



**WPI**



# UNIVERSAL DESIGN

Improving User Experience for People with  
Cognitive Disability

*A Major Qualifying Project*

Submitted to

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## Abstract

As the Internet grows and information becomes increasingly available online, the web needs to become accessible to everyone, including people with cognitive disabilities, who may not be able to fully or easily access all that the Internet offers. In order to address this issue, we worked alongside UMass Medical School to develop a set of easy to follow guidelines to simplify text passages using plain language standards. Utilizing eye tracking technologies we were able to measure the effectiveness and engagement of reading simplified text. Our project will aid the overall efforts of text simplification for web accessibility through our developed simplification process and supporting results.

## Acknowledgements

We would like to take the time to thank the many people who contributed significant time and energy into our project. This project would not have been nearly as successful without these people and we wanted to thank each of them personally for their support and assistance.

We would to thank:

*John Rochford, our Project Sponsor, for giving us this opportunity to work on such an important and exciting project. Not only did you guide us throughout this process, you gave us great advice to help benefit us in our future careers.*

*Professor Soussan Djammasbi, our Project Advisor, for her guidance and expertise that pushed our project well beyond expectations. You provided us constant support, assistance, and most importantly, motivation to push the limits.*

*Mina Shojaeizadeh, a PhD student working with Professor Djammasbi, for taking the time to teach us how to use the eye tracking equipment and helping us to conduct all of our studies. You were extremely instrumental in making this project a success and we cannot thank you enough for your help and generous support.*

*WPI User Experience and Decision Making (UXDM) Laboratory ([www.uxdm.wpi](http://www.uxdm.wpi)), for the high-end equipment and labs you supplied us with that helped make our project unique and cutting-edge*

Thank you all so much for your time, support, and guidance throughout our entire MQP experience.

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## Executive Summary

Web accessibility refers to the ability to easily explore and understand the web and to have equal rights and access to the information available to all users (Accessible, 2015). During a United Nations' Convention on the Rights of Persons with Disabilities, it was stressed that having access to technologies is a "basic human right" (UN enable, 2015). This right, however, is one that is not currently available to everyone. For example, while the people with cognitive disabilities, such as those with intellectual disability, can gain tremendous benefits from the World Wide Web, "they are traditionally the group within society least likely to gain access to and receive the full benefits from the Internet" (Chadwick, 2013, p. 379).

A person with a cognitive disability, in general terms, is someone who experiences more difficulty with one or more mental tasks than the average person. In the United States alone, roughly 1-3% of Americans have some kind of cognitive disability; this includes those with an intellectual disability or ID (Intellectual Disability, n.d.). Those with cognitive disabilities face many functional, cognitive, and sensory challenges that make using the current form of the web nearly impossible. By not making the web fully accessible to those with cognitive disabilities, it excludes an entire community from using a tool that has become a part of everyday life, preventing them from the benefits of the Internet. Web usage has been shown to increase "social contact, reducing stigma and identity development, and increasing life opportunities to practice self-determination and self-advocacy" (Chadwick, 2013, p. 387). Thus, it is imperative that actions are taken to help make the process of web accessibility easier in order to allow everyone to reap the benefits of using the Internet.

In order to help make the web more accessible, our project compiled a comprehensive set of plain language standards from various existing reputable resources. Plain language provides a more effective form of communication, using basic word and sentence structure. Next, in order to make the comprehensive set of plain language rules easily to follow, we quantified those rules that could be quantified. While it is commonly believed that plain language makes it easier to understand text, little work has been done to examine this assertion. We employed eye tracking to measure the comprehension of the simplified text passages in order to determine the success of our simplification process. Eye tracking serves as a valuable tool for information processing (Djamasbi 2014). It is extremely useful in user experience and design research, as it helps communicate the user's actual experience (Eye Tracking in User Experience Design, 2014). Examining the effectiveness of plain language standards through eye tracking techniques for people with cognitive disabilities has not yet been thoroughly explored. Our systematic search in various well-known databases (like Web of Science, PubMed, etc.) showed that from over two hundred articles, only thirty eight were relevant to using eye tracking, text simplification, and reading comprehension for those with cognitive disabilities. None of these articles attempted to quantify plain language standards and test the effectiveness with eye tracking. Thus, our project has helped taking first steps toward a major research gap.

Before we began the simplification of passages, we developed a final list of plain language rules that would be used to consistently and effectively to simplify passages in a repeatable way. We gathered existing rules from government official websites, nonprofit organizations devoted to web accessibility, and the Plain Language International Association. In total, we found 33 rules (Appendix A) for plain language guidelines. However, we then further narrowed down the list to only rules that could be fully

quantified. After multiple attempts and revisions, we determined a final list of 19 rules that we used to simplify text passages.

Our next step was to determine a way to simplify text passages that could be done similarly by any web designer. We first generated a sample set of original text passages taken from actual websites (such as WebMD, Fox Sports, etc.). Because this type of research has not been fully explored, we conducted various trials of text simplification using our plain language rules in order to find the most effective method that would generate the same result, regardless of the editor. We also ran a preliminary survey to test the readability of these simplified passages, and found that the original text passages were deemed more difficult to read with more negative comments by the participants, in comparison to the simplified versions. Our results also showed that the simplified text passages were significantly easier to read than the original text after running t-tests. Our final simplification method consisted of each individual team member editing each original passage on their own (so that we could compare the reading level of simplified passages). With the set of rules, each member identified a violation within the original passages, changed the passage to rectify the rule violation, conducted a readability score using online tools, and repeated the process until there were no more violations within the original text passage.

After determining the best method to simplify passages with our rules, we conducted two studies with WPI students to test the reading comprehension and engagement of the original text passages versus their corresponding simplified versions. Both studies were conducted in the exact same manner, the only difference were the passages used. For each study we created a website that had four pages. The study used 2 original passages, with their corresponding simplified versions, and two questions of each text passage (one literal and one inferential). The studies were followed with a demographics survey and an interview in order to get more user feedback on the passages. The first study used a set of relatively easier original passages. The second study was conducted using passages that were harder, in order to show more variation in our results.

The results for the first study, with the easier set of original text passages conducted with 18 students, demonstrated that participants were more likely to answer both questions about the text passage correctly when shown the simplified passage versus the original passage. The participants also ranked the simple passage as easier to read on a scale of 1 to 7. The preliminary analysis of eye-tracking data from the first version of the study however, yielded few differences in viewing behavior for the two passages.

The results for the second study, conducted with 36 students, showed more robust and statistically significant results. In terms of performance data, those given the simplified passages were more likely to answer both of the questions correctly compared to the original passages, with an almost significant difference. Overall, the interview answers showed that more people found the simple passages easier to read, more preferable to read on the web, and more interesting to read. Also, when shown both versions of each passage, the majority of participants preferred the simplified version for both. The eye tracking data indicated that simplified passages were more engaging, having higher average visit counts and normalized fixation durations.

# 1. Introduction

## 1.1 Text Simplification and Web Accessibility

The web is a virtual place that could provide endless opportunities for everyone, every day. Not only does it make educational collaboration easier, but it is also beneficial for people with disabilities. Since technology is continuously improving, the development of screen readers, audio, and text simplification has been improving the lives of people with disabilities. About 20% of the population of people on the web has a disability (Introduction to Web Accessibility, 2014). The major categories of disabilities among that percentage include: visual, hearing, motor, and cognitive disabilities (Introduction to Web Accessibility, 2014).

## 1.2 The Problem

For those not living with a cognitive disability, there is little awareness of how difficult it can be to explore the web without text simplification. In order to make all websites accessible, there needs to be an increase in awareness on the importance of text simplification. This is an important problem that needs to be thoroughly addressed. The web is a place providing extraordinary opportunities and exploration for every individual, and should be highly accessible for everyone, including those living with disabilities.

## 1.3 About Our Major Qualifying Project

Our Major Qualifying Project (MQP) set out to formulate a list of operationalized rules for text simplification. These rules can be used to develop accessible websites for people with cognitive disabilities. Our project shows that simplifying text is not only important for making the web accessible for people with cognitive disabilities, but it can be beneficial to everyone. Our user studies showed the significance of text simplification through eye tracking data. Eye tracking allowed us to examine user-viewing behavior through heat maps and fixation duration statistics that showed how long participants viewed certain sections of the web page. These results could be beneficial for web developers to better understand whether or not a web page is accessible.

## 2. Background

### 2.1 Accessibility

The term accessible is defined as being able to be “reached or approached”; “used or obtained”; or “easy to appreciate or understand” (Accessible, 2015). Based on this definition, accessible places or services must have the capability to be utilized by any user, including both persons with and without disabilities.

#### 2.1.1 The Eunice Kennedy Shriver Center and INDEX

The Eunice Kennedy Shriver Center is a part of the University of Massachusetts Medical School that conducts research on Behavior Analysis, Neurobehavioral Science and Neurogenetics, Health Promotion, Learning Technologies, and Popular Health to benefit people living with intellectual and developmental disabilities (“About Us”, 2015).

INDEX is a program within the Eunice Kennedy Shriver Center that supports web development to better web accessibility for people living with intellectual and developmental disabilities. Our sponsor is the director of the INDEX program, and provides technological solutions for people with disabilities.

#### 2.1.2 Importance of Internet Accessibility

When in reference to technology, accessibility refers to the equal right to use Information and Communication Technologies (ICTs), and providing equal access to all users (Jaeger, 2008). Due to the rapid growth in the functionalities and information available on the Internet, it can be inferred that accessible technology is important for all people with and without disabilities. In fact, the United Nations’ Convention on the Rights of Persons with Disabilities identifies access to these technologies as a “basic human right” (UN Enable, 2015). Accessibility of the Internet is extremely important to those with disabilities, especially in the networked society (Jaeger, 2008).

In order to make websites more accessible, they must have accommodations for those with physical or cognitive disabilities. For people with physical disabilities, these accommodations must address visual accessibility, auditory accessibility, and physical accessibility. These accommodations may even be required by law, depending on the organization. (Cunningham, 2012). Visual accessibility includes building a website with the consideration of screen readers, which cannot read images of text, reads the page from top to bottom, and cannot skip navigation sections. Auditory accessibility must take into account the quality of captioning on videos as well as any features without visual components. Physical accessibility on the Internet takes into consideration any actions that may be difficult for a user who does not possess fine motor skills or who may have tremors. For people with cognitive disability it is recommended to use simplified textual content within a visual environment with a great deal of white space and no distractions (Meiert, 2009). These considerations allow the Internet to be accessed and enjoyed by more people, which helps to support social inclusion (W3C, 2015).

### 2.1.3 Accessibility and the Law

Throughout the United States' legislative history, the rights for people with disabilities have expanded and web accessibility has come into greater focus.

#### Rehabilitation Act of 1973

The Rehabilitation Act of 1973 was the first act by the United States government to address discrimination against people with disabilities. This act prohibited discrimination based on disabilities for programs by federal agencies or those receiving federal assistance, and those employed with federal contractors (The Rehabilitation Act of 1973, 2011). This act outlines the beginnings of modern day affirmative action that must be taken by employers, but solely in the federal space. These regulations were expanded upon nearly 20 years later.

#### Americans with Disabilities Act

In 1990, the Americans with Disabilities Act expanded upon Section 504 of the Rehabilitation Act of 1973 (Colker, 2004). The act defined a disability as having either: “

- a) a physical or mental impairment that substantially limits the major life activities of an individual
- b) a record of such impairment or
- c) being regarded as having such an impairment” (Colker, 2004, p.25)

The act had three titles. The first (ADA Title I), stated there must be non-discrimination against a qualified person with a disability, for any job. This expands upon the regulations of solely federal contracts and employment in the Rehabilitation Act of 1973, to all areas. The second title (ADA Title II), calls for non-discrimination from “public entities,” such as a public university or hospital (Colker, 2004). The final title (ADA Title III), requires non-discrimination at “places of public accommodation,” including hotels or restaurants. These titles also include any organization that receives federal funding.

#### Section 508

In June 2001, an amendment to the Rehabilitation Act of 1973 went into effect (GSA, n.d.). This amendment, Section 508, deals with the accessibility of electronics and information technology for all federal agencies. The section describes E-government, or the government information and services in the networked environments (Jaeger, 2008). Although it was originally intended for federal employees and federal website access, it has been interpreted more broadly to include all states receiving money from the federal government (Kim, 2002).

### 2.1.4 Legal Implications

How do these laws and regulations affect non-government agencies? Section 508, in combination with the Americans with Disabilities Act, has been interpreted in a variety of ways. Some interpret these to include public website and service providers, which is discussed below.

#### Interpreting the Laws in Terms of the Internet

As of 2003, the circuits were split on whether the phrasing “place of public accommodation” in the Americans with Disabilities Act (Title III) means solely physical locations or can be interpreted as services on the Internet (Georgia State Law Review, 2003). This unclear understanding of exactly what the section means has played out in multiple lawsuits.

## Lawsuits

The following are some of the major lawsuits that arose from the Americans with Disability Act and Section 508, and its interpretation with the Internet. These lawsuits ended with varied results, and left the status on the extent of interpretation for the Internet as still undefined.

### *National Federation of the Blind v. America Online*

In 1999, the National Federation of the Blind (NFB) filed a lawsuit against America Online (AOL), one of America's largest Internet providers at the time (Kim, 2002). This lawsuit was because of the inaccessibility of AOL's website, particularly, due to the lack of compliance with screen readers. The NFB argued that as an Internet service provider, AOL was a public accommodation. The lawsuit was settled out of court, and AOL adopted the necessary changes in the next software update.

### *Access Now v. Southwest Airlines*

In October of 2002 a notable lawsuit was filed by Access Now, a human rights organization that defends all people's rights to accessible Internet (George State Law Review, 2003). The suit was filed against Southwest Airlines, because the company's virtual ticket counter failed to provide accessible forms. The blind client was not able to navigate the page because of the set up. In this case, the court upheld the airline's website, citing that it was not a place of public accommodation because the language of the Americans with Disabilities Act was ambiguous.

### *National Federation of the Blind v. Target Corporation*

The case of the National Federation of the Blind v. Target Corporation occurred in August 2008, and was similar to the aforementioned cases (Target.com, 2008). This case ended in a \$6 million settlement of a class-action lawsuit, and again left the ruling on web accessibility and whether these are classified as public accommodations as still ambiguous.

## 2.1.5 Web Accessibility Initiative

The World Wide Web Consortium (W3C) began the Web Accessibility Initiative with the goal of "providing a single shared standard for web content accessibility" that can be used by entities around the world (W3C, 2015). In order to do so, the organization outlined guidelines aimed at text, image, or sound on a website, as well as code or markups that define the presentation of the page.

### Web Content Accessibility Guidelines

The Web Content Accessibility Guidelines (WCAG) was developed through W3C, and recognizes that pages may not have been designed in the past with accessibility in mind (Harper, 2008). WCAG contains 12 guidelines under 4 principles:

1. Perceivable
2. Operable
3. Understandable
4. Robust (W3C, 2015)

The twelve guidelines are grouped into broader categories, and have specific regulations within each section. These criteria include:

1. Text Alternatives
2. Time-Based Media
3. Adaptable
4. Distinguishable
5. Keyboard Accessible
6. Enough Time
7. Seizures
8. Navigable
9. Readable
10. Predictable
11. Input Assistance
12. Compatible

These testable criteria then translate to one of three levels: A, AA, or AAA (AAA being the most accessible).

Although these guidelines provide a comprehensive list some argue they have a “lack of scientific rigour” and some argue they were not designed with the developer in mind or tested on website developers (Harper, 2008, pg. 68). This may be interpreted as to why many websites still do not follow these or other accessibility guidelines.

