\_S0
  - For Mr Nambu, Pasona’s mission transcends the workplace.
  - For Mr Nambu, Pasona’s mission includes government leading this transformation of the workplace.

- P4.S5
  - Mr Nambu’s flashy ways do not go down well in traditional, buttoned-up Japan.
  - Mr Nambu’s flashy ways go down well in a changing, transitional Japan.
- P5.S2
  - Rather than undermining Japan’s social ties between employee and company, he says, he is empowering workers by giving them more choice and flexibility.
  - Rather than undermining Japan’s social ties between employee and company, he says, he is empowering employers by giving them more guidance and flexibility.
- P7.S1
  - In the decade since, Pasona’s revenues and temporary workforce have both more than doubled, yet Mr Nambu remains as controversial as ever.
  - In the decade since, Pasona’s revenues and temporary workforce have both leveled off, because Mr Nambu remains as controversial as ever.

### **A.3.3 Web Page 3 (12 sentences)**

- P0.S0
  - A new company called Cognitive Code has built software that it believes will let everyday gadgets talk with humans.
  - A new company called SILVIA has built software, called Cognitive Code, that it believes will let everyday gadgets talk with humans.
- P0.S2

- The developer’s studio could let businesses, such as cell-phone manufacturers and toy makers, use the technology to add conversational abilities to a product.
  - The developer’s studio could let Cognitive Code add conversational abilities to products, such as cell-phones and toys, without work by the manufacturers.
- P2\_S0
    - The problem that the company is tackling is called natural-language processing, and it’s been the subject of intense research at world-renowned research labs for decades.
    - The problem that the company is tackling is called natural-language processing, and it’s been neglected at world-renowned research labs for decades with the decline of AI.
- P3\_S0
    - Spring claims that Cognitive Code’s product, SILVIA (which stands for symbolically isolated, linguistically variable intelligence algorithm), is more advanced than chatbots for a couple of reasons.
    - Spring acknowledges that Cognitive Code’s product, SILVIA (which stands for symbolically isolated, linguistically variable intelligence algorithm), is less advanced than chatbots for a couple of reasons.
- P3\_S1 (\*\*)
    - First, SILVIA remembers and understands the context of a conversation.
    - First, SILVIA works without having to understand the context of a conversation.
- P3\_S3 (\*)

- The other key aspect of SILVIA that makes it different, says Spring, is its ability to comprehend concepts that are worded in a variety of ways and produce uniquely worded responses.
- The other key aspect of SILVIA that makes it familiar, says Spring, is its ability to comprehend concepts that are worded in a variety of ways but produce identically worded responses.
- P4.S0
  - The system works like this: during a conversation, words are turned into conceptual data, Spring explains.
  - The system works like this: before a conversation begins, conceptual data are turned into lists of words, Spring explains.
- P4.S1 (\*\*)
  - SILVIA takes these concepts and mixes them with other conceptual data that's stored in short-term memory (information from the current discussion) or long-term memory (information that has been established through prior training sessions).
  - SILVIA takes these concepts and splits them into two disconnected categories: conceptual data that's stored in short-term memory (information from the current discussion) or long-term memory (information that has been established through prior training sessions).
- P4.S2
  - Then SILVIA transforms the resulting concepts back into human language.
  - Then Cognitive Code engineers transform the resulting concepts back into human language.
- P4.S3 (\*\*)

- Sometimes the software might trigger programs to run on a computer or perform another task required to interact with the outside world.
- Sometimes the software might need the user to run programs on a computer or perform another task required to interact with the outside world.
- P6\_S0 (\*)
  - Spring says that SILVIA could work with Windows, Mac, or Linux operating systems.
  - Honavar says that SILVIA is already working on Windows, Mac, and Linux operating systems.
- P8\_S0
  - And while Honavar is pleased to see Cognitive Code exploring business models for natural-language processing technology, he is hesitant to get too excited.
  - And while Honavar is disappointed to see Cognitive Code ignoring business models for natural-language processing technology, he is hesitant to be too critical.

#### **A.3.4 Web Page 4 (18 sentences)**

- P0\_S0
  - IN HIS early years there was little to suggest that Taddy Blecher would end up in Johannesburg's inner city, surrounded by youngsters from poor backgrounds.
  - IN HIS early years there telltale signs to suggest that Taddy Blecher would end up in Johannesburg's inner city, surrounded by youngsters from poor backgrounds.



- P0.S6
  - He and three partners then started CIDA City Campus, an almost-free business university for students who cannot afford mainstream higher education.
  - He and three partners then took over CIDA City Campus, which was an expensive business university for students who could afford the best higher education.
  
