Enhancing Web Page Readability for Non-native Readers

Chen-Hsiang Yu and Robert C. Miller
MIT Computer Science and Artificial Intelligence Lab
32 Vassar Street, Cambridge, MA 02139
{chyu, rcm}@mit.edu

ABSTRACT
Readers face many obstacles on today's Web, including distracting content competing for the user's attention and other factors interfering with comfortable reading. On today's primarily English-language Web, non-native readers encounter even more problems, even if they have some fluency in English. In this paper, we focus on the presentation of content and propose a new transformation method, Jenga Format, to enhance web page readability. To evaluate the Jenga Format, we conducted a user study on 30 Asian users with moderate English fluency and the results indicated that the proposed transformation method improved reading comprehension without negatively affecting reading speed. We also describe *Froggy*, a Firefox extension which implements the Jenga format.

Author Keywords
Reading comprehension, readability enhancement, Web page customization

ACM Classification Keywords
H5.2 Information interfaces and presentation: User Interfaces - *Graphical user interfaces (GUI)*

General Terms
Design, Experimentation

INTRODUCTION
Readers face many obstacles on today's Web. On today's primarily English-language Web, *non-native readers* (whose first language is not English) encounter even more 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 [24]. Some web sites are better, but many are worse. All of these problems hinder non-native readers from reading the content fluently.

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We defined 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 paper 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. who developed a visual-syntactic text formatting (VSTF) method to enhance online reading, but our transformation format is easier to implement and can provide flexible interaction design for reading web pages.

We 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 the paper, we discuss related work and explain the motivation and reasons of the proposed transformation. The detailed user study procedure and the results are also presented and discussed. To allow more users to experience the proposed transformation, we introduce a new Firefox extension, *Froggy*, which not only implements the studied transformation method, but also introduces new ideas for readability improvement such as (1) automatically detecting and deemphasizing distracting elements and (2) summarizing content by making key sentences stand out. Evaluation of these additional techniques is left for future work.

RELATED WORK
There has been much work in online reading focusing on new interaction techniques [9, 16, 29] to support practices observed in fluent readers [1, 14, 21, 23], such as annotation, clipping, skimming, fast navigation, and obtaining overviews. Some work has studied the effect of presentation changes like fonts [4, 6, 11, 15] and hyperlink appearance [10, 39] on reading speed and comprehension. Other work considers users with reading limitations, including children learning to read [22], users with visual impairments and/or motor impairments [2], users with dyslexia or other learning disabilities [31], and older adults with reduced eyesight [4]. Our paper aims at a different population, non-native readers.

In hypertext reading, there are some studies investigating factors related to the web page reading. In Protopsaltis'

study, the reading goal did not influence reading times and comprehension score [26]. But, if the subjects exposed to extensive reading, they can achieve significant faster reading speed and higher score in reading comprehension [3]. On the other hand, Dyson's studies showed 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 [12]. In electronic documents, Hornbæk et al. studied the reading patterns and visualizations for reading [17]. The study indicates that different visualization user interfaces might be helpful in different conditions. For example, the fisheye interface is more appropriate for tasks that understanding the detail of the document is not the subjects' main purpose.

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 [19]. However, it is not clear if the study could also be applicable to online reading. William's work provides another idea to enhance the comprehension by adding different symbols to recognize the textual cohesive ties on the document, such as arrow, rectangle, dot line, line etc. [36], but it takes time to annotate the content for reading. One of our paper prototype transformations was inspired by William's work.

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 [25, 38]. But these tools need manual actions, such as pressing a hot key, on the specific content or region. In addition, too many options on the user interface of the tool will reduce the user's intention to use it when reading web pages. Some studies investigate how to segment web pages on the semantic level [8, 32] or extract content structure from web pages [33], but none of them focus on readability enhancement on the user interface level. Richards et al. [27] proposed to have web content adaptations and transformations for specific populations. Different with other approaches, Walker et al. [35] used a visual-syntactic text formatting (VSTF) method to enhance online reading. Our transformation is similar to VSTF, but our transformation focuses on sentence separation and spacing in selected paragraph, which provides simpler implementation, better reading comprehension and better user satisfaction for reading web pages.

TRANSFORMATIONS

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

The iterative study suggested two important factors affecting reading speed and comprehension -- *sentence separation* and *sentence spacing*. This finding inspired us to enhance web page readability by transforming web page content for the readers.