### User Agent Accessibility Guidelines

While the WCAG focuses on web content and is utilized by developers, the User Agent Accessibility Guidelines (UAAG) addresses Web browsers, media players, and some aspects of assistive technologies (W3C, 2015). These are also more content focused than the prior guidelines. Below are the sections for the UAAG:

1. Support input and output device-independence
2. Ensure user access to all content
3. Allow configuration not to render some content that may reduce accessibility
4. Ensure user control of rendering
5. Ensure user control of user interface behavior
6. Implement interoperable application programming interfaces
7. Observe operating environment conventions
8. Implement specifications that benefit accessibility
9. Provide navigation mechanisms
10. Orient the user
11. Allow configuration and customization
12. Provide accessible user agent documentation and help



## Other Guidelines

In addition to WAI and UAAG, other guidelines have been developed by both external companies and federal agencies. These include: the Section 508 Guidelines, Royal National Institute of Blind People (RNIB) Guidelines, American Foundation for the Blind (AFB) Guidelines, IBM Guidelines, and Publicly Available Specification 78 (PAS 78) (Harper, 2008).

These guidelines, although extensive, also have the aforementioned shortcoming of lacking measurement, making them difficult to hold developers accountable for. They also have the issue of being “optional, not enforceable, and not accurately testable” (Harper, 2008, pg. 200). Moving towards the future of web accessibility in design, there will need to be a furthered focus in effort on testing websites for guidelines in an easy and automated fashion.

## 2.2 Cognitive Disabilities and Web Accessibility

### 2.2.1 What are Cognitive Disabilities?

Research shows that “an estimated 15-20% of the population, including many of the brightest minds of recent generations such as Albert Einstein, Thomas Edison, and Henry Ford, has some sort of language or text comprehension difficulty” (Cognitive, n.d.). That 15-20% includes those with cognitive disabilities. Roughly 1-3% of Americans possess a cognitive disability, including those with an intellectual disability or ID (Intellectual Disability, n.d.). Defining what the term ‘cognitive disability’ means is quite difficult, as it covers a wide range of disabilities. In general terms, a person who has more difficulty with one or more mental tasks than the average person would be diagnosed with a cognitive disability. The term, which may seem clear in the definition, is very broad because it includes various groups of disorders and covers many different individuals. Furthermore, each individual experiences different levels and types of cognitive disabilities (Cognitive Disability: Information on Intellectual Disabilities, n.d.). Those who possess cognitive disabilities with extreme functional challenges require constant help with many aspects of their life. On the other end of the spectrum, someone may experience a very minor cognitive disability, so much so that it may go unnoticed and never be discovered or diagnosed (Cognitive, n.d.).

There are two ways to classify cognitive disabilities: functional and clinical. A clinical diagnosis includes the specific type of disability the person may be experiencing, such as Down syndrome, Autism Spectrum Disorder, or Dyslexia. A functional diagnosis focuses on the behavioral challenges that arise as a result of the type of clinical diagnosis an individual may have (Cognitive, n.d.). In terms of accessibility, understanding the functional abilities and challenges would be more useful for developers. For instance, if a developer was told that the target group of a website were those with Autism, the developer may not know what the specific needs are for individuals with Autism. It is more beneficial to help the developer understand that those with Autism may react negatively to auto-playing video or audio, or may have a hard time paying attention, or need clear instructions (Gap Analysis, 2014). As a result, the developer is now more easily able to design a website that better directly meets their needs. There are many different types of functional disabilities, this includes: memory, problem solving, attention, reading comprehension, linguistic comprehension, verbal comprehension, math comprehension, and visual comprehension (Cognitive, n.d.). Many of these functional disabilities overlap within the variety of clinical disabilities. Although it is more useful for developers to understand the different functional disabilities, it is not expected that the developers will accommodate to every need and reading level, as it would be extremely difficult. It is, however, possible for developers to write simply and clearly to help increase reading comprehension (Cognitive, n.d.). As it stands, the web is currently not accessible for

those with cognitive disabilities and, as a result, those with cognitive disabilities “experience a wide range of difficulties when it comes to understanding and using internet services” (Easy Surfing, n.d.).

### 2.2.2 Difficulties Faced When Using the Web

Since the Internet is not accessible for those with cognitive disabilities, it is not surprising to see that those same individuals opt to not use the Internet. In fact, only 54% of people with intellectual disabilities access the Internet in the United States; a more favorable percentage than that of the 36% in the United Kingdom (Fox, 2011 and Dutton, 2005). The Internet is a large source of information, and also provides social and economic connections. There are many benefits to using the web and “although people with ID potentially stand to gain the most from this technology, they are traditionally the group within society least likely to gain access to and receive the full benefits from the Internet” (Chadwick, 2013, p. 379). As mentioned in the previous section, those with cognitive disabilities face many functional, cognitive, and sensory challenges that make using the current web extremely difficult. The article, *An Accessibility Frontier: Cognitive Disabilities and Learning Difficulties*, by Russ Hudson stated that:

“[The] needs of the largest disability group in our community, those with cognitive disabilities and learning difficulties, appear to have slipped through the cracks to a large extent when it comes to website accessibility” (Hudson, 2005).

There are many reasons as to why the web is currently inaccessible to those with cognitive disabilities. The biggest barrier is the skills needed to access and correctly use computers and the web. Many of those with cognitive disabilities do not receive the necessary training or help to make the web easier for them to use (Chadwick, 2013). Beyond technical abilities, there are many reasons that cause the web to be inaccessible to those with cognitive disabilities. First, terminology that is not common in normal conversation can cause confusion (Chadwick, 2013). Also, many websites require numerous commands or steps in order to get to a certain page or complete a task. Much of this requires a strong working memory and can also be an issue for those with cognitive disabilities (Chadwick, 2013).

There are also many web design concepts that cause confusion and frustration for people with cognitive disabilities. This could include too many objects, including text, images, video, etc. on the screen at the same time. A second design concept that creates difficulties are web pages that include a lot of text, or text that is typically too complex for those with cognitive disabilities. This also includes the inability to increase text size and having too many rows of text. This can be a spatial issue for those with cognitive disabilities because the text will appear too small and condensed, making it hard for the reader to separate words and sentences (Lohman, 2014). There can also be too many inconsistencies in design. For instance, when a user does one task and tries to reenact that on a new page when the new page does not work the same way; thus causing confusion (Lohman, 2014).

In summary, there is a lot that needs to be considered when it comes to making the web more accessible. Those with cognitive disabilities can receive a tremendous amount of benefits if given the chance to better access the web. Some of these benefits are explained in the following section.

### 2.2.3 The Importance of Web Accessibility for Those with Cognitive Disabilities

Being on the web allows people access to all sorts of information, social aspects, and connects people with all parts of the world.

“[Being] digitally connected is increasingly fundamental to economic and education advancement and community participation. No longer is access to the Internet considered a luxury, instead it is an integral and important life survival tool which can make life more enjoyable and empower individuals” (Shapiro, 2000, p.36).

The Internet has become a part of everyday life and excluding an entire community of people takes away their chance to take part and reap the benefits that the Internet could provide for them. Many people with cognitive disabilities face challenges communicating and connecting with people. This creates a barrier for them to be able to develop friendships. In turn, this can cause a feeling of loneliness. However, the Internet can help with those challenges (McVilly, 2006). By making it easier for them to access the internet, it opens up doors for communication with many people and engaging in social media that has the potential to help get rid of the feeling of loneliness people with cognitive disabilities face (Kydland, 2012). It is clear that the Internet can provide plentiful amounts of social opportunities for those with any disability. Therefore, web accessibility should be more widely considered (Seeman, n.d.).

In addition to increasing social contact and reducing the feeling of loneliness, web accessibility can also help users to gain a sense of freedom and provide a release from the stereotypes some people with cognitive disabilities face. A qualitative study was conducted in Sweden to see the effects of giving individuals with cognitive disabilities access to the Internet. It was shown that young people with cognitive disabilities felt freedom having the ability to use the Internet as they please and also experienced increased positive morale (Löfgren-Mårtenson, 2008). Many people with cognitive disabilities face negative stereotypes, attitudinal biases, and social challenges on a daily basis. The web can provide easy access to aid websites and support groups where those with cognitive disabilities can connect with others who feel the same way and get help if needed (Chadwick, 2013). In addition, increasing inclusion to the Internet would allow those with cognitive disabilities to access information regarding education. The Internet “has also been found to be successful in reducing physical barriers to education and learning with respondents reporting receiving long-distance education via the Internet” (Guo, 2010). Lastly, if all of the information available on the web was accessible, it has the potential to advance careers and increase educational opportunities (Seeman, n.d.).

In general there are many reasons why web accessibility is important for those with cognitive disabilities. Web accessibility has the potential to increase “social contact, reducing stigma and identity development, and increasing life opportunities to practice self-determination and self-advocacy” (Chadwick, 2013, p. 387). From these potential opportunities, the importance of web accessibility is clear, and currently there is a substantial lack of research and studies that advocate web equality, based on research conducted in the systematic literature review in Section 3. Systematic Literature Review of this paper.

## 2.3 Plain Language

Plain language, also known as plain English, is an effective form of communication using basic word and sentence structures. Its purpose is to eliminate any confusion or obscurities between the author and reader. This allows the reader to better understand the author's message. As stated by the late Professor Robert Eagleson of the University of Sydney, plain language "is not baby talk, nor is it a simplified version of the English language." Plain language allows readers to focus on the main idea or message of writing, rather than being distracted by confusing or complex language (Plain Language, n.d.).

Plain language writing enhances reading comprehension and makes reading more efficient. Fewer explanations are needed for the reader to understand of the material (Plain Language, n.d.). This is beneficial because less time is required for reading comprehension. Utilizing plain language can increase the understanding of a given text passage while decreasing reading time, making the use of these standards favorable from both an inclusive and economic standpoint.

Passages that are difficult to comprehend can often be off-putting to the reader. This could leave a reader frustrated and possibly without interest in completing a passage of text. Often times, complex writing will encourage readers to bypass the text without attempting to truly comprehend what the author is attempting to convey (Clear Language, n.d.). The challenge of reading comprehension is often intensified for individuals with a cognitive disability. Researchers have identified text comprehension as a challenging skill for those with cognitive disabilities. Although more intensive research is necessary to find concrete relationships between cognitive disabilities and reading comprehension, a 2001 study was able to distinguish some connections between children with and without cognitive disabilities in regards to their reading comprehension levels (Conners et al, pg. 292-299).

Various officials, including the President of the United States, have addressed transparency and openness in the federal government. The overlying issue with transparency is the inability for most of the general public to understand official government documents. The 1998 Supreme Court case of *Walters v. Reno*, ruled that multiple government forms violated due process requirements regarding effective communication on legal actions that may be taken against individuals. This was in response to multiple immigrants being deported due to document fraud without their knowledge of the possible consequences of improperly completing these forms (Walters v. Reno).

On June 1, 1998 President Clinton issued a government-wide memorandum addressing the use of plain language standards in official government documents. The President believed that by using plain language standards in all official documents, the government would be able to "send a clear message about what the Government is doing, what it requires, and what services it offers" (Plain Language, n.d.). President Clinton's memorandum was seen as one of the first wide-scale initiatives towards implementing plain language standardization at the federal level. This act was extended in 2010 through President Obama's "Plain Writing Act of 2010". This act was created to "enhance citizen access to Government information and services by establishing that Government documents issued to the public must be written clearly, and for other purposes." Specifically, the act states that all official government websites must include plain language writing sections that are easily accessible to any viewer (Law 1).

There are many issues regarding the standardization, as well as the operationalization, of plain language guidelines. First and foremost, almost all guidelines are subjective to the specific passage being written

and cannot be easily quantified. President Clinton's memorandum referenced the following guidelines to be used in all official documents: common, everyday words, except for necessary technical terms; "you" and other pronouns; the active voice; and short sentences (Plain Language, n.d.)

It is clear that these standards, while effective, cannot be standardized very easily. While these guidelines have grown over the years, their ability to become operationalized remains weak. Many organizations and websites, such as PlainLanguage.gov, the Center for Plain Language, and WebAIM (Web Accessibility in Mind), provide useful guidelines for writing in plain language, and each list is similar to one another. The issue, however, remains that these guidelines cannot be standardized across any style of writing or towards the literate population as a whole. Additionally, there has been no attempt to scientifically examine the impact of plain language on comprehension and performance.

## 2.4 Eye Tracking

Eye tracking measures eye activity and allows data to be collected by what the user is seeing through the movement of their eyes, while they look at a page. Eye tracking measures where one looks, when one blinks, and the different reactions the pupil has to stimuli (What is Eye Tracking?, n.d.). In user experience and design research, eye tracking helps researchers understand the actual user's experience, in way that the user may not even be able to describe (Djamasbi, 2014).

### 2.4.1 Eye Tracking Capabilities

Eye tracking data can be collected using a head mounted "eye tracker" connected to a computer, a remote, an eye tracker with a removable monitor, or a mobile eye tracker. There are two components to the eye tracker: a light source and a camera. The camera is used to track the reflection of the light source. According to the article *What Is Eye Tracking?*, the data collected from the light source and camera are used to extrapolate the rotation of the eye and the direction of the gaze. This allows researchers to analyze the actions of the gaze in a variety of different ways. Aforementioned, researchers can measure and analyze where a participant is looking on the webpage, when they blink, and how long they are looking at the webpage. Another area of analysis that can be done through eye tracking, particularly when testing reading comprehension, is seeing how many times one looks back at a particular area of the web page.

### 2.4.2 Determining Comprehension

Using our eyes is a part of our everyday routine. Understanding how we use them in the ways that we do is of high importance in research and design today. As a participant looks at a webpage, the eye tracking device focuses on the pupil of the participant's eye and determines the direction and concentration of their gaze (Djamasbi, 2014). The eye tracking software then formulates data, based on the participants' actions and forms heat maps and saccade pathways to show a visual representation of what the participants' eyes were doing when they were focused on the webpage (Djamasbi, 2014).

#### Heat Maps

Research shows that heat maps represent where the participant concentrates their gaze and how long their eyes were staring at a certain spot (Djamasbi, 2014). The red color that appears on Figure 1, shows this was an area of high intensity and the eyes were focused on that area for the longest period of time that the participant was looking at the webpage. The green color represents that the participant's eyes were only focused on that specific area for a short amount of time, and the yellow color is an intermediate level between the green and red.

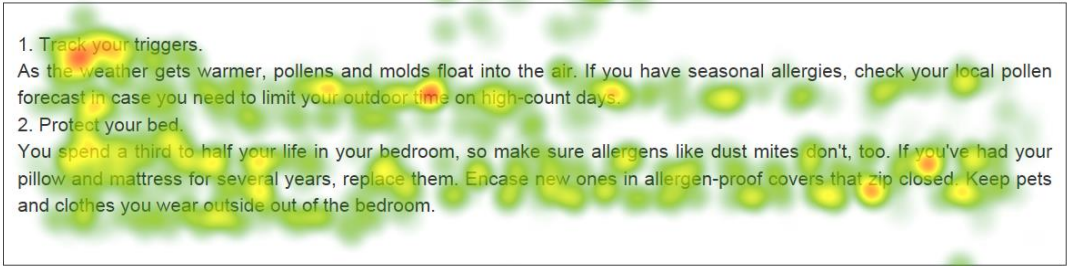


FIGURE 1: SAMPLE HEAT MAP

### Gaze Plots

Gaze plots are another way to analyze where the eyes are focused when the participant is looking at a webpage. As shown in Figure 2, there are red dots that show where the focus of the eye was. The red line indicates the flight that the eye took to move to another spot on the webpage (Djamasbi, 2014).

