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Improving Manual and Automated Text Simplification

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Improving Manual and Automated Text Simplification

Major Qualifying Project Submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

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Abstract

In an effort to make information more accessible, our team set out to refine and update a set of guidelines for clear writing and develop an initial paired text dataset to be used for improving automated text simplification. The simplification of text allows for more effective and efficient processing of textual content and the ability to automatically simplify text can make the web more accessible to everyone. Automated text simplifiers require a large dataset of paired text in order to be significantly useful. Our team partnered with IBM, UMass Boston, and UMass Medical School to create an initial dataset for automated text simplification using a refined set of operationalized guidelines for manual simplification and develop a methodology for expanding the dataset.

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Executive Summary

This Major Qualifying Project (MQP) set out to accomplish four main objectives:

1. Assess complexity of textual information based on guidelines introduced by a previous MQP
2. Simplify text passages from a set of actual websites through multiple simplification techniques (automated and manual)
3. Develop a database from the set of original and simplified text types generated in objective 2
4. Develop a methodology for collecting user evaluation of passages in the database and test the methodology via a user study

Assessing the complexity of textual information was important to understand why certain text can be hard to read and how to simplify text without losing content or the message behind the words. We modeled our guidelines based on a previous MQP “Universal Design, Improving User Experience for People with Cognitive Disability” (Daboll-Lavoie, Greff, Lally, & McAvoy, 2016). We also wanted to revise and add any new requirements that would be needed since the previous MQP paper was written.

We evaluated a set of government websites based on their requirement to be written in plain language due to new legal requirements introduced in 2010 (Siegel, 2010). Our team set out to procure passages from government websites based on differing domains from Benefits to Voting information. This was necessary as to test different subject matter text simplification. Once obtained, the sample passages would be simplified through multiple simplification techniques.

In order to assist in the development of automated text simplification, a database containing a large corpus of passages needed to be created containing original passages paired with multiple simplified versions of each passage. This dataset was necessary as to provide enough information for the automated systems to learn how to simplify text on their own. For this purpose, having user evaluation of text passages was an invaluable source of information. Our project was a first step toward building such a large and rich dataset. We collected a set of original text passages, simplified them via several different methods, and then developed a study to gather user evaluation of the original and simplified text passages.

I. Introduction

1.1 Text Simplification and Readability Measurements

Text Simplification generally stands for a process which modifies, improves, and ameliorates a readable text or paragraph in order to simplify the structure, and the grammar without changing the meaning and missing any important information (Siddharthan,2006). Text simplification applied to websites is important to allow greater accessibility to complex information. The internet is a popular resource that is accessed daily by people with varying levels of literacy and cognitive abilities. In this Major Qualifying Project (MQP), our team utilized automated text simplification and manual simplification to simplify text.

Automated text simplification involved the use of deep-learning tools from the International Business Machines Corporation (IBM) and the University of Massachusetts Boston (UMB). These tools simplify given text automatically.

Manual simplification involved our team simplifying the selected texts based on 22 Operationalized Plain Language Rules, found in Appendix A. These rules were gathered and selected from the latest plain language rules posting online and from last year's MQP "Universal Design, Improving User Experience for People with Cognitive Disability" (Daboll-Lavoie, Greff, Lally, & McAvoy, 2016), found in Appendix B. Each of the Operationalized Plain Language Rules have been proven by various articles to simplify text for better comprehension and readability.

II. Background

There are four main concepts our team considered and used to simplify text: The Plain Writing Act, readability measurements, Operationalized Plain Language Standards, and Revised Operationalized Plain Language Rules. The Plain Writing Act of 2010 is an act to make the language more simplified in all government websites. Readability measurements are used to quantify the reading level of a selected text. Operationalized Plain Language Standards were provided by UMass Medical Center from their current work in this field. Revised Operationalized Plain Language Rules were expanded and updated to measure and simplify the readability of a text manually (Appendix A, B, and C).

2.1 Plain Writing Act of 2010

President Obama signed the Plain Writing Act of 2010 on October 12, 2010. The law requires federal agencies to write “clean Government communication that the public can understand and use” (PlainLanguage.gov, n.d). It also requires the federal government to write all new publications, forms, and publicly distributed documents in a “clean, concise, well-organized” manner (PlainLanguage.gov, n.d).

2.2 Readability Measurements

The readability of text refers to how easy a piece of writing is to read and comprehend. This depends on a range of factors, including content, structure, style, layout, and design (Young, 2014). There are many tools that can be used to measure the readability of a selected text or website. The following sub-sections discuss several readability formulas and an online readability scoring system that are used in our project for readability measurement.