- P0.S7
  - (Students are charged only \$21 per month in tuition, and some also receive additional financial help.) In a country where poverty and poor skills remain endemic, he has become a local hero.
  - (Students are charged only \$21 per month in tuition, and some also receive additional financial help.) But in a country where poverty and poor skills remain ignored, he is by no means a local hero.
  
- P1.S1 (\*)
  - The apartheid system deliberately provided sub-standard schooling to the country's black majority; today, good education is still beyond the reach of many poor South Africans.
  - The apartheid system never deliberately provided sub-standard schooling to the country's black majority, but good education was still beyond the reach of many poor South Africans.
  
- P1.S2 (\*\*)
  - In addition, too few manage to finish high school, and many of those who make it to university drop out, often because they cannot afford it.

- In addition, while almost all manage to finish high school, many of those who make it to university drop out, often because they see no value in it.
- P1\_S4
  - “We are throwing away our people.” As a result, masses of unskilled South Africans cannot find jobs, while firms complain of a crippling lack of skilled people.
  - “We are throwing away our people.” As a result, masses of unskilled South Africans have low-paying jobs, and firms no longer wish to hire skilled people.
- P2\_S0
  - Believing that a new way of thinking about education was needed, Mr Blecher decided to start a free university.
  - Believing that a return to an older way of thinking about education was needed, Mr Blecher decided to start a public university.
- P2\_S3
  - “My deepest interest”, he explains, “is to help people realise how great they are.”
  - “My deepest interest”, he explains, “is to help those people who realise how great they can be.”
- P3\_S4
  - Today 80% of CIDA’s income comes from donations, amounting to about 50m rand (\$7m) a year.
  - Today 20% of CIDA’s income comes from donations, amounting to about 50m rand (\$1m) a year.

- P3\_S6
  - Students help to run the school, providing them with experience and keeping costs down.
  - Students intern at sponsor companies, providing them with experience at low cost to the sponsor.
  
- P4\_S0 (\*\*)
  - Today about 1,500 students are enrolled at CIDA.
  - Today about 1,500 students have graduated from CIDA.
  
- P4\_S1
  - The business school offers a general Bachelor in Business Administration (BBA) course, as well as practical specialities such as information technology, construction and entrepreneurship for those who qualify.
  - The business school plans to offer a general Bachelor in Business Administration (BBA) course, as well as practical specialities such as information technology, construction and entrepreneurship, once it hires faculty who are qualified.
  
- P4\_S4
  - Mr Blecher describes CIDA as “a whole ecosystem created to support kids.” Many students come from very poor rural backgrounds, and moving to Johannesburg means a huge adjustment and often extreme financial hardship.
  - Mr Blecher describes CIDA as “a whole ecosystem created to support kids.” Many students come from very poor rural backgrounds, so CIDA is located in Johannesburg, where moving is not a huge adjustment.
  
- P5\_S0 (\*\*)

- Students are also required to volunteer for community work when they go back home during the holidays.
- Students are also asked to volunteer for community work, except when they go back home during the holidays.
- P6\_S1 (\*)
  - As well as adding further specialist courses, CIDA hopes to open new schools elsewhere in South Africa.
  - As well as adding further specialist courses, CIDA hopes to open new schools in neighboring African countries.
- P6\_S3
  - CIDA remains intimately associated with its founder and chief executive, and there are questions about whether it would survive without him.
  - CIDA has grown independent from its founder and first chief executive, and there is no question about whether it can survive without him.
- P6\_S4
  - Though it is no longer mandatory, the exact role of transcendental meditation in the curriculum remains controversial.
  - Because it is no longer mentioned, the role of transcendental meditation in the curriculum, once controversial, has been eliminated.
- P6\_S8
  - The quality of education will need to improve if CIDA's degree is to compare with that of mainstream universities.
  - The general quality of education will need to improve if a mainstream university degree is to compare with that of CIDA.

### A.3.5 Web Page 5 (8 sentences)

- P1.S0
  - Add it all up, and it represents an emerging trifecta of color, video, and flexibility set to transform a display technology once seen as suited only for rigid black-and-white e-readers like the Kindle and the Sony Reader, and other niche applications like train-station schedule displays that don't need to change quickly.
  - Add it all up, and it represents an intractable trifecta of color, video, and flexibility problems that mean the display technology will be suited only for rigid black-and-white e-readers like the Kindle and the Sony Reader, and other niche applications like train-station schedule displays that don't need to change quickly.
- P1.S2
  - “Until this point, you have been limited to static image applications.”
  - “Until this point, you haven't been limited to just static image applications.”
- P3.S0 (\*)
  - But the basic technology only produces a black-and-white image.
  - And the basic technology produces both black-and-white and full color images.
- P4.S0 (\*\*)
  - This higher brightness makes color displays possible.
  - This faster switching time makes color displays possible.
- P4.S2 (\*\*)