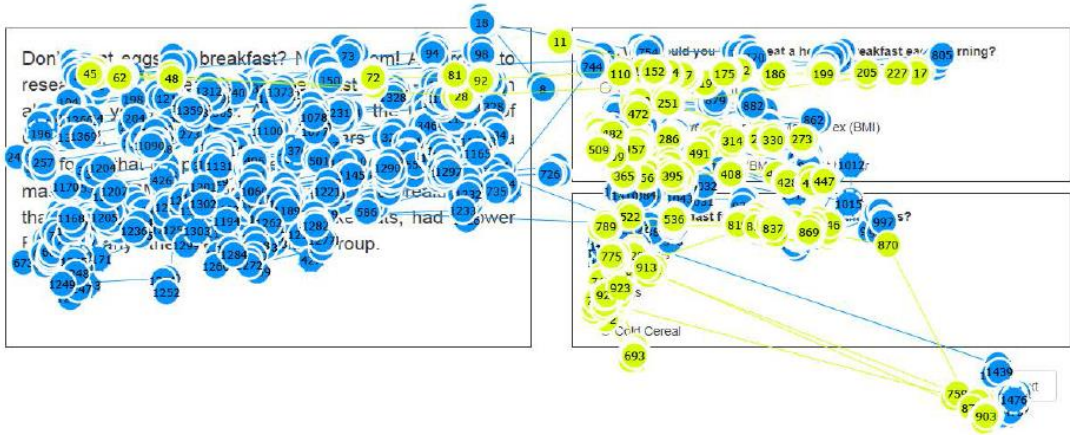


FIGURE 2: SAMPLE GAZE PLOT

### 2.4.3 Capabilities and Limitations

Eye tracking is a useful tool for capturing objective, non-conscious, and continuous behavior unobtrusively in studies and experiments. For example, eye tracking can capture behavior even when users do not intentionally or conscientiously aim their eyes at certain areas and they may not know why they do it. However, eye tracking data alone does help us to detect why the users look at specific areas, we need to triangulate the eye tracking data with other measures (Djamasbi 2014).

### 2.5 Benefits of Eye Tracking in This Project

Using eye tracking will be helpful in understanding user reactions to simplified text. Testing comprehension with simple text, and using the Plain Language Standards are critical. Capturing user eye movements when reading text can give us a more comprehensive picture of user experience and thus a better understanding of the effect of text simplification on user behavior.



### 3. Systematic Literature Review

In order to determine what has already been done with text comprehension, plain language standards, eye tracking, and cognitive disability studies, we conducted a systematic literature review. This allowed us to notice any research gaps in these areas that we could fill with our project. After meeting with the WPI librarian multiple times, we determined the best method to conduct our systematic literature review. Following a research paper that utilized a clear and detailed systematic literature review (Liberati et al. 2009), recommended to us by the WPI librarian, we were able to efficiently conduct our review based on those methods. We constructed our review in a multi-step fashion. The steps are outlined below:

*Step One: Determined a set of literary databases that we would use for our literature review*

Based on discussions with our Librarian, we generated a list of resources that would be relevant to our project, this list included the following databases:

- Web of Science
- ScienceDirect
- Engineering Village
- ACM Digital Library
- Business Source Premier
- ABI Inform
- IEEE
- PsycINFO
- PubMed

*Step Two: Determined the key words that were be searched in each database*

After discussions with the WPI librarian, our advisor, and our sponsor, we determined two sets of keywords used in our database research:

- Initial Search 1: "Eye Tracking" and "Text Comprehension"
- Initial Search 2: "Eye Tracking" and "Text Comprehension" and "Cognitive Disability"

*Step Three: Generated excel extracts of the result from each of the databases for the two sets of keywords*

*Step Four: Generated a combined excel spreadsheet of all the results with no duplicates*

*Step Five: Read the abstracts of each article, determined whether or not the article was relevant to the topic or relevant to our study and defined a category that this article fit into*

*Step Six: Of the remaining articles that were relevant based on abstract alone, we then read the full article to again to determine the relevance*

*Step Seven: A final excel spreadsheet was created with the list of relevant articles that were also useful to our study. Another tab was included with the articles, after reading them fully, that did not seem relevant and included the category the article fit into.*

**Below are the results from our Systematic Literature Review:**

We started with 222 results from the databases, but after multiple reviews by each team member individually and then by all team members collectively, we determined a final list of 38 articles that were relevant to our study. Our findings also showed a major gap that our study can fill, as there were no studies that focused on developing text simplification methods; they typically just tested specific writing techniques or formatting for ease of reading, which is also useful for our study. Not only that, only one study focused on text comprehension for those with cognitive disabilities. In general, the articles focused on how to use eye tracking to measure text comprehension. Table 1 displays how we categorize the papers based on the focus of their topics.

**TABLE 1: RELEVANT ARTICLE TOPICS**

Topic	Search Results
How to use eye tracking to measure text comprehension	N = 25
Testing specific writing techniques for ease of reading	N = 10
Studies conducted on formatting, little focused on the text itself	N = 2

None of the studies focused on text simplification, but rather on more specific sentence structuring (such as where to use annotations or how to use certain words). Our study will thus contribute to the existing body of the literature 1) by developing a comprehensive set of rules that can be easily followed by website content developers and 2) by testing the effectiveness of simplified text generated by these rules.

Below are the results from all the databases we used for our systematic literature review. Initial Research 1 below refers to using the keywords "Eye Tracking" and "Text Comprehension", while Initial Research 2 refers to using the words "Eye Tracking", "Text Comprehension", and "Cognitive Disability". The results consisted of 205 articles for Initial Research 1 and only 5 articles for Initial Research 2:

**TABLE 2: SYSTEMATIC LITERATURE REVIEW DATABASE INITIAL SEARCH**

Source	"Eye Tracking" and Text Comprehension"	"Eye Tracking", "Text Comprehension", and "Cognitive Disability"
Web of Science	N = 33	N = 0
ScienceDirect	N = 118	N = 1
Engineering Village	N = 3	N = 0
ACM Digital Library	N = 39	N = 4
Business Source Premier	N = 0	N = 0
ABI Inform	N = 17	N = 0
IEEE	N = 1	N = 0
PsycINFO	N = 3	N = 0
PubMed	N = 8	N = 0

After generating the total list of articles and removing duplicates, we had a final list of 205 articles for Initial Research 1 (there were 17 duplicates) and kept the same 5 articles for Initial Research 2, as there were no duplicates.



With our final list, we then read through each of the abstracts to determine their relevance to our study. An article was deemed irrelevant if it did not focus on using eye tracking to test reading comprehension, text simplification, text comprehension with those with cognitive disabilities, or any other variation of the keywords used in our search. Many of the articles were deemed irrelevant because they did not focus on textual content, e.g., they focused on topics such as web navigation, or using hyperlinks, or focusing on physical attributes of electronic devices, etc. Below are the results of analyzing the abstracts alone:

**TABLE 3: ARTICLE ANALYSIS BASED ON ABSTRACT**

"Eye Tracking" and Text Comprehension"	Relevant: N = 70
	Irrelevant: N = 135
"Eye Tracking", "Text Comprehension", and "Cognitive Disability"	Relevant: N = 2
	Irrelevant: N= 3

For the final stage of our analysis, we went through the remaining 72 relevant articles and read them in full to get a more detailed understanding of the article or study in order to again determine relevance. After reading through the articles, we determined that there were only 38 articles that would be useful to our study relevant to our focus area. The final results are listed in the table below; the list of 38 articles are provided in Appendix E:

**TABLE 4: COMMON THEMES AMONG RELEVANT RESULTS**

Using eye tracking for text comprehension	25
Specific methods for writing text	8
Text comprehension and cognitive disabilities	1
Similar studies to help design our research study	2
Text comprehension in general	2
Total	38

**TABLE 5: COMMON THEMES AMONG IRRELEVANT RESULTS**

Foreign Speakers	1
Determining Reading Skill	3
Not focused on text simplification	10
Electronic/Digital	3
Web and text Formatting	3
Effects of Prior Knowledge	3
Skimming	1
Focused more on Working Memory/Aging/Disorders	7
Formatting versus Text	1
Total	32

## 4. Methodology

### 4.1 General Overview

The operationalization of plain language standards is important for making the web accessible for all users, both with and without cognitive disabilities. Our research focused on both the operationalization of plain language standards, as well as data collection and analysis on the effectiveness of these rules. Our team created a set of quantifiable rules to create plain language and used a standardized approach to simplify text passages using these rules. We then tested the comprehension of our simplified passages versus their original versions using various eye tracking metrics, as well as interview questions to gauge effectiveness.

### 4.2 Developing Plain Language Rules

#### 4.2.1 Exploring Operationalized Plain Language Rules

We initially attempted to operationalize all plain language rules. The first step of this process was to compile a comprehensive list of all existing, credible rules pertaining to writing in plain language. We consolidated a full set of rules from multiple, credible websites. We focused on government official websites, nonprofit organizations devoted to web accessibility, and that of the Plain Language International Association. Those websites are listed below:

- a) <http://webaim.org/techniques/writing/>
- b) <http://wave.webaim.org/cognitive>
- c) <http://plainlanguagenetwork.org/plain-language/what-is-plain-language/>
- d) <http://www.plainlanguage.gov/>
- e) <http://www.plainlanguage.gov/> Felker – Guidelines for Document Designers
- f) <http://webaim.org/techniques/writing>

From these websites, we created a list of 33 rules, as found in Appendix A – Compiled Rules.

After condensing all the applicable rules of plain language writing from these sources, we then sorted our rules into three distinct categories: Writing Process, Usage / Verbiage, and Design. ‘Writing Process’ rules related to the overall structure of the written passage and how the document should be formatted. ‘Usage / Verbiage’ rules referenced the syntax of individual sentences and words, ensuring that there was fluency with each sentence and idea. In addition, this category covered the tone of the passage to ensure that each sentence was clear, concise, and easy to comprehend. The ‘Design’ category dealt with the formatting and visual aspects of the passage, such as font, appropriate use of alternative text, and other effects.

Using these categories, we were able to scan passages and count the number of rules that were not followed in a given text passage. An example of two Plain Language rules and their corresponding process for determining and counting number of violations are shown in Figure 3.

Example of Rules	Detecting Violations	Counting Violations
Sentences must be no longer than 25 words	If the number of words in the sentence are larger than 25 then the rule is violated, else the rule is not violated	Set Violation-Count=0
Paragraphs must contain no more than 5 sentences	If the number of sentences in the paragraph are larger than 5 then the rule is violated, else the rule is not violated	As long as there is text to process If a violation is detected Increment Violation-Count by 1

**FIGURE 3: EXAMPLE OF PLAIN LANGUAGE RULES AND CORRESPONDING VIOLATION DETECTION AND COUNT**

We then determined how to further refine the simplification process by identifying the level of complexity for quantifying each individual rule. After discussing these rules with our sponsor, we agreed that our comprehensive list should only include rules that could be operationalized and quantified. For certain rules we assumed that the necessary word-based databases existed in which words could be pulled from these databases when simplifying or identifying rule infractions in passages. This would include synonyms, definitions, and other necessary concepts. For example, the assumption was made that a database of slang terms and colloquialisms existed that we could access to identify when a sentence used one of those words, thus breaking a rule and would therefore replace the word with a new simplified term. Next we narrowed down the list to 23 rules, as shown in Appendix B – Final Compiled Rules.

**4.2.2 Identifying Automatable Plain Language Rules**

Our next step was to refine our list of rules to contain only those rules that could be quantified. That is we dropped rules that could not be operationalize and quantified those that could. For example, we eliminated the rules “Stick to the point” and “Place words carefully” and quantified the rule “Write short sentences” to keeping sentences to less than 25 words. Again here the assumption was made that databases existed to pull certain words from (like slang words, negative words, etc.).

The final list of automatable plain language rules are displayed in Table 6, which we narrowed down to 19 rules. We used these rules to simplify a set of text passages from the web.

**TABLE 6: QUANTIFIED PLAIN LANGUAGE RULES**

1.	Avoid slang, jargon, colloquialisms, non-literal text
2.	Use short, simple words (no more than ~3 syllables)
3.	Use concrete, familiar words/combinations of words
4.	Use "must" instead of "shall" ("must not" vs. "shall not")
5.	Use an active voice, simple present tense
6.	Avoid weak verbs (defined: a verb that is made past tense by adding -ed, -d, -t)
7.	Use parallel sentence structure (proper word endings – ‘John likes biking, swimming, and fishing.’ v. ‘John likes to swim, bike, and go fishing.’)
8.	Use positive terms (avoid "don't" or "didn't")
9.	Avoid multiple negatives ("don't forget to not...")
10.	Explain all acronyms/abbreviations and avoid if possible
11.	Write short sentences (20-25 words), be succinct
12.	Short paragraphs (no more than 150 words in 3-8 sentences)
13.	Use transition words in paragraphs (pointing words, echo links, explicit connectives) Pointing Words: This, that, these, those, and the Echo Links: Words or phrases that echo a previously mentioned idea Explicit Connectives: Further, also, therefore
14.	Check/use correct grammar and spelling
15.	Use "you" and other pronouns to speak to the reader
16.	Use lists and tables to better visualize text and data
17.	Do not use ALL CAPS for emphasis
18.	Do not use underlining for emphasis
19.	Use bold and italics for emphasis

### 4.2.3 Simplifying Passages

Our next step was to apply our final list of quantified plain language rules to simplify text. Because we were working toward web accessibility for people with cognitive disability, we looked for appropriate text passages that people with cognitive disabilities would read on the web. Through consultation with our sponsor and our own research (“Facebook Tops List of Preferences”, 2015), we found that for those with cognitive disabilities, the websites most commonly visited are: social media (Facebook), entertainment (YouTube), hobbies, sports, gaming sites, movies, recipes, and legislature. Thus, we took text passages from websites based on these topics, combined with an additional site focused on health, because this is an important web resource (Table 7).

TABLE 7: WEBSITES USED FOR TEXT PASSAGES

Category	Website	URL
Sports	Fox Sports	<a href="http://www.foxsports.com/">http://www.foxsports.com/</a>
Games	Miniclip.com	<a href="http://www.miniclip.com/">http://www.miniclip.com/</a>
Movies	Worcester Showcase Cinema North	<a href="https://www.showcasecinemas.com/theatre/4786/showcase-cinemas-worcester-north/worcester/ma?tab=showtimes">https://www.showcasecinemas.com/theatre/4786/showcase-cinemas-worcester-north/worcester/ma?tab=showtimes</a>
Health	WebMD.com	<a href="http://www.webmd.com/">http://www.webmd.com/</a>
Food	The Food Network	<a href="http://www.foodnetwork.com/recipes.html">http://www.foodnetwork.com/recipes.html</a>
Legislation	Massachusetts Legislature	<a href="https://malegislature.gov/">https://malegislature.gov/</a>

We simplified the passages using the determined list of rules in Table 6. Each individual team member edited all of the original passages. After identifying a violation of any rules, the necessary change was made to rectify it, and a readability score using two online tools (see 4.2.4 Readability Scoring) was calculated in order to compare the level of complexity of text simplified by each individual team member. This step was repeated for each rule, until the editor had been through every one of the plain language rules and applied it to the passage. We also added an additional step of simplifying until each sentence had 15 words or less and performing a readability test, and then simplifying until each sentence had 10 words or less and performing a readability test. This allowed us to get simplified versions at a variety of reading levels. After which, a final readability score was calculated for the text passage, both with and without proper nouns, which occasionally skewed the score. This method left us with four simplified versions of each original text passage.

We also developed a set of questions for each set of passages during this time. We made sure that these questions were all at or below a 5th grade reading level, so that it would better test comprehension of the text passage as opposed to comprehension of the question itself. We developed one literal and one inferential question and answer set for each passage, based on specifications from our sponsor. The literal questions was beneficial in determining if the content of the passage was easily read, but more importantly, that no key information was lost in the simplification process. The inferential question allowed us to see if the readers were still receiving the necessary information for comprehension of the passage. The original and corresponding passages both received the same two questions.