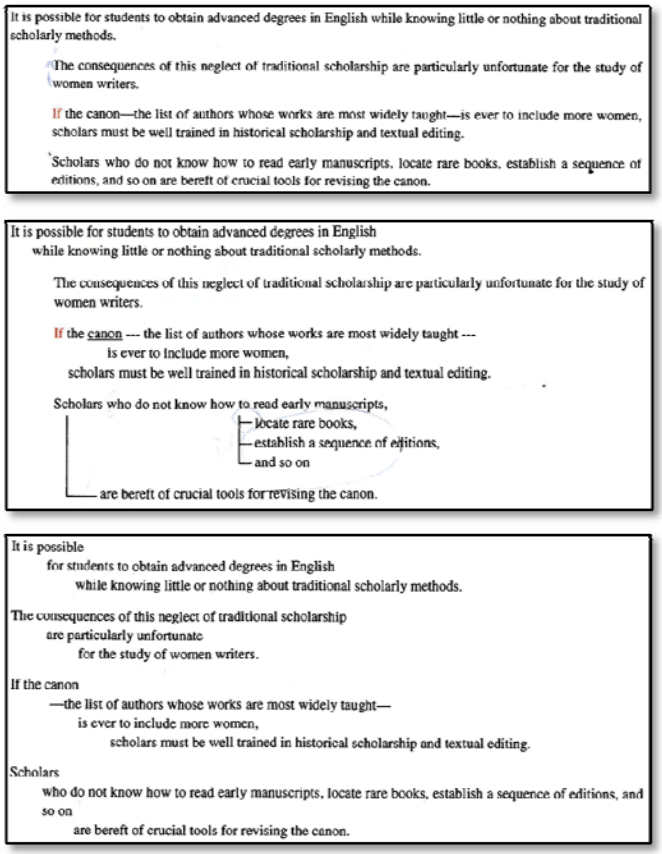

Figure 1: Paper prototypes of 3 paragraph transformation examples

Conventionally, most web pages display the content in traditional paragraph format (Figure 2), which we call *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 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 [35] 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) [35], which replaces the block-shaped text of the standard format with a cascading pattern to help readers identify grammatical structure and increase reading comprehension. Figure 3 shows an example of using Clip Read software to read the content in VSTF format.

The study conducted by Walker et al. [35] found that VSTF increased reading comprehension and the efficiency of reading online text for college-level readers. 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.

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 2: Standard Format (SF).

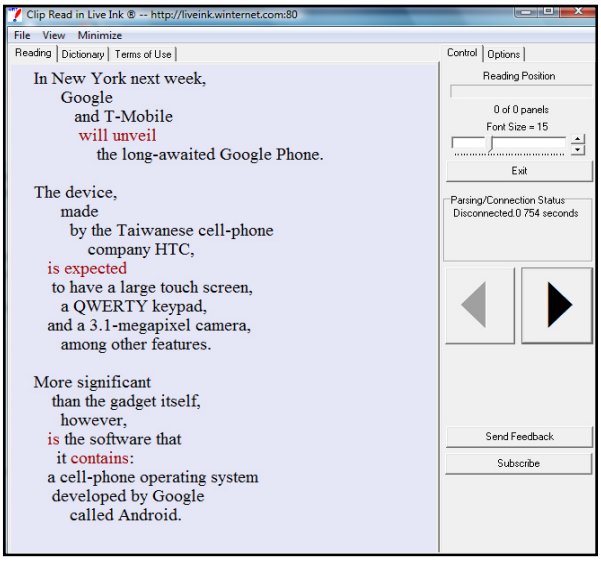

Figure 3: Using Clip Read to read content in VSTF format.

JENGA FORMAT (JF)

Based on the two factors we found from the paper prototypes, we 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* we found above. When the user clicks on a specific paragraph of a web page, the indicated paragraph will be converted into sentences which are all separated and aligned to the left automatically. The expanded paragraph will turn back to the original format if a user clicks it again. 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 article. In addition, because each sentence is identified separately, the sentences are easier to follow in sequence.

However, motivated by further observation, we developed another enhancement to the above transformation. Although sentence separation is helpful to reading, it forces the reader to move their eyes to the left margin every time they finish reading a sentence, which interrupts the continuity of reading in the paragraph. To solve this, we designed a new transformation method, Jenga Format (JF), which inserts space between sentences without changing their shape (Figure 4). The format is named Jenga because the gaps between interlocking sentences are reminiscent of the Jenga puzzle game.