- In essence, software controls groups of microcapsules sitting below filters of particular hues, and it only turns the microcapsules white when those hues are sought.
- In essence, software controls groups of microcapsules of particular hues, and it only turns the microcapsules from black to red, green, or blue when those hues are sought.
- P5\_S0 (\*)
  - In another set of advances, tweaks to the E Ink particles and their polymer coatings, and to the chemistry of solution inside the microcapsules, have helped improve the speed at which the particles can move.
  - In another set of advances, tweaks to the E Ink particles and their polymer coatings, and to the chemistry of solution inside the microcapsules, have helped improve the accuracy of the colors, at a small cost to the speed at which the particles can move.
- P6\_S0
  - In the company's Cambridge, MA, headquarters, two prototypes show the payoff.
  - In the company's San Diego, CA, headquarters, two prototypes show the payoff.
- P9\_S0 (\*\*)
  - Other companies are also making advances in e-paper.
  - Other companies have largely ignored the possibilities of e-paper.

### **A.3.6 Web Page 6 (12 sentences)**

- P0\_S0 (\*\*)

- UNTIL a few years ago foreign capitalists were unlikely to look for investment opportunities in the Indian state of West Bengal, seat of the world's longest-serving democratically elected communist government.
- UNTIL a few years ago foreign capitalists were keen to look for investment opportunities in the Indian state of West Bengal, seat of the world's longest-serving democratically elected communist government.
- P0.S3
  - He is Buddhadeb Bhattacharjee, the state's chief minister, a poet and playwright, the translator of the great Colombian-born novelist??and a life-long communist.
  - He is Buddhadeb Bhattacharjee, the state's chief minister, a poet and playwright, the translator of the great Colombian-born novelist??and a life-long capitalist.
- P1.S0 (\*\*)
  - Since taking charge of West Bengal in 2000, Mr Bhattacharjee has embraced business with apostate zeal.
  - Since taking charge of West Bengal in 2000, Mr Bhattacharjee has embraced communism with apostate zeal.
- P1.S4 (\*\*)
  - But only in recent years, after Mr Bhattacharjee began traveling the world and wooing foreign companies, have many actually come.
  - But in all these years, after Mr Bhattacharjee began traveling the world and wooing foreign companies, very few have actually come.
- P1.S5
  - They have joined an influx of Indian firms in computer services, manufacturing and steelmaking.

- They have joined an influx of Indian firms in banking, farming and agriculture.
- P3\_S8
  - They are, he says, to “protect the poorest of the poor, protect un-organised workers, protect womenfolk who have no income.”
  - They are, he says, to “protect the middle class, protect unionized workers, protect womenfolk who want to work.”
- P4\_S0
  - Mr Bhattacharjee is not the first leader to preach socialism while practising capitalism.
  - Mr Bhattacharjee is not the first leader to preach capitalism while practising socialism.
- P5\_S1
  - He is now suffering a disastrous fallout from a key policy of Mr Singh's - the creation of special economic zones (SEZs) - that has gone badly awry in West Bengal.
  - He is now enjoying a massive success from a key policy of Mr Singh's - the creation of special economic zones (SEZs) - that has gone brilliantly in West Bengal.
- P6\_S0 (\*)
  - His government promised 9,000 hectares (22,000 acres) of farmland in the district of Nandigram to the Salim Group of Indonesia, which wants to build petrochemical plants in two SEZs.
  - His government purchased 9,000 hectares (22,000 acres) of farmland in the district of Nandigram from the Salim Group of Indonesia, which wanted to build petrochemical plants in two SEZs.



- P6.S1 (\*\*)
  - But it did not bother to consult the peasants who were to be dispossessed.
  - But it did not bother to consult the workers who were to be downsized.
- P6.S2
  - This sparked protests in January in which at least six people were killed.
  - At least six people were killed, which sparked protests in January.
- P8.S1
  - And with a general election expected next year, in which the Communists are expected to do badly, there is talk that party bosses, wedded to the outworn ideology that he has so sensibly forsaken, might force Mr Bhattacharjee to quit.
  - And with a general election expected next year, in which the Communists are expected to do badly, there is talk that party bosses, looking past the outworn ideology that he has so sensibly forsaken, might beg Mr Bhattacharjee to run again.

## **A.4 Questions for Mobile Continuous Reading Project**

In mobile continuous reading project, the questionnaire of each web page reading contains three parts: (1) Part 1 - reading comprehension questions; and (2) Part 2 - user's satisfaction questions. I use the questions from readability enhancement project (Please refer to Questions for Readability Enhancement Project section of this appendix), including reading comprehension questions and user's satisfaction questions. I selected four out of six web pages in the user study: web page 1, 2, 3, and 4.

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