After determining a final list of original and simplified passages, the next step was to conduct a proof of concept study. In order to achieve this goal, we conducted a set of experiments with students at WPI. If our tests show that text simplification can improve the performance of WPI students, then it is reasonable to assume that text simplification would be even more useful to people with intellectual disability. Additionally, such an outcome will demonstrate, as the principal of universal design suggests, that simplification would benefit not only users with cognitive disabilities, but any user.

#### 4.2.4 Readability Scoring

We used two separate readability scores to identify the success of our simplifications (<http://readable.com/check.php>, <https://readability-score.com/>) and to generate scores for the original passages as well. This helped us quantify and verify the success of our work and how well the passages were simplified using our comprehensive set of plain language standards. We used both websites to determine specific grade levels during the entire process of simplifying passages.

#### 4.2.5 Preliminary Survey Study

In order to test user reactions to simplified text using our plain language rules, we performed a preliminary survey of two passages we simplified during the above process in order to gauge general feedback about whether our simplified versions were easier to understand compared to the original passages. Participant were asked to rate the understandability of each text passage (Figures 4 and 5).

**MQP: Understanding Passages**

Please note: These passages are taken from larger passages. The purpose of this survey is to test the level of comprehension, not specific to the information within the passages.

1. How easy is this passage to understand? Please scale from 1-5.

Lux Level is a luxurious, in-theatre dining experience at select theatres. Movie-goers can indulge themselves with premium reserved-seating, in-seat dining throughout the show, as well as other special amenities. Each seat is equipped with a server call button so your server is always there when you need them. This truly is the finest movie-going experience available today.

Very easy      Sort of easy      Not easy, not hard      Sort of hard      Very hard

2. Please explain why you chose the above answer.

3. How easy is this passage to understand? Please scale from 1-5.

Miniclip.com offers a wide range of games for all users, including:

- Action
- Sports
- Puzzles
- Mobile games
  - a. iPhone
  - b. Android
- and more!

Very easy      Sort of easy      Not easy, not hard      Sort of hard      Very hard

4. Please explain why you chose the above answer.

Next

FIGURE 4: FIRST PAGE OF SURVEY IN THE PRELIMINARY STUDY

**MQP: Understanding Passages**

5. How easy is this passage to understand? Please scale from 1-5.

Welcome to Miniclip.com, the leading online games site, where you can play a huge range of free online games including action games, sports games, puzzle games, games for girls, mobile games, iPhone games, Android games, Windows Phone, games for kids, flash games and many more.

Very easy      Sort of easy      Not easy, not hard      Sort of hard      Very hard

6. Please explain why you chose the above answer.

7. How easy is this passage to understand? Please scale from 1-5.

Lux Level is a rare movie theatre that acts as a place where you can eat while you are watching your desired movie. If you hit the button that is on the seat, a waiter or waitress will come and serve you.

Very easy      Sort of easy      Not easy, not hard      Sort of hard      Very hard

8. Please explain why you chose the above answer.

Prev Done

**FIGURE 5: SECOND PAGE OF SURVEY IN THE PRELIMINARY STUDY**

The readability scores for both of the original passages were the same (10<sup>th</sup> grade), thus they both had similar complexity levels. The simplified version of the movie passage had a score of 6<sup>th</sup> grade. The simplified version of the gaming passage had a score of 5<sup>th</sup> grade. Hence, the simplified passages were slightly different in complexity level. We sent out a survey to WPI students, with a total of 57 respondents. Within the survey, we asked the user to rate each passage as “Very Easy,” “Sort of Easy,” “Not Easy, Not Hard,” “Sort of Hard,” or “Very Hard” to read. We also had a place for optional comments on each passage. Each participant evaluated four text passages (simplified and original) from two websites. Figure 6 shows the percentage of each answer from our survey results.

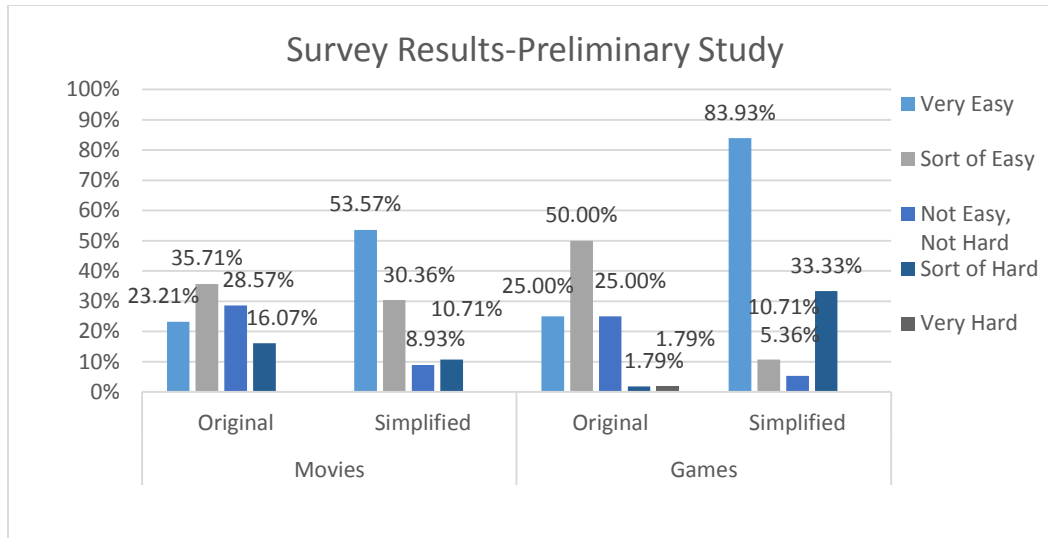


FIGURE 6: INITIAL SURVEY RESULTS

The initial results showed the original passages had higher difficulty ratings and more negative comments than the simple versions, which had lower difficulty ratings and more positive comments. Next, we performed a t-test on comparing the original simplified text pairs. The results showed a statistically significant difference in average difficulty for both sets of passages, showing that participants found the simple passages to be easier than the original passages (Movie-Original= 3.69, Movie-Simplified= 4.24; df=110, t-stat=5.36, p=0.000; Games-Original=3.84, Games-simplified =4.67, t-stat=2.91, p=0.004). The results of the t-test showed that the simplified text passages were significantly ( $p < 0.01$ ) easier to read than the original text.

## 4.3 Eye Tracking Study

### 4.3.1 Design and Participants

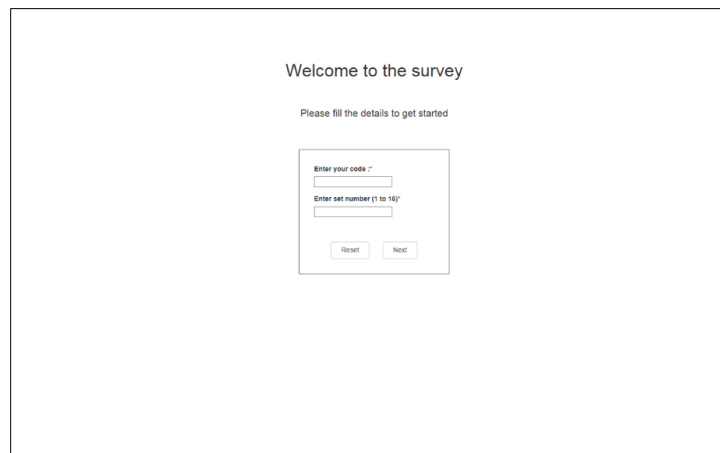
After finalizing the best method for simplifying complex text passages, two versions of a study were conducted in order to test the effectiveness of the simplified passages for better comprehension. Each version of the study was conducted in the exact same manner, the only difference between the versions were the passages used. We selected two original passages from our list of passages found online, and two of their corresponding simplified passages for the study. The study took place in the WPI User Experience and Decision Making (UXDM) eye-tracking lab on campus. We recruited WPI students as participants for our study by reaching out to different clubs, sports teams, fraternities and sororities, and courses. As an incentive for students to sign up, we offered that one randomly chosen participant would win a \$50 Dunkin Donuts gift card, who we chose after the study was complete. In total, we recruited a total of 54 participants for both versions of the study; the first 18 participants took part in the first version and the remaining 36 participants took the second version of the study.

Our first version of our study used two text passages at two different text difficulties (10<sup>th</sup> and 6<sup>th</sup> Flesch-Kincaid Grade Levels). Additionally, the difference between the original and simplified versions for one of the original-simplified text pairs was more pronounced than the other. For this study, we used passages that focused on food and health. The original version of the passage about food was at a 10<sup>th</sup> grade reading level, and its corresponding simplified version was at a 5<sup>th</sup> grade level. For the passage about health, the original version was at a 6<sup>th</sup> grade level and its simplified version was at a 5<sup>th</sup> grade



level. After conducting the study with the first 18 participants, our preliminary results showed that the difference between the original and simplified versions of the text used, particularly the health passage, was too subtle. Thus, for the second version of the study we chose complexity levels that were more nuanced. For this version of the study, we used passages focused around the topics of sports and legislation. The original grade levels for the sport passage was 10<sup>th</sup> grade and the legislation passage 19<sup>th</sup> grade. The simplified text grade levels for the sport passage was 4.9<sup>th</sup> grade and for the legislation passage was 10.5<sup>th</sup> grade.

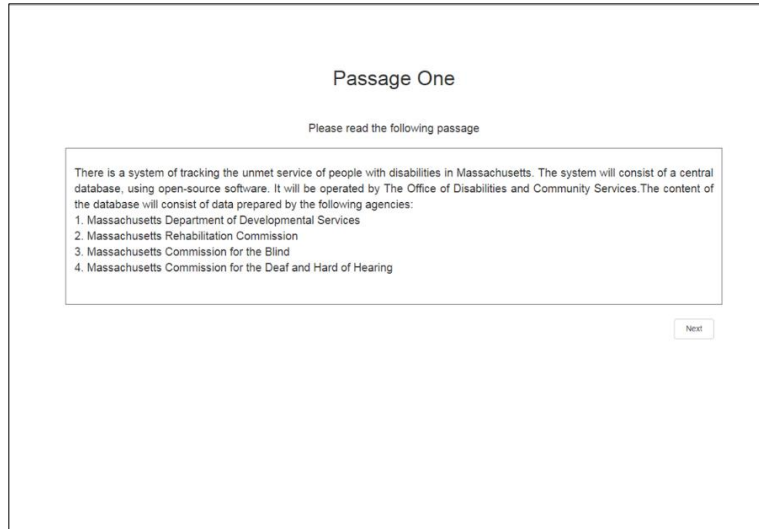
The passages were presented to participants in a Latin Square fashion. During the study, each participant saw 2 passages that had 2 questions for each passage. The first webpage they saw is as follows in Figure 7.



The screenshot shows a web page titled "Welcome to the survey". Below the title, it says "Please fill the details to get started". There is a form with two input fields: "Enter your code" and "Enter set number (1 to 16)". Below the form are two buttons: "Reset" and "Next".

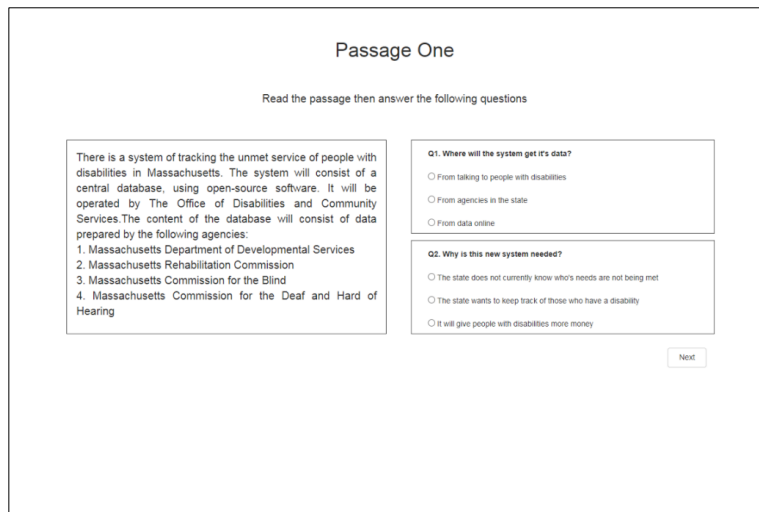
**FIGURE 7: FIRST PAGE OF WEBSITE**

This page allowed the participant to type their participant ID and their sequence number in, to make sure the data collected matches the correct ID and sequence. After that, the study began with a page that has just the first passage displayed. The participant was asked to read the passage and once done, to select "Next". The page they saw is shown below in Figure 8.



**FIGURE 8: SECOND PAGE OF WEBSITE**

On the next page, they were showed the same passage, but also had two questions that corresponded to the passage they read. The questions included a literal question and an inferential question. Each question was multiple choice with three possible answers. Once the participant answered both questions, they moved on to the second passage. The page is shown below in Figure 9.



**FIGURE 9: THIRD PAGE OF WEBSITE**

The next two pages were designed to look exactly the same as the previous pages. They included the second passage the participant saw and its corresponding questions. Once completed, a "Thank you" page appeared, indicating that the study had been completed. The participant would then be asked to answer a brief demographics survey. The follow-up interview session started soon after. During the interviews, we showed both original and simplified versions of each text passage to participants and asked them to rate their readability. We also asked them whether they would prefer the original or simplified version of the text passage on the web. The passages and questions each participant saw during the interview can be found in Appendix C – Interview Questions.

### 4.3.2 Materials Used

The first set of passages and questions that were used in the first version the study, with the first eighteen participants, are shown in Table 8. The second set of passages and questions used in the second version of the study, with the last 36 participants, are shown in Table 9.