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.

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Figure 4: Jenga Format (JF) transformation.

As Figure 4 illustrates, the JF transformation separates the sentences of a paragraph, and each sentence connects to previous sentence with a space. To identify each sentence, we highlight them with a light yellow color. A gray line separates paragraphs.

USER STUDY

To understand the effect of content presentation transformation, we 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.

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 are not English. We 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 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). The study procedure was automated by using Chickenfoot [5] script and it works as the following. 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 2-3 hours spent on the study included not only reading web pages but also obtaining informed consent, describing the procedure, answering questionnaires, and 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. For comparison purpose in the user study, the background color and the click to expand and collapse were also added to the content transformed to VSTF. (Figure 5)

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 reader's subjective feeling (Figure 6).

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 [12, 13], including Main Idea, Structure, Main Factual and Incidental. In addition, we added a new type of question, Reasoning, to increase the difficulty. However, in the questionnaire, we didn't add type information before each question to tell users. (Figure 6 (a))

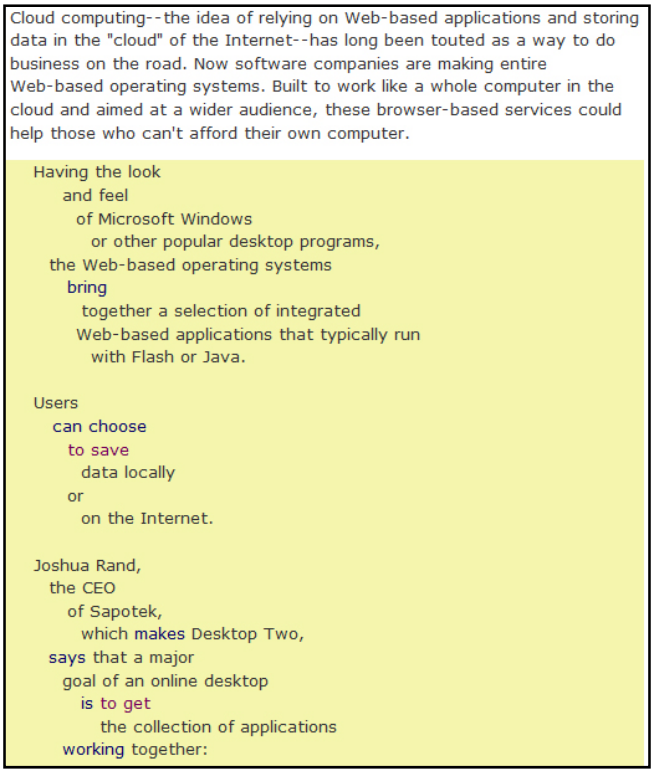

Figure 5: Visual-Syntactic Text Formatting (VSTF) transformation [35].

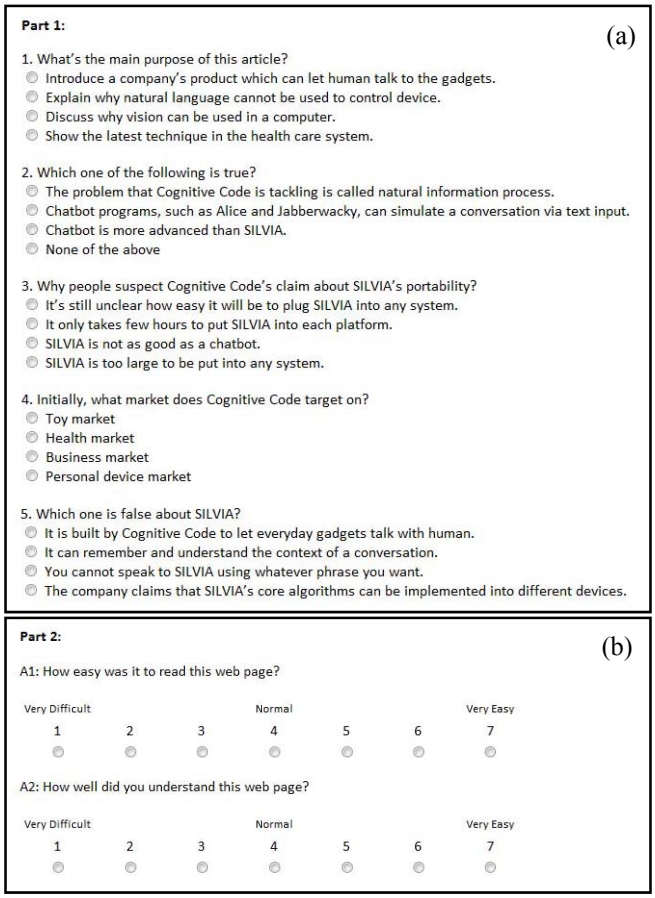

Figure 6: Example questions from the user study.