2.2.1 Dale-Chall

The Dale-Chall Readability Formula was inspired by Rudolf Flesch’s Flesch-Kincaid readability test. The creator of this formula are Edger Dale and Jeanne Chall, and they used a list of 763 words that 80% of fourth-grade students were familiar with, such as “no”, “yes”, and other basic words to determine which words were difficult. The formula was published in *A Formula for Predicting Readability* and improved and updated in *Readability Revisited: The New Dale-Chall Readability Formula* where the word list was expanded to 3,000 familiar words (Chall & Dale, 1995). The Dale-Chall readability score

can be calculated with the following formula (1), and the corresponding grade level is shown in Table 2.1:

$$\text{Dale-Chall Score} = 0.1579 \left(\frac{\# \text{ of difficult words}}{\text{total words}} * 100 \right) + 0.0496 \left(\frac{\text{total words}}{\text{total sentences}} \right) (1)$$

The difficult words refer to words that are not included in the 3,000 familiar word list. In addition, if the percentage of difficult words is above 5% in a passage, then add 3.6365 to the score to get the adjusted score. (Chall & Dale, 1995)

Dale-Chall Readability Score and Corresponding US Grade Level	
Readability Score	Meaning
4.9 or lower	Understood by an average 4th-grade student or lower
5.0 - 5.9	Understood by an average 5th or 6th-grade student
6.0 - 6.9	Understood by an average 7th or 8th-grade student
7.0 - 7.9	Understood by an average 9th or 10th-grade student
8.0 - 8.9	Understood by an average 11th or 12th-grade student
9.0 - 9.9	Understood by an average 13th to 15th-grade student

TABLE 2.1: ADAPTED FROM "A FORMULA FOR PREDICTING READABILITY" (DALE & CHALL, 1948)

2.2.2 Flesch-Kincaid

The Flesch-Kincaid readability test includes two tests, the Flesch Reading Ease and Flesch-Kincaid Grade Level. Contracted by the U.S. Navy in 1975, J. Peter Kincaid and his team developed the Flesch-Kincaid reading grade level (Kincaid, Fishburne Jr., Rogers, & Chissom, 1975). The Flesch Reading Ease score (FRES) can be calculated with the following formula (2), and the corresponding grade level is shown in Table 2.2. In the FRES, a higher score indicates that the passage is easier to read.

$$\text{The Flesch Reading Ease score} = 206.835 - 1.015 \left(\frac{\text{total words}}{\text{total sentences}} \right) - 84.6 \left(\frac{\text{total syllables}}{\text{total words}} \right) (2)$$

Flesch Reading Ease Score and Corresponding U.S. Grade Level		
Reading Ease Score	Grade Level	Meaning
90.0-100.0	5th grade	Very easy to read. Easily understood by an average 11-year-old student.
80.0-90.0	6th grade	Easy to read. Conversational English for consumers.
70.0-80.0	7th grade	Fairly easy to read.
60.0-70.0	8th & 9th grade	Plain English. Easily understood by 13 to 15-year-old students.
50.0-60.0	10th to 12th grade	Fairly difficult to read.
30.0-50.0	College	Difficult to read.
0.0-30.0	College graduate	Very difficult to read. Best understood by universities graduates.

TABLE 2.2: ADAPTED FROM "DERIVATION OF NEW READABILITY FORMULAS (AUTOMATED READABILITY INDEX, FOG COUNT, AND FLESCH READING EASE FORMULA) FOR NAVY ENLISTED PERSONNEL" (KINCAID, FISHBURNE JR., ROGERS, & CHISSOM, 1975)

The Flesch-Kincaid Grade Level is used to present scores as U.S. grade level, and the result corresponds with the specific U.S. grade level, which can be calculated by the following formula (3):

$$\text{Flesch-Kincaid Grade Level} = 0.39 \left(\frac{\text{total words}}{\text{total sentences}} \right) + 11.8 \left(\frac{\text{total syllables}}{\text{total words}} \right) - 15.59 \quad (3)$$

2.2.3 Gunning Fog Index

The Gunning Fog Index was created by Robert Gunning in 1952, and is considered to be one of the most popular readability formulas, and possibly the easiest to use (Impact Information Plain Language Services, 2004). The Fog Index corresponds to reading level by grade (shown in Table 2.3). In addition, the Gunning Fog Index is calculated with the following formula (4):

$$\text{Gunning Fog Index} = 0.4 \left[\left(\frac{\