**TABLE 8: PASSAGES AND QUESTIONS FOR STUDY V1**

Passage A – Food	Questions
<p><i>Original</i> Don't want eggs for breakfast? No problem! According to researchers, another popular breakfast food –oats – can also help you fill you up. A study from the University of California, Berkeley analyzed six years of nutrition data and found that people who ate breakfast had a lower body mass index (BMI) than people who skipped breakfast, and that those who ate cooked cereal, like oats, had a lower BMI than any other breakfast-eating group.</p> <p><i>Simple</i> Want a food other than eggs for breakfast? No problem! Oats can help you fill you up. The University of California, Berkeley analyzed six years of data. They found that people who ate breakfast had a lower body mass index (BMI). Those who ate oats had the lowest index.</p>	<p><i>Inferential</i> Why would you want to eat a healthy breakfast each morning? 1. You could gain weight 2. You could have a lower Body Mass Index (BMI) 3. Your Body Mass Index (BMI) could get higher <i>Answer: Option 2</i></p> <p><i>Literal</i> What breakfast food is healthy other than eggs? 1. Pancakes 2. Oats 3. Cold Cereal <i>Answer: Option 2</i></p>
Passage B – Health	Questions
<p><i>Original</i> 1. Track your triggers. As the weather gets warmer, pollens and molds float into the air. If you have seasonal allergies, check your local pollen forecast in case you need to limit your outdoor time on high-count days. 2. Protect your bed. You spend a third to half your life in your bedroom, so make sure allergens like dust mites don't, too. If you've had your pillow and mattress for several years, replace them. Encase new ones in allergen-proof covers that zip closed. Keep pets and clothes you wear outside out of the bedroom.</p> <p><i>Simple</i> 1. Track your triggers. As the weather warms, pollens and molds float around. If you have allergies, check your local pollen count. You must limit your outdoor time on high-count days. 2. Protect your bed. You spend almost half your life in your bedroom. Make sure allergens are removed. Replace your pillow and mattress after several years. Encase new ones in allergen-proof covers that zip closed. Keep pets and worn clothes outside out of the bedroom.</p>	<p><i>Inferential</i> You have had your mattress for 10 years, what should you do? 1. Buy new pillow cases 2. Buy a new mattress 3. Buy a new mattress and get new pillow cases <i>Answer: Option 3</i></p> <p><i>Literal</i> What should you be worried about when it is warm outside? 1. The outside weather making your clothes dirty 2. A lot of pollen, mold, and other allergens 3. Just pollen <i>Answer: Option 2</i></p>

TABLE 9: PASSAGES AND QUESTIONS FOR STUDY V2

Passage A – Legislation	Questions
<p><i>Original</i> There is hereby established a system of tracking the unmet service needs of individuals with developmental disabilities in Massachusetts. The system will consist of a central electronic database, using open-source software, operated and maintained by The Office of Disabilities and Community Services at the Executive Office of Health and Human Services. The content of the database will consist of data prepared by the following agencies, including but not limited to: the Massachusetts Department of Developmental Services, the Massachusetts Rehabilitation Commission, the Massachusetts Commission for the Blind and the Massachusetts Commission for the Deaf and Hard of Hearing.</p> <p><i>Simple</i> There is a system of tracking the unmet service of people with disabilities in Massachusetts. The system will consist of a central database, using open-source software. It will be operated by The Office of Disabilities and Community Services. The content of the database will consist of data prepared by the following agencies: 1. Massachusetts Department of Developmental Services 2. Massachusetts Rehabilitation Commission 3. Massachusetts Commission for the Blind 4. Massachusetts Commission for the Deaf and Hard of Hearing</p>	<p><i>Inferential</i> Why is this new system needed? 1. The state does not currently know whose needs are not being met 2. The state wants to keep track of those who have a disability 3. It will give people with disabilities more money <i>Answer: Option One</i></p> <p><i>Literal</i> Where will the system get its data? 1. From talking to people with disabilities 2. From agencies in the state 3. From data online <i>Answer: Option Two</i></p>
Passage B – Sports	Questions
<p><i>Original</i> PITTSBURGH -- Ben Roethlisberger's season doesn't appear to be over. Still, the Pittsburgh Steelers will have to move forward indefinitely without their star quarterback. Coach Mike Tomlin said Monday Roethlisberger has a sprained medial collateral ligament in his left knee and there is no timetable for his return. Michael Vick will start Thursday night when the Steelers (2-1) host winless Baltimore (0-3). Roethlisberger left in the third quarter of Sunday's 12-6 win over St. Louis after the knee bent awkwardly while getting sacked by Rams safety Mark Barron. An MRI taken late Sunday night revealed no major damage, leaving the door open for Roethlisberger to return at some point.</p> <p><i>Simple</i> Ben Roethlisberger's season doesn't appear to be over. The Steelers have to move forward without their star quarterback. Coach Tomlin said Ben has a sprained left knee. There's no plan to return. Michael Vick will start Thursday night. The Steelers host winless Baltimore. Ben left in Sunday's win over St. Louis. His knee bent badly. He was getting tackled by Rams safety Mark Barron. A scan taken late Sunday night showed no major damage. This gives the chance for Ben to return at some point.</p>	<p><i>Inferential</i> Why does Michael have to play? 1. He always plays quarterback 2. He has to replace Ben because Ben is injured 3. He does not play quarterback <i>Answer: Option 2</i></p> <p><i>Literal</i> Who will be playing in Ben's place? 1. Aaron Rodgers 2. Ben Roethlisberger 3. Michael Vick <i>Answer: Option 3</i></p>

### 4.3.3 Results

In order to analyze the eye-tracking data, we identified different Areas of Interest (AOIs) for each page. The AOIs were created by drawing and identifying boundaries around different areas of the page in order to generate descriptive statistics about a specific area within the page. In our study, the AOIs for pages with only the text passage include the total page area and the section of the page with text (example shown in Figure 10 below). The pages with a text passage and questions had AOIs of the total area of the page, the area of the page with the passage, the area of the page with the first question, and the area of the page with the second question (example shown in Figure 11 below). Below shows an example of the AOIs for the two screens of the simple version of Passage A. All identified AOIs with their descriptions can be found in Appendix D – AOIs.

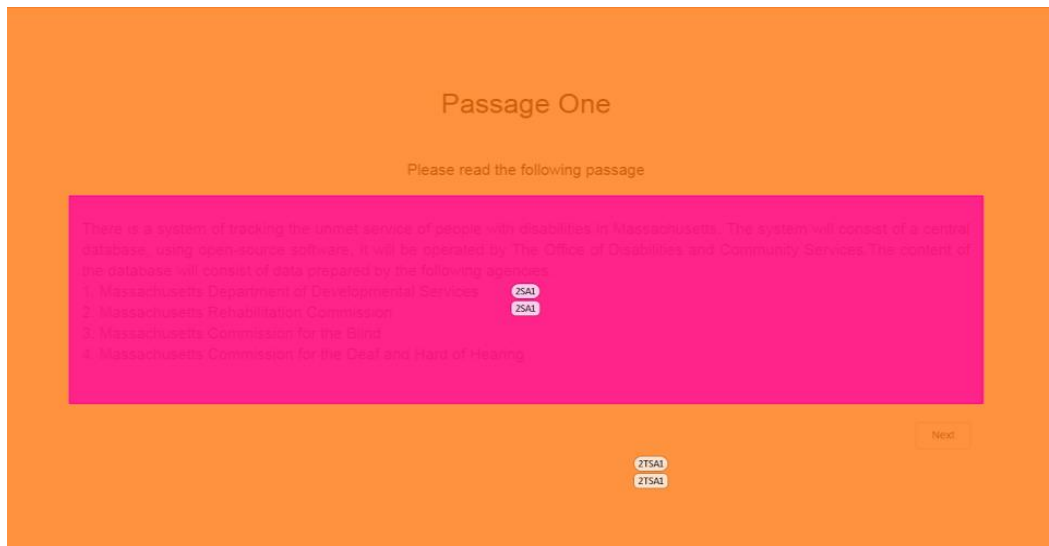


FIGURE 10: AOI SIMPLE PASSAGE A

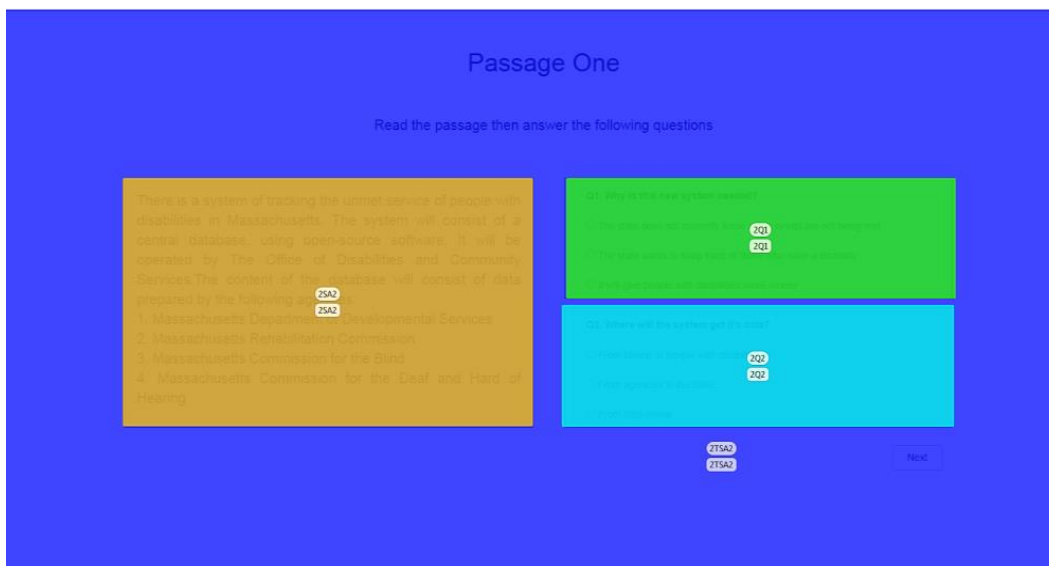


FIGURE 11: AOI SIMPLE PASSAGE A WITH QUESTIONS

For the eye-tracking data, we examined the total fixation duration, as well as the visit count for various areas on each page each participant viewed. Total fixation duration is the sum of the duration for all fixations within an AOI on the page. This allowed us to analyze how long it took participants to read passages and answer questions. We also created and analyzed ratios for different AOI combinations for each participant. We looked at the ratio on pages with just text passages of the passage area to the total page area. On pages with the text passage and questions, we looked at the ratio of the text passage area to the total page area, and the combined question area to the total page area. We believed these ratios would allow us to account for different reading speeds between participants. We then created a normalized total fixation duration to account for difference in passage length, which we did by dividing each participant's total fixation duration length within the area of the text passage by the number of words in the passage.

We also utilized the visit count statistic, which measures the number of visits by the participants' eyes within a specific section of the page. This statistic allowed us to look at how often the participant looked back to the text passage when answering questions in our study.

### Study I v1 Results

For our first version of the study, we calculated descriptive statistics about the number of questions answered correctly for both the simple and original passages for each participant. On average, participants answered 1.77 questions correct based on simple passages, as opposed to 1.61 questions correct when based on original passages (see Figure 12 below). These results were not found to be statistically significant, which we attributed to small gap in reading complexity of text pairs. This interpretation was supported by the fact that most participants were able to answer all the questions correctly. However, it is likely that with a larger sample size we are able to detect differences even when we have subtle differences in complexity levels in text pairs. For example, we observed that more participants answered both questions correctly for the simple passages (83.33%) versus the original passages (66.67%) (see Figure 13 below).

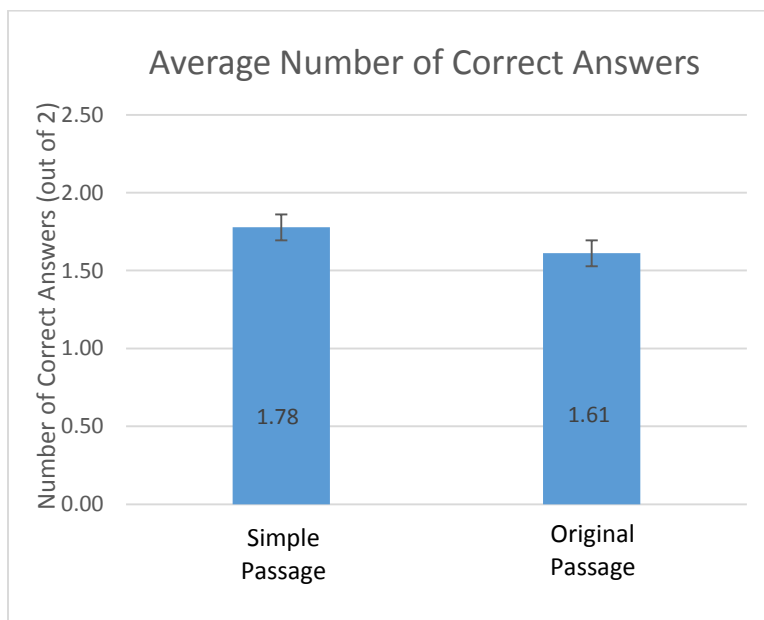
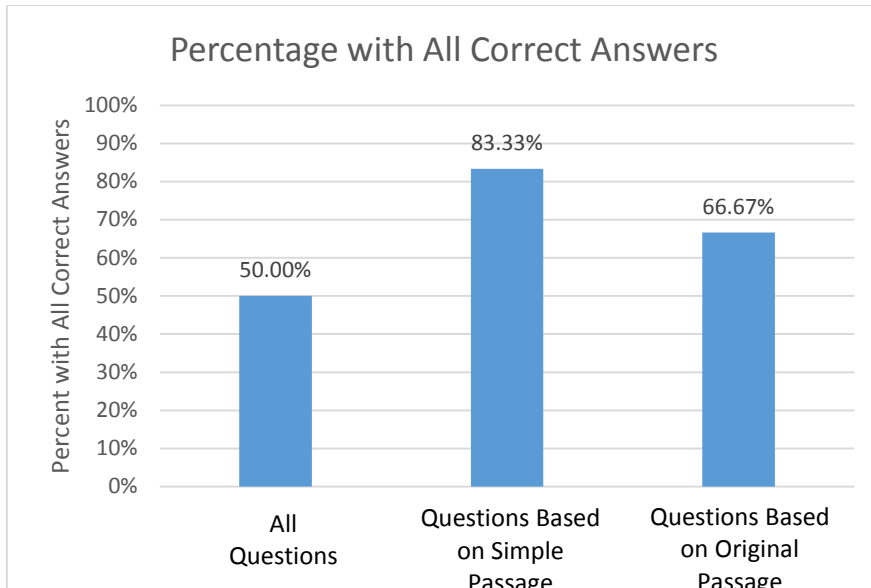
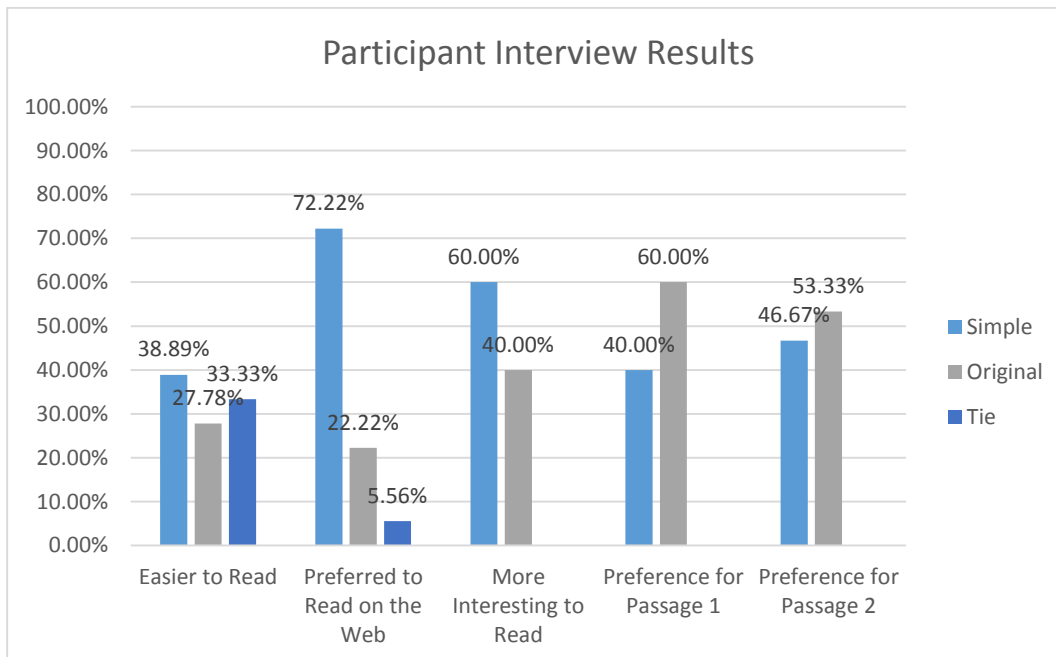


FIGURE 12: v1 AVERAGE NUMBER OF CORRECT ANSWERS



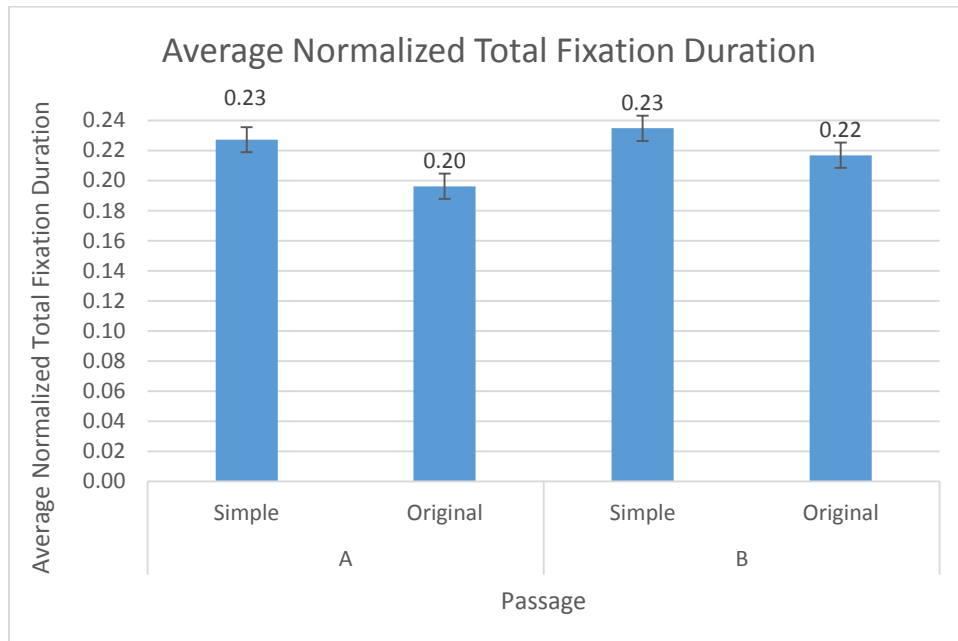
**FIGURE 13: V1 PERCENTAGE WITH ALL CORRECT ANSWERS**

The interview results found that participants ranked simple versions easier to read on a scale of 1 to 7, participants preferred to read the simple version, and found the simple passages more interesting. However, when shown both the simple and original versions of the same passage, there seemed to be not much difference in preference for the two passages; in fact more participants said they preferred the original passage. These interview results can be found in the figure below (Figure 14).



**FIGURE 14: V1 PARTICIPANT INTERVIEW RESULTS**

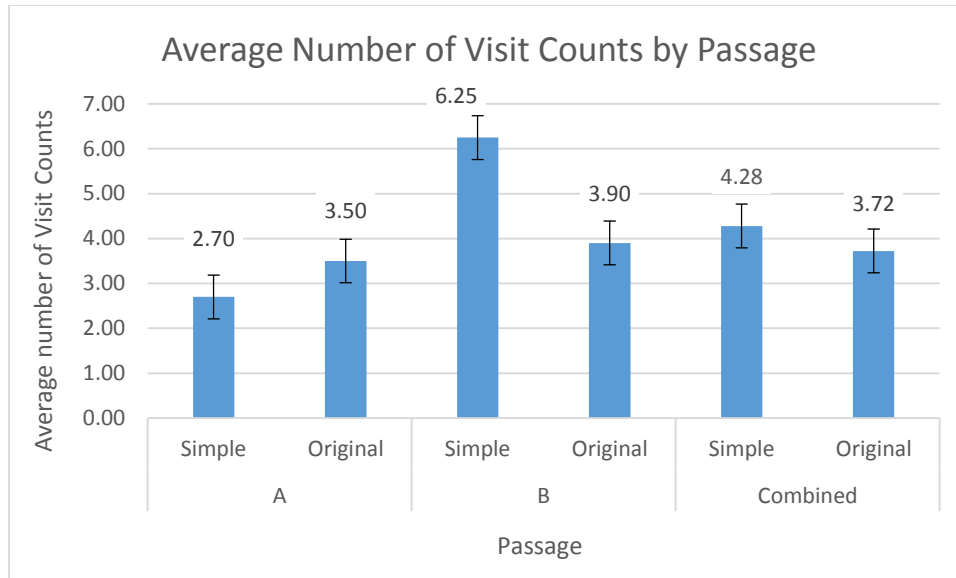
The eye-tracking data from the first version of the study yielded little differences in viewing behavior for the two passages. The total fixation duration ratios we calculated for this version did not noticeably differ between the simple and original versions of the passages, and when we calculated a t test the data produced no statistically significant results. We also normalized the total fixation duration in order to account for differences in passage lengths. The normalized total fixation durations did not show much difference between the simple and original versions, with the averages for the simple versions of the text being slightly higher than the average for the original versions (see Figure 15 below), and the difference was not statistically significant.



**FIGURE 15: V1 AVERAGE NORMALIZED TOTAL FIXATION DURATION**

We also analyzed the visit counts for the area of the passage on the page with the passage and the questions. This allowed us to have the number of times the participant looked back at the text while answering questions. Figure 16 shows a graphical representation of this. The average visit count for the simplified version of passage A proved slightly less than the average for the original version, whereas the average visit count for the simplified version of passage B proved to be quite a bit higher than the original version.



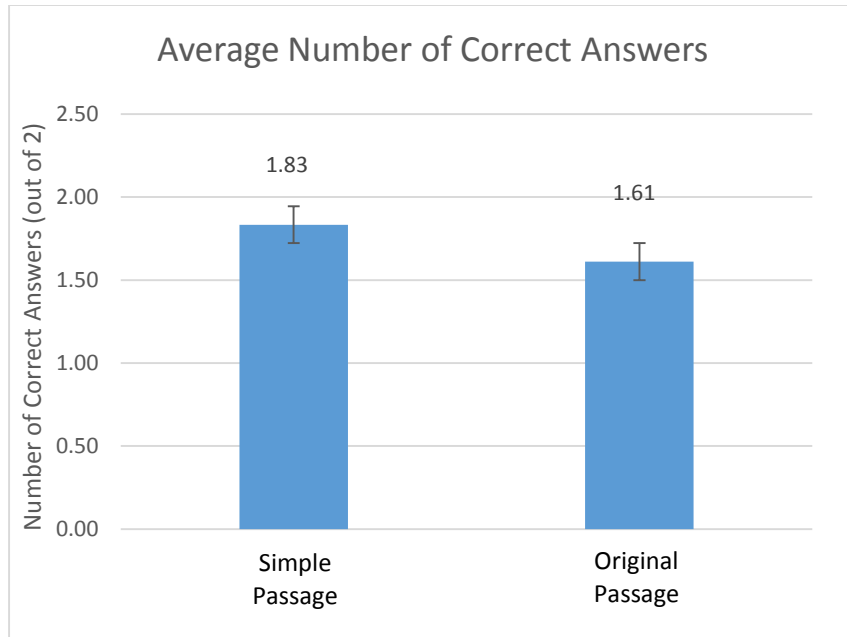


**FIGURE 16: V1 AVERAGE NUMBER OF VISIT COUNTS BY PASSAGE**

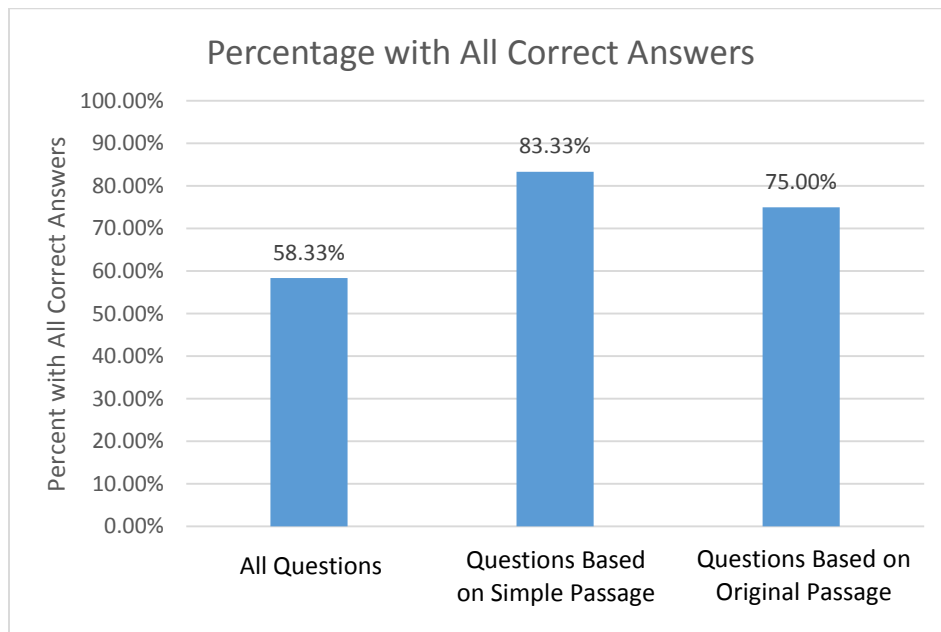
We believe these small differences in performance and eye-tracking results can be mostly attributed to relatively low reading levels of the original passages and less pronounced differences between original and simplified versions. Thus, in the next study we simplified text that was originally much harder than the text in the first set.

#### Study I v2 Results

In our second version of the study, our data was more robust and statistically significant with 36 participants and increased difficulty in the passages. On average, participants correctly answered 1.83 questions when based on a simple version of a passage versus 1.61 questions correctly answered when based on an original passage (see Figure 17). This shows a slight increase in differences in performance that we saw in the first version of the study. When conducting a t test of two-samples assuming equal variances, the p value for one-tail was 0.0543, which is almost statistically significant. Participants were again more likely to answer both questions correctly for the simple version as opposed to the original version, this time with 83.33% of participants answering both questions correct based on a simplified passage versus 75.00% of participants answering both questions correct based on an original passage (see Figure 18).

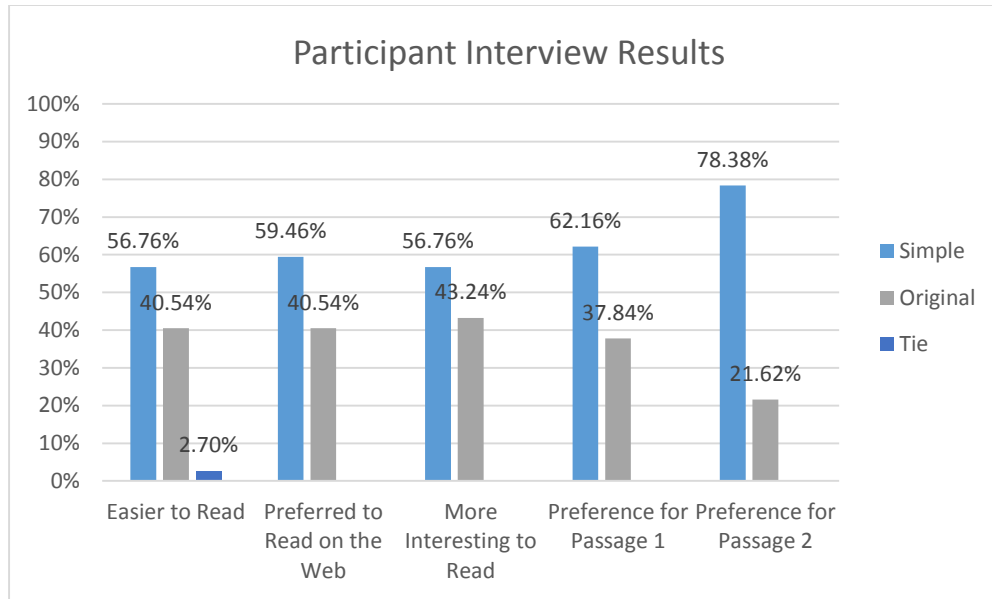


**FIGURE 17: V2 AVERAGE NUMBER OF CORRECT ANSWERS**



**FIGURE 18: V2 PERCENTAGE WITH ALL CORRECT ANSWERS**

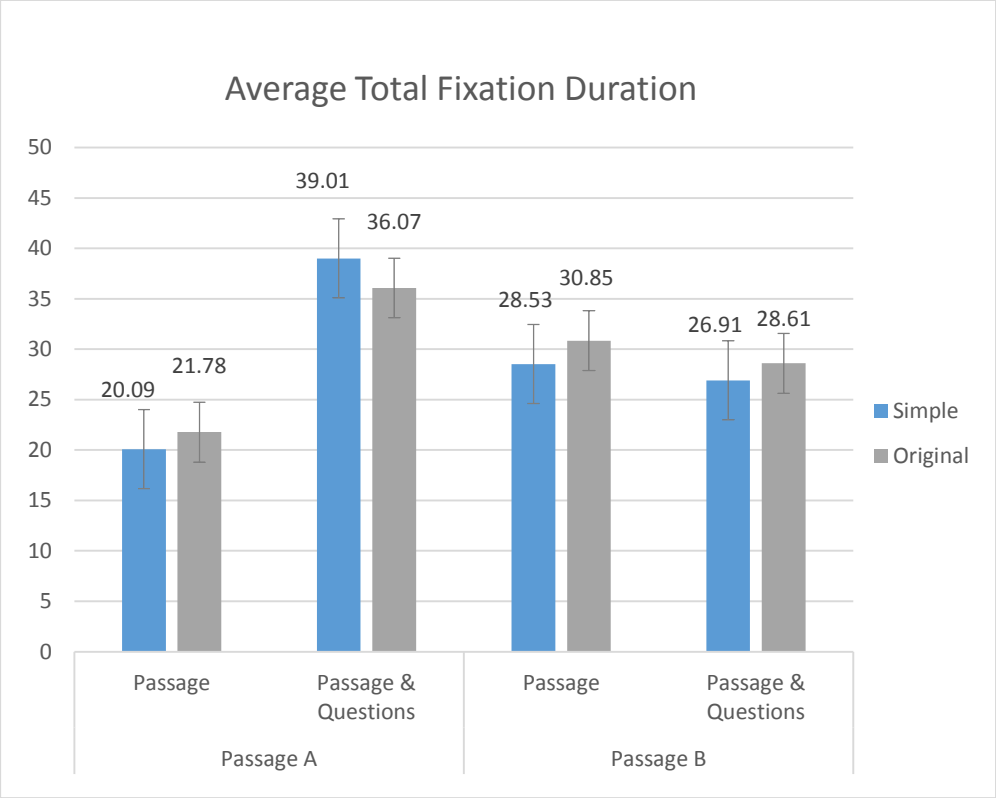
For the interview answers, 50.76% of participants ranked the simple passage easier to read, as opposed to 40.54% who ranked the original passage easier to read (2.7% ranked them as a tie). Further statistics are shown in the chart below (see Figure 19). Overall, it appears as though more people found the simple passages easier to read, preferred to read them on the web, and found them more interesting to read. Also, when shown both versions of each passage, the majority of participants preferred the simplified version of both passages.



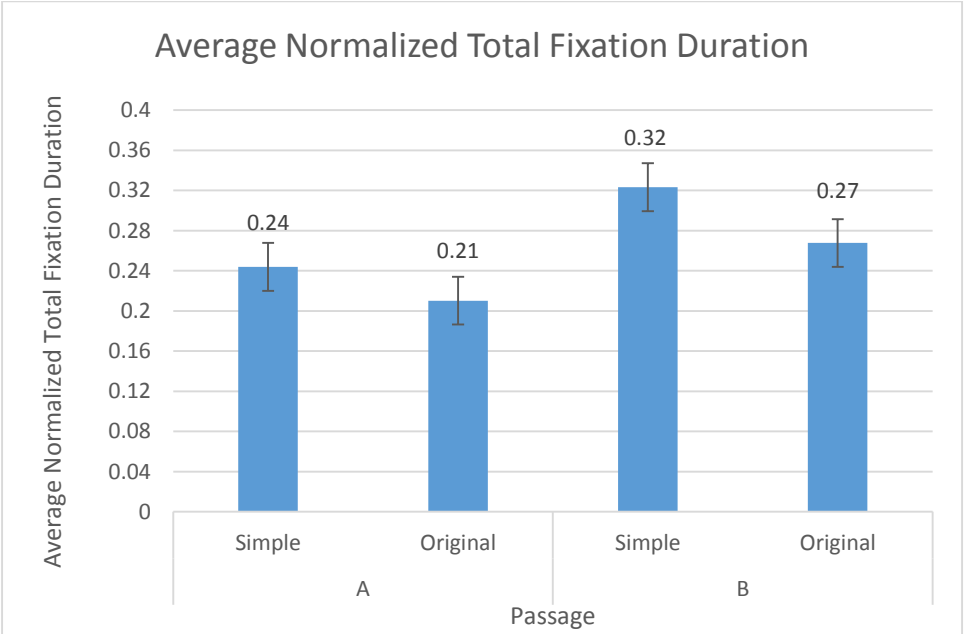
**FIGURE 19: V2 PARTICIPANT INTERVIEW RESULTS**

For the eye-tracking data, we analyzed the total fixation duration and visit count statistics for this version. The total fixation duration ratios proved to have no statistical significance. We also analyzed the total fixation duration for the amount of time spent on the entire page with just the passage, which we translated to the amount of time spent reading the passage. We also analyzed the amount of time spent on the entire page with the passage and questions, which we translated to the amount of time spent answering the questions. The mean total fixation duration sum for the total page for the simple and original versions of both passages are shown below (see Figure 20). Based on these statistics we can see that it took less time on average to read the simple version of passage A compared to the original version, but it took more time on average to answer the questions for the simple version compared to the original. For passage B, it again took less time to read the simple version of the passage, but in this case it took less time on average to answer questions for the simple version. In order to account for lower total fixation duration times due to shorter passages, we normalized the total fixation duration for the passage area of the page with only the text passage.

The results show a higher average rate of total fixation duration per word for participants when reading the simplified versions of both passages compared to reading the original versions (see Figure 21). Passage A showed a difference between the simple and original versions, but when a t test was run it was not shown to be statistically significant. However, for passage B, the p-value was 0.041, which showed a statistical significance between the simple and original version averages. These results indicate that simplified passages were more engaging.

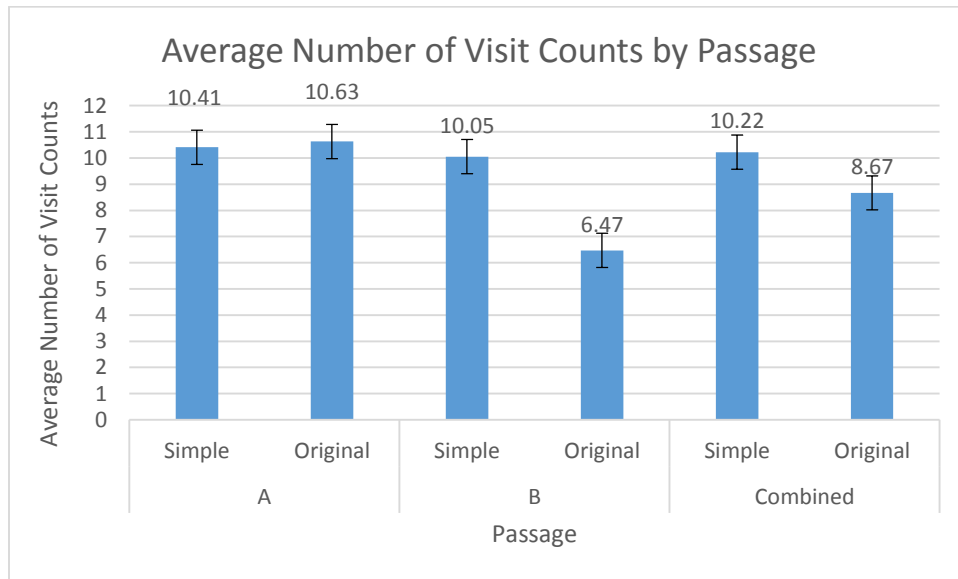


**FIGURE 20: v2 AVERAGE TOTAL FIXATION DURATION**



**FIGURE 21: v2 AVERAGE NORMALIZED TOTAL FIXATION DURATION**

For the visit count statistics, we focused on the visit count for the passage on the page with the passage and questions. This allowed us to have a count of the number of times the participant went back and forth between the text and the questions when answering. We performed paired t tests between the simple and original passages that each participant read (simple passage A : original passage B, simple passage B : original passage A). The t test between simple passage A and original passage B was found to have a statistically significant difference with a p value of 0.0133 for the original version having less visit counts than the simplified version. The other test was found to not be statistically significant. Figure 22 shows the average number of visit counts for each version of the passages. Overall, it appears as though there were less visit counts for the original versions of the text. Again, these results combined with the performance results suggest that simplified text were more engaging.



**FIGURE 22: V2 AVERAGE NUMBER OF VISIT COUNTS BY PASSAGE**

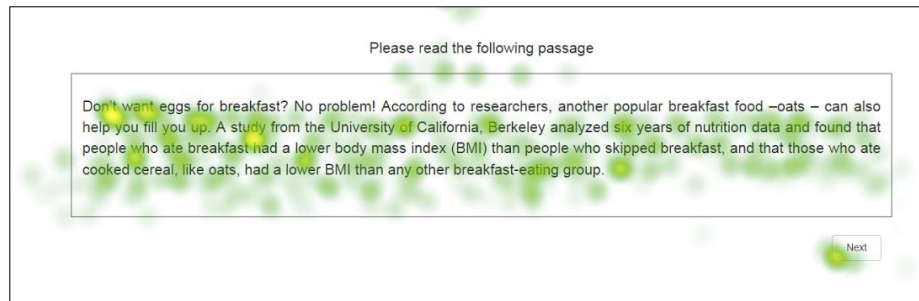
#### 4.3.4 Discussion

##### Study 1 v1

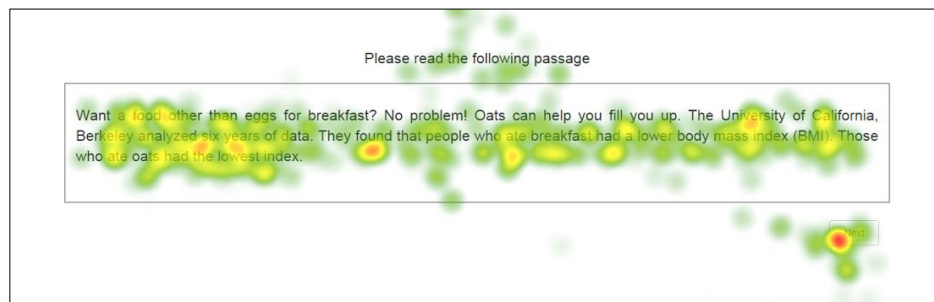
For the first version of the study, none of our data was found to be statistically significant or have a large variation between the simplified and original versions of the passages. We found a higher average of correct answers for questions based on simple passages, as well as a higher likelihood of participants answering both questions correct when given a simple passage. However, the differences in values were minimal. Our interview results showed that on average, participants found the simplified version of the text easier to read, preferred to read it on the web, and found it more interesting to read compared to the original passage they read during the study. However, we found that when shown both versions of the text, the participants preferred to read the original version of the passage, because for the most part it felt less broken up.

The normalized eye tracking heat maps support these results. Heat maps show how gazes are distributed over a stimulus. It is a visualization of the focus of attention for the participants who viewed the page. As the color shifts from green to yellow to red, the intensity increases. In the heat map for the original version of passage A in the first version of the study, shown below in Figure 23, the text area shows mostly light green, with the beginning of the passage showing a small amount of yellow.

However, for the simple version of passage A, shown below in Figure 24, the heat map shows much more yellow throughout the text and even some red in the middle of the passage area. This indicates more focus throughout the passage for the simplified version compared to the original.



**FIGURE 23: v1 ORIGINAL PASSAGE A HEAT MAP**



**FIGURE 24: v1 SIMPLE PASSAGE A HEAT MAP**

Our eye-tracking data showed minimal differences between the simplified and original passages. The average normalized total fixation duration for the simple version of both passages was found to be slightly higher than its corresponding original versions. The number of visit counts for the passage, on the page with the passage and questions, showed a higher average for the simplified versions, but not by a great difference.

Overall, our results yielded slight, but statistically insignificant differences between the simplified and original versions of the passages. The heat maps, however, indicate that fixations were more focused and intense on the simplified version. These results supported our decision to increase the difficulty of the original and simplified passages for the population under study.

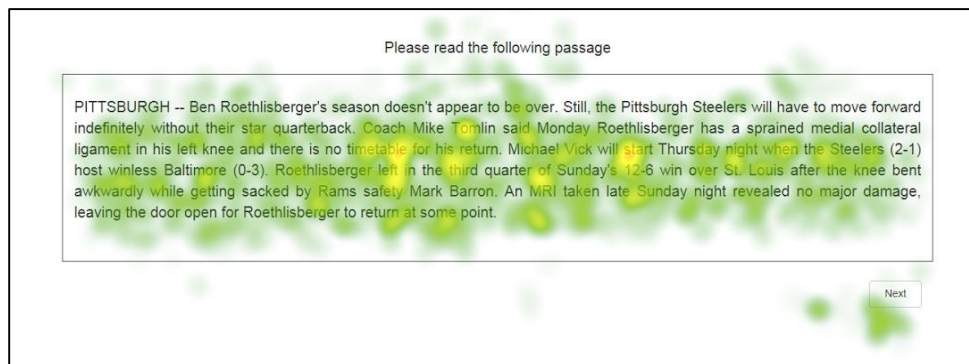
### Study 1 v2

For the second version of our study, we found results that were more significant. The average number of questions answered correctly was almost significantly higher statistically for the simple version, proving a better performance for simple passages. We also found that participants were more likely to correctly answer both questions when given a simple passage (83.33%) than an original passage (75.00%). Finally, our interview results showed that the majority of participants found the simplified passage: easier to read, more preferable to read on the web, and more interesting to read. Also, when shown both versions of each passage, the majority of participants chose the simplified version as more preferable. These results prove that not only does simplified text improve performance, and one may thus argue comprehension, but is also more desirable for the reader if given the choice.

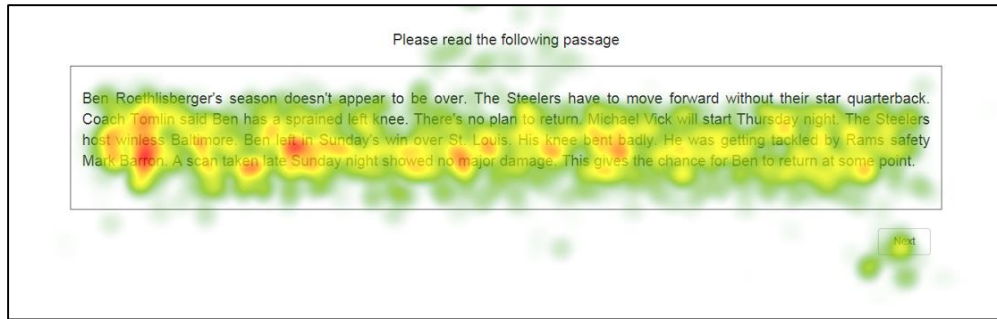
With the eye-tracking data, we found that participants spent less time reading the simplified versions of the passages overall. When answering questions, they spent more time with the simplified version for passage A and less time with the simplified version for passage B. However, when we normalized the total fixation durations for participants to account for the number of words in the passage, for both passage A and passage B, the simplified version had a higher rate of average total fixation duration per word. In fact, for passage B, the simplified and original versions had a statistically significant difference, with the simplified version taking more time on average. The fact that participants spent more time when reading the simplified passages combined with the performance and interview data indicates that the simplified passages were more engaging for the reader.

The average number of visit counts for the simple and original passages showed interesting results. For passage A, the simple and original versions of the passage both had similar averages. However, for passage B, the difference between the simple and original versions were statistically significant, with the simplified version having a higher average of visit counts. Again, this combined with other results indicate more engagement for the simplified version because the participants were willing to look back and forth between the text passage and the questions more often and performed better overall on answering the questions.

The normalized heat maps for the second version of the study show a notable difference between the simple and original version for passage B. The original version shows almost entirely green (Figure 25), and a small portion of yellow in the center of the text. However, the simplified version shows mostly yellow with spots of red within the middle of the text (Figure 26). This, along with the higher average fixation duration per word and better performance, indicates that the simplified version of the text was more engaging for the readers.



**FIGURE 25: V2 ORIGINAL PASSAGE B HEAT MAP**



**FIGURE 26: V2 SIMPLE PASSAGE B HEAT MAP**

### General Results

Overall, our results support the case for the simplification of text on web pages for generation Y users. Participants both performed better and preferred the simplified versions of text compared to the original versions. Also, we believe participants had a higher level of engagement with the simplified passages, given the higher total normalized fixation duration for the simplified versions of text. With participants both understanding and focusing more on the simplified versions of passages, this can bring increased business value to websites that provide text in a simplified way - creating more engagement and comprehension for potential customers.

### 4.2 Study 2 – Next Steps

While the full analysis of eye tracking data is beyond the scope of our MQP, more insight will be gained once more analysis is completed. Additionally, we will continue working with the UXDM lab as necessary after our MQP has concluded to increase the sample size for the experiment and ensure the successful completion of the second study.



## 5. Overall Discussion

### 5.1 Limitations and Future Steps

Although our project was overall deemed successful, it is important to note the shortcomings we experienced during the span of our work. As with any experiment, the result of our study is limited to the task and text passages. More experiments with different text and tasks could verify and extend our results. Additionally, future studies are needed to repeat our study for people with different types and levels of cognitive disabilities.

The continuation and succession of this project and our research is important for future refinement of plain language standards and making the web more accessible for those with cognitive disabilities. The data collected from this study will give us better insight into how participants with or without a disability are able to read and understand the text passages and, more specifically, where their focuses lies while reading each passage and answering the corresponding questions. We provided a set of text passages for our sponsor to use for future studies with people who have intellectual disabilities. While assisting our sponsor and advisor to analyze the results of the study for people with intellectual disability is beyond the scope of the present MQP, we believe that the work we completed can provide important insight for continuing this project. For example, the full analysis of eye tracking data that was collected by the MQP team can provide additional insight for the impact of text simplification on user behavior.

### 5.2 Contributions

#### 5.2.1 Theoretical

The theoretical contributions of our project will advance the justification for text simplification of web pages. The project developed a set of simplification rules that is easy to follow by content providers. Whenever the method is used, the simplification results in a similar quality of simplified text. Thus, our study will help to address the need for developing accessible content. Text simplification is a key aspect of accessibility, but there are many other attributes that go along with making the web accessible. Some examples include: color and contrast, graphical elements, timing, etc. Our study provides a step toward improving web experience and accessibility. We hope that this study will not only advance research in text simplification, but also helps identify eye tracking measures that can help in understanding the effect of text simplification on reader comprehension.

#### 5.2.2 Practical

The results of this study also produced important practical implications. Most notably, the project yielded a set of standard guidelines for a repeatable text simplification process. There are currently no step-by-step, quantified guidelines for text simplification, and these rules fill that void. These guidelines could allow web developers to more easily meet accessibility standards of plain language, and subsequently allow for their websites to reach a further audience. The results also provide concrete reasoning to simplify all websites during development. The simplified versions of the passages had, on average, better performance in questioning, was more preferred to read on the web, took readers less time, and was found to be more engaging than the original passage versions. These results provide justification for plain text simplification on the web. Furthermore, applying these processes would create more accessible, consistent, and easier to understand websites, where users can retain more information— invaluable qualities in web design.

## 6. Conclusion

The creation of an accessible internet for those with cognitive disabilities is a necessary task in the age of information and technology. The internet is a vast source of information for a majority of the modern world and it must adapt to the needs of any persons, both with and without a cognitive disability. The creation of an accessible internet has been made a more prevalent initiative following a series of lawsuits against companies and other organizations that did not make their web presence accessible, as well as the creation of guidelines by the World Wide Web Consortium (W3C). These efforts have helped pave the way toward creating an accessible internet for all.

Our project objective was to aid in the creation of an accessible internet through developing and testing a set of quantifiable plain language rules that can easily be followed by web designers. The results of our studies support the effectiveness of the set of rules that we operationalized. Our results showed that participants were able to more effectively grasp the concept of the passage when simplified with our set of rules. Participants were able to answer more questions correctly when referring to a simplified passage, as opposed to an original passage. In addition to analyzing performance, our team also analyzed the eye-tracking metrics for each participant. This eye-tracking data showed us that participants focused more on simplified passages, shown by the higher average total fixation duration per word, higher visit counts, and more intense heat maps for the simplified versions of text; which suggests a higher engagement with the simplified passages.

The results of our studies with students contribute to the case for the simplification of text on web pages, which will increase web accessibility for everyone. If simplified text improves performance and engagement for college students, it is likely to do the same for other populations as well, particularly those with limitations in reading. As research continues, our quantified rules can be utilized by website designers to develop more accessible user interfaces. The full examination of the impact of text simplification on universal design will require repeating our study for people with cognitive disabilities and/or reading limitations. While this research is beyond the scope of this current project, it is planned to be completed in the near future. The implications of increasing web accessibility go beyond the ability to read articles or text passages, but can also allow for learning and further social connections online. Overall, the simplification of text passages online using plain language standards has the potential to tremendously benefit the everyday lives of people both with and without cognitive disabilities.

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# Appendices

## Appendix A – Compiled Rules

Writing Process
1. Before you begin writing, get a clear idea of: <ol style="list-style-type: none"><li>-What you want to write</li><li>-Why you are writing it</li><li>-Who you are writing it for</li><li>-How you can write it clearly</li></ol>
2. Stick to the point - Write the main point of a section 1st and then have supporting details follow
3. Provide an overview of the main ideas portrayed in the text (Intro or Abstract)
4. Give summaries, introductions, or a Table of Contents for complex or lengthy content
5. Ensure that every word and paragraph is necessary - omits excess words / details to stay relevant to the point you are making
6. Use positive terms - do not write using negative tones to the reader
7. Use parallel sentence structure <b>Not Parallel:</b> Mary likes hiking, swimming, and to ride a bicycle. <b>Parallel:</b> Mary likes hiking, swimming, and riding a bicycle.
8. Give background knowledge / explanation for any technical terms that may be used - This applies when the idea cannot be construed any other way and the technical term must be used, it will allow the reader to comprehend that matter more easily
9. Avoid slang and cultural phrases (beat around the bush, baker's dozen, etc.) - they will not make sense out of context to the reader
10. Ask for feedback! <ol style="list-style-type: none"><li>Most people that struggle with literacy, regardless of how the document is written, will blame it on themselves.</li><li>Ask for constant and detailed feedback to target issue-causing areas so that they may be dealt with appropriately</li><li>Don't let them shy away or act intimidated by the fact they can't understand the text → Reassure them!!!</li></ol>

11. Avoid double negatives
12. Avoid acronyms and abbreviations - only use acronyms when they help convey the message and make things easier to comprehend
<b>Usage / Verbiage</b>
13. Use “must” to convey actions that need to be taken
14. Use the active voice when speaking - focus on the present and verb-based sentence structures (avoid “to be”)
15. Use consistent terminology - Reader or User, one or the other - not both
16. Use simple, “everyday” words
17. Constantly revise to avoid grammatical errors (spelling, punctuation)
18. Provide appropriate alternative text - context is everything!
<b>Design</b>
19. Words → No more than 3 syllables / word ... everyday terms!
20. Sentences → 20-25 words / sentence
21. Paragraphs → 4-5 sentences / paragraph ... No more than 6 lines to a section
22. Section / Chunk ideas for easier comprehension → 1 idea per section, include supporting details
23. Do not use ALL CAPS
24. Avoid italics entirely
25. Avoid serif-filled, decorative fonts - stick to Calibri, Arial, and other plain fonts
26. Use color and bolding to draw attention <b>only when necessary</b>
27. Avoid too long/short strings of text (see Usage / Verbiage)
28. Do not ‘justify’ text - it confuses reader and makes it look like newsprint
29. No horizontal scrolling
30. Ensure text readability - have the option to increase font sizes
31. Clear, distinct spacing between elements and sections of the page (MORE WHITE SPACE)



32. Use bullets, tables, and checklists to illustrate structure and flow within sections of text

33. Textboxes can help draw attention to important chunks of text - highlights the area well

## Appendix B – Final Compiled Rules

The rules we compiled into a final list are as follows:

1. Stick to the point; Avoid tangential, extraneous, or non-relevant information
2. Avoid slang and jargon; Be careful with colloquialisms, non-literal text, and jargon
3. Use familiar words and combinations of words; Uses “must” not shall (ambiguous)
4. Use active voice
5. Avoid weak verbs; Uses base verbs (not nominalizations); Keeping subject, verb, object close together
6. Use parallel sentence construction
7. Use positive terms
8. Avoid multiple negatives
9. Avoid acronyms and abbreviations if possible; explain all acronyms and abbreviations
10. Write short sentences
11. Ensure that every word and paragraph is necessary
12. Check Spelling
13. Use language that is as simple as is appropriate for the content
14. Provide summaries, introductions, or a table of contents for complex or lengthy content
15. Ensure text readability
16. No horizontal scrolling
17. Provide appropriate document structure
18. Written for average reader
19. Organized to serve reader’s needs
20. “You” and other pronouns to speak to reader
21. Simplest tense possible (best is simple present)
22. Place words carefully
23. No more than two to three subordinate levels

## Appendix C – Interview Questions

### Question One

On a scale from 1 to 7 (1 being very easy to read/understand, 7 being very harder to read/understand), rate the first passage you read.

### Question Two

On a scale from 1 to 7 (1 being very easy to read/understand, 7 being very harder to read/understand), rate the second passage you read.

### Question Three

Which passage would you prefer to read on the web?

### Question Four

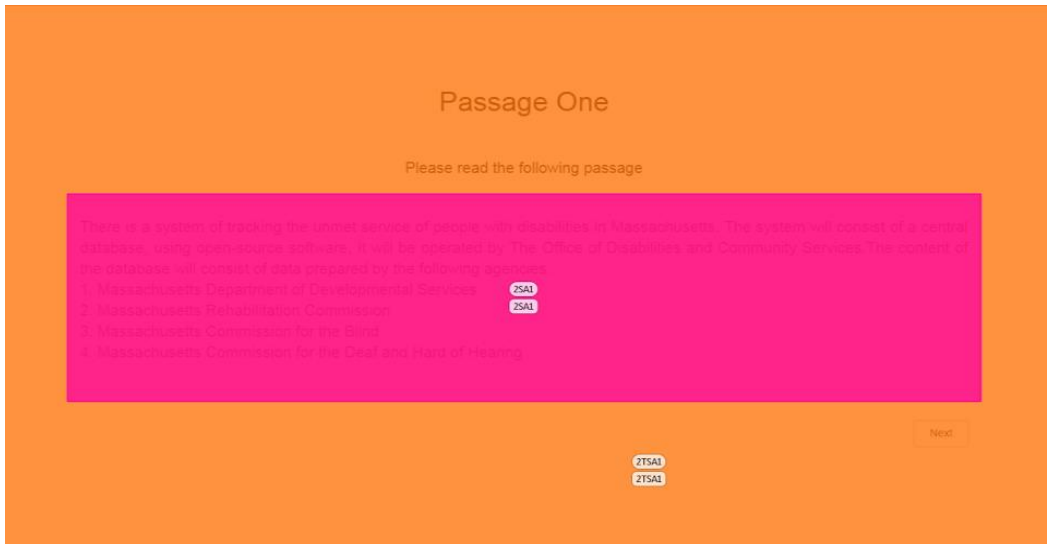
Not based on content, when given both the original and simple version of the first passage, which do you prefer?

### Question Five

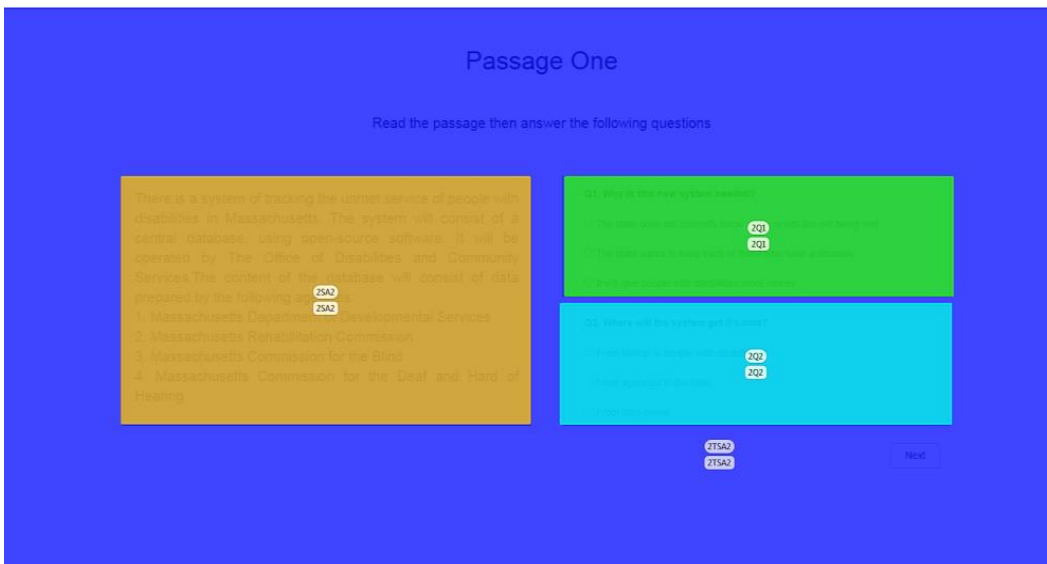
Not based on content, when given both the original and simple version of the second passage, which do you prefer?

## Appendix D – AOIs

Below are the examples of AOIs with their descriptions:



AOI for a screen with just a passage



AOI for a screen with a passage and questions

Below is a key for the AOI label abbreviations that were used when naming the AOIs

S = Simple

O = Original

T = Total

A = Legislature passage

B = Sports passage

Q1 = First legislature question

Q2 = Second legislature question

Q3 = First sports question

Q4 = Second sports question

SA1 = Text box of Simple passage A on page with only text

TSA1 = Entirety of page on page with Simple passage A with only text

SA2 = Text box of Simple passage A on page with text and questions

TSA2 = Entirety of page on page with Simple passage A with text and questions

OA1 = Text box of Original passage A on page with only text

TOA1 = Entirety of page on page with Original passage A with only text

Q1 = Text box of questions and answers for first question for passage A

Q2 = Text box of questions and answers for second question for passage A

SB1 = Text box of Simple passage B on page with only text

TSB1 = Entirety of page on page with Simple passage B with only text

SB2 = Text box of Simple passage B on page with text and questions

TSB2 = Entirety of page on page with Simple passage B with text and questions

OB1 = Text box of Original passage B on page with only text

TOB1 = Entirety of page on page with Original passage B with only text

Q3 = Text box of questions and answers for first question for passage B

Q4 = Text box of questions and answers for second question for passage B

## Appendix E – Relevant Articles

Below is the list of 38 articles we deemed relevant through our systematic literature review:

- Altmann, G., Kamide, Y. (November 7). The real-time mediation of visual attention by language and world knowledge: Linking anticipatory (and other) eye movements to linguistic processing. *Journal of Memory and Language* 57(4), 502-518.
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# Appendix F – MQP Poster Presentation

## Universal Design



ROBERT A. FOISIE  
SCHOOL OF BUSINESS

**Improving User Experience for People with Cognitive Disabilities**  
Abigail DaBoll-Lavoie (MIS), Tyler Greff (MIS), Jennifer Lally (MIS), Kayla McAvoy (MIS)  
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### Abstract

As the Internet grows and information becomes increasingly available online, the web needs to become accessible to everyone, including people with cognitive disabilities, who may not be able to fully or easily access all that the Internet offers. In order to address this issue, we worked alongside UMass Medical School to develop a set of easy to follow guidelines to simplify text passages using plain language standards. Utilizing eye tracking technologies we were able to measure the effectiveness and engagement of reading simplified text. Our project will aid the overall efforts of text simplification for web accessibility through our developed simplification process and supporting results.

### Background

The term accessible is defined as being able to “reached or approached”; “used or obtained”; or “easy to appreciate or understand.”<sup>1</sup> Based on this definition, accessible places or services must have the capability to be utilized by any user, including both persons with and without disabilities. The Internet is currently not accessible for those with cognitive disabilities, and it is therefore not surprising to see that those same individuals opt to not use the Internet, even though the Internet can present many benefits to all users. An important tool used for web accessibility efforts is Plain Language. This is an effective form of communication using basic word and sentence structures. Its purpose is to eliminate any confusion or obscurities between the author and reader.

1. Accessible. (2015). In Merriam-Webster online. Retrieved from <http://www.merriamwebster.com/dictionary/accessible>

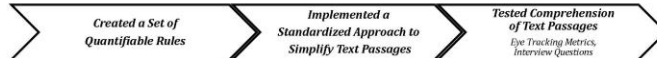
### Project Goals & Objectives

The objective of this project is to determine a set of plain language rules that can be used to simplify text passages consistently and to then test the effectiveness of these rules for reading comprehension. To do so, our objectives were as follows:

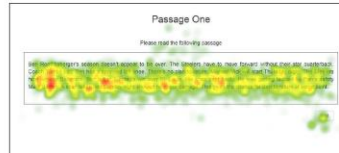
1. To research and finalize a list of quantifiable plain language rules to be used for simplification
2. To gather a wide set of text passages to simplify and test in various studies
3. To use eye tracking in order to gain more objective measures of reading comprehension

### Methodology

The operationalization of plain language standards is important for making the web accessible for all users, both with and without cognitive disabilities. Our research focused on both the operationalization of plain language standards, as well as data collection and analysis on the effectiveness of these rules.



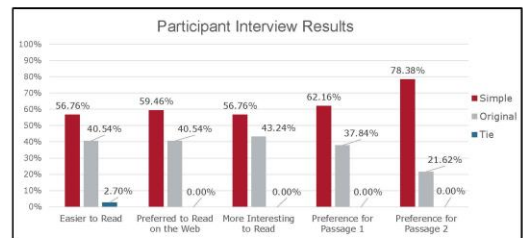
Study v2 Passage B Original



Study v2 Passage B Simple

### Results

For our study, we found that participants performed better on the simplified versions of passages than the original versions, with an almost statistically significant difference ( $p = 0.0543$ ). Participants also more often chose the simplified version of text as easier to read, more preferable to read on the web, more interesting to read, and, when shown both the original and simple version of the same text, chose the simple version.



Additionally, our data suggests that participants were more engaged while reading the simplified versions of text. The above heat maps show the simplified version as having a much higher intensity throughout the passage while the original version shows spots of mid to high intensity in the middle of the text. This suggests a higher engagement throughout the text passage, which is supported by the fact that we found a higher normalized fixation duration for simplified versions, as well as better performance by participants.

### Discussion

Overall, we found that participants had a higher engagement for the simplified versions of text. This indicates plain language can help both those with and without cognitive disabilities, and can be translated into business value for websites that utilize these standards. Our standards can also be used by website creators in the future for a more accessible Internet.

### Acknowledgements

We would like to take the time to thank those who contributed significantly to our project:

- John Rochford, *Project Sponsor*
- Professor Soussan Djamasbi, *Project Advisor*
- Mina Shojaeizadeh, *PHD Student*
- WPI User Experience and Decision Making Laboratory