The subjective part of the questionnaire had 2 questions, which were similar to Walker et al.'s [35] survey on VSTF, but we used scale degrees from very difficult (1) to very easy (7) instead of using Walker's scale degrees, i.e. disagree, uncertain, agree, to each defined question. (Figure 6 (b))

The first part was graded based on the number of correct answers, and the second part used the satisfaction score user selected (ranging from 1 to 7). In each test round, the web pages were presented in a random order, and two continuing pages used the same transformation method, which was also selected in a random order. The transformation methods selected in a random order is 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 observed and took notes without answering questions related to the content. After the whole test, a face-to-face interview was made to collect additional feedback from the users.

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 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.) [34] The users were moderately fluent in English and had learned English for more than ten years, which is common in Asian's education in learning English. Table 1 to 4 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 1. Analysis of all users' language background.[1]

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

Table 2. Analysis of all users' education

[1] SAT CR means SAT I Critical Reading section, which contains reading comprehension, sentence completions, and paragraph-length critical reading. The highest score of this section is 800.

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%
USA	1	3%
Japan	1	3%

Table 3. Analysis of all users' nationality.

Major	# 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 4. Analysis of all users' major.

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

1. We 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.

Results

The results of the user study are illustrated in Figure 7 to Figure 11. Figure 11 shows the average reading speed of all users and Figure 12 illustrates the average comprehension score on the web pages. Figure 13 shows the average comprehension score per unit time. Figure 14 and 15 are the results of subjective questions rated by all the users.

We use one-way ANOVA analysis to our data and find that there is a significant difference between SF, VSTF and JF on reading speed ($F_{2,177} = 3.35$, $p < 0.05$) and comprehension ($F_{2,177} = 4.62$, $p < 0.05$). In addition, there is also a significant difference on the first subjective question, i.e. How easy was it to read this web page? ($F_{2,171} = 3.13$, $p < 0.05$) However, we don't see any significant difference on the second subjective question: How well did you understand the web page?

A post-hoc Tukey test gives an honest significant difference between VSTF and SF on reading speed and also gives an honest significant difference of JF over both SF and VSTF on reading comprehension ($p < 0.05$). In addition, it gives an honest significant difference of JF over SF ($p < 0.05$) and of VSTF over SF ($p < 0.05$) on the first subjective question.

We use one-way ANOVA analysis to our data and find that there is 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 ($p < 0.05$). However, there is no honest significant difference of JF over SF on comprehension per unit time. We think part of the reason is that the slightly increase of the reading time of using JF balances the comprehension score.

When observing the user study, we 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 they were reading at. Some users used the mouse to highlight the whole paragraph when reading in original format (SF). The most repeated behavior we observed is that many users read lengthy paragraphs repeatedly.

There were many interesting comments from the users when we 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 color scheme to the subject and verb, but others complained about its frequent segmentation of the sentence. In the observation, although we noticed that repeat reading to 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."

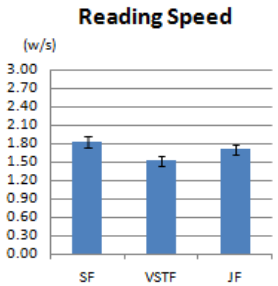

Figure 7: Reading speed for each condition, in words per second. Error bars show standard error.

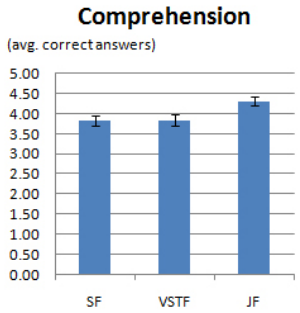

Figure 8: Comprehension for each condition (measured by number of correct answers to a 5-question quiz about the article).

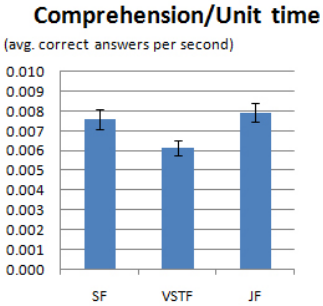

Figure 9: Comprehension per unit time (measured by number of correct answers per second).

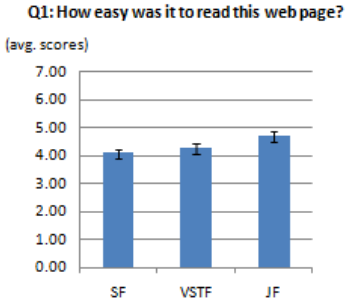

Figure 10: Ease of reading (rated on a scale from 1=very difficult to 7=very easy).

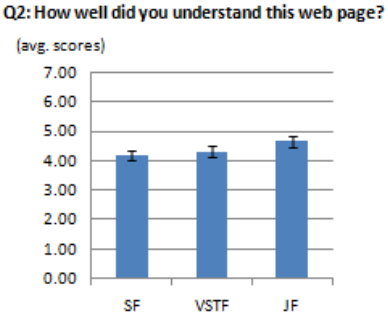

Figure 11: User's self-evaluation of understanding (measured on a scale from 1=very difficult to 7=very easy).

Based on the results of the user study, we can answer parts of the questions we propose in the previous section.

1. The transformation of content presentation enhances the web page readability to the 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 slower the reading speed.
4. In general, JF transformation makes the web page reading easier than SF format.

FROGGY: USER INTERFACE AND DESIGN PRINCIPLES

To apply these findings, we designed a tool to support these presentation transformations in a web browser. *Froggy* is a Firefox extension that we built to demonstrate these ideas. *Froggy* adds a toolbar (Figure 12) to the browser for interactively controlling the content transformation.

Froggy implements the Jenga transformation method we developed and verified in the previous sections. It also adds several new techniques for web page readability enhancement that were inspired and motivated by our interviews with users mentioned in user study section. Among these are: (1) Reducing Distractions: automatically detecting and deemphasizing distracting elements; (2) Emphasizing Key Sentences: summarizing content by making key sentences stand out; and (3) Expanding Paragraphs: breaking paragraphs into sentence chunks separated by whitespace.

Figure 12: *Froggy* toolbar.

Reducing Distractions

We conducted a face-to-face interview with 14 users on web behavior survey. One of our 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.

To eliminate advertisements on web pages, there are some available add-ons for Firefox browser, such as Adblocker and Adblock Plus. After applying the ad blocking, however, you might also risk losing information you might be interested in. If you want to recover eliminated content, you need to change the settings and reload the page. It is not easy to hide and show advertisements. Although Firefox browser offers image blocking, this feature is not widely used for some reasons. For example, when removing all images, the corresponding visual cues will miss, such as corresponding positions, layout, etc. [18, 28] As we found in the interviews, some users are interested in knowing some information from these removed images. The Daily You [30] and AdEater [20] use machine learning techniques to remove Web advertisement, but they face the same problems as mentioned above.

When the Clean Page button is toggled on, *Froggy* changes the current page to reduce distracting page components to make the page cleaner, such as large images, animations, and Flash (Figure 13). Unlike Adblocker, which typically remove offending images, *Froggy* reduces them in the size and dims them out, so that the user can still recognize them. When Clean Page button is toggled off, the images return to their original size and appearance. This decision was motivated by users who mentioned that some advertisements might be useful to them and they don't want to delete them completely.

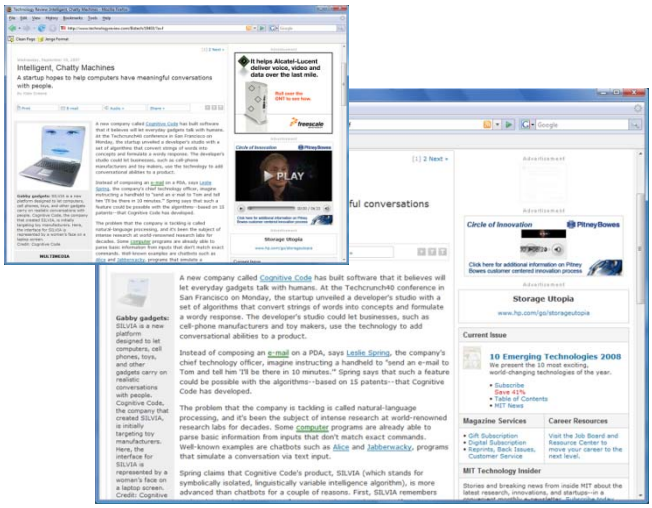

Figure 13: Clean Page takes a web page (top) and reduces distracting images (bottom).

Emphasizing Key Sentences and Expanding Paragraphs

Where Clean Page transforms image components, the Jenga Format button transforms the text itself. In Jenga Format, *Froggy* summarizes the page by emphasizing the main sentence of every paragraph and shrinking the font size of other sentences (Figure 14). This mode also allows paragraphs to be individually expanded by clicking on them, which will be explained in the next section.

The Font slider on the toolbar can adjust the font size of secondary sentences. When the user drags the Font Slider to its smallest value, all the secondary sentences actually disappear, so a lengthy article can be shortened to only a few topic sentences. This is similar to the fisheye interface in Hornbæk et al.'s work [17] and panel-based salient topic stamps design of ViewTool in Boguraev et al's work [7]. However, the design of the Font slider provides more interactive adjustment to the content and gives readers more flexibility.

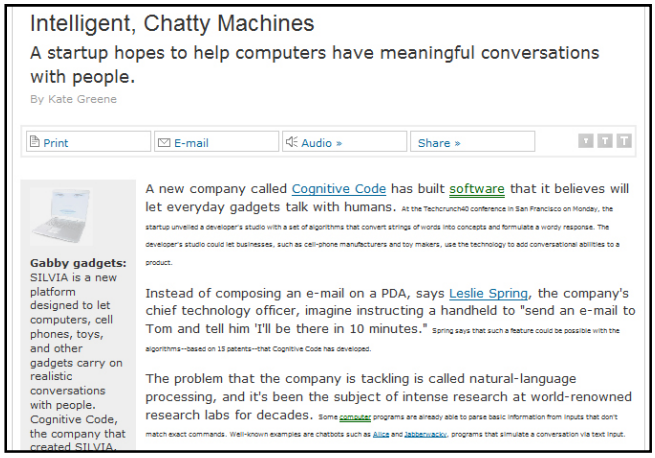

Figure 14: When clicking the Jenga Format button, all secondary sentences shrink automatically, leaving the topic sentence of each paragraph emphasized.

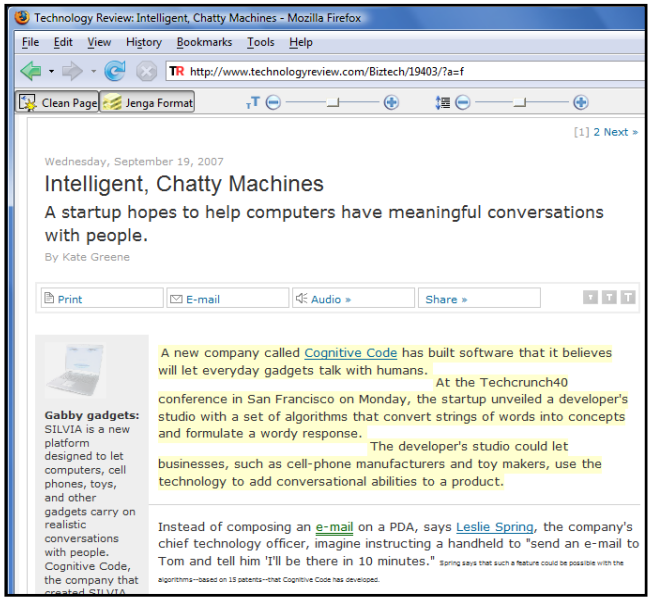

Figure 15: When user clicks on a paragraph, it will transform a paragraph to JF transformation.

Froggy uses the JF transformation. When the Jenga Format button is checked, the user can click on any paragraph to transform it into JF. (Figure 15) The Space slider on the toolbar increases and decreases the spacing between sentences, as Figure 16 illustrates. With the Space slider set to minimum space, Jenga Format looks the same as the familiar standard format.

IMPLEMENTATION

Clean Page

The Clean Page algorithm of *Froggy* operates in two phases: content classification and content transformation. In content classification phase, we use rule-based methods to parse the DOM tree and identify 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.

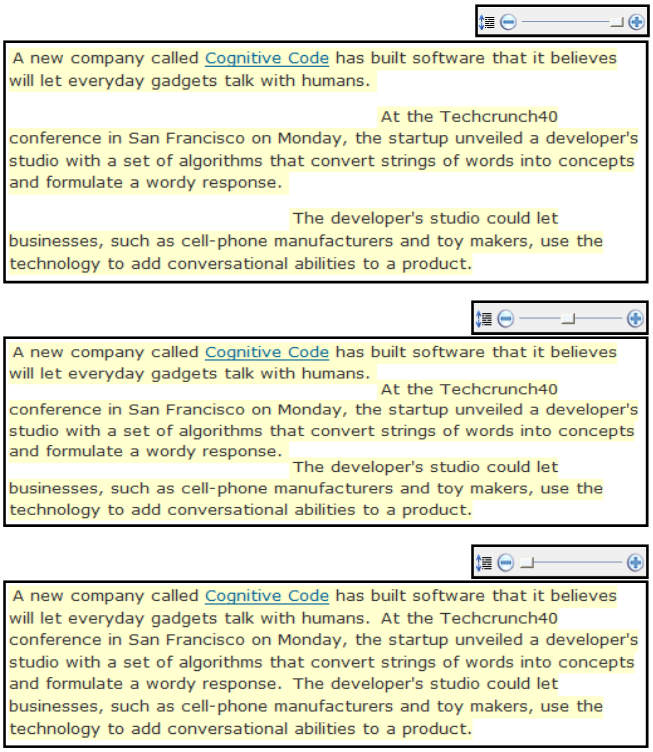

Figure 16: Using the Space slider to change the space between sentences for reading.

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

Text Parsing and Main Sentence Selection

When Jenga Format is enabled, *Froggy* extracts paragraphs from the current viewing page by using Document Object Methods (DOM). Then, it applies regular expressions to separate the sentences of each paragraph, and adds new HTML elements around the main sentence and secondary sentences of each paragraph. These new elements allow the font size and positions of the sentences to be controlled independently by the Font slider and Space slider work.

Currently, we assume that the first sentence of each paragraph is the main sentence. If the content is well written, the first sentence of each paragraph is generally the main sentence, which is taught as a basic rule in reading and writing skills. [37] However, that is not guaranteed for all the web pages. Therefore, we are investigating and integrating salient topic sentence selection and text summarization, such as [7], from natural language processing to enhance the main sentence selection on web pages.

Jenga Spacing

When user clicks on any paragraph, *Froggy* transforms it into JF format. The key technique is the use of inline CSS property, top, to adjust the space between sentences. If we only add top property to sentences without doing any adjustment, the shifted sentences will overlap to next

paragraph. To solve this problem, we calculate the total shift distance of a paragraph and append a new node with CSS property, line-height, to embed this information at the end of the paragraph. When the user drags the Space slider, we not only change top property value of sentences, but we also dynamically recalculate the total shift distance and apply it to line-height property of the node, which is the node we added to keep the layout correctly.

FUTURE WORK

There are three directions in our future work. First, we plan to deploy another user study to investigate if our Firefox extension, *Froggy*, helps non-native readers in their daily reading on the Web. Although this work was driven by the needs of non-native readers, we also want to know if the techniques we propose could improve the experience for native readers as well. Second, we plan to extend the functionality of *Froggy* to integrate salient topic sentence selection algorithm and text summarization techniques from natural language processing to enhance main sentence selection on web pages. Third, we plan to investigate skimming techniques, which are common to experienced readers, but uncommon to non-native readers. After the study, we hope to implement parts of these techniques to *Froggy* to allow non-native readers have the same skimming techniques as the experienced readers.

CONCLUSION

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

In the user studies, we focused on investigating the effect of transformations to web pages for web page readability enhancement. We designed a user study to verify our 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 our user study, and the study showed promising results that JF transformation we proposed in this paper can enhance the web page reading comprehension to Asian users. Another advantage of the transformations we proposed is that the reading speed does not have a significant difference compared with the original reading, i.e. SF format.

To share the benefit of the new transformation method with larger audience, we designed a tool to integrate the transformation method we verified in the user study section and extend its functionalities to include two more new techniques, which have not been evaluated, for web page readability enhancement. These two new functionalities are (1) Reducing Distractions: automatically detecting and deemphasizing distracting elements and (2) Emphasizing Key Sentences: summarizing content by making key sentences stand out. *Froggy* is a Firefox extension we developed to demonstrate our ideas. It reduces distractions, emphasizes key sentence and changes paragraph format to enhance the comprehension of web page reading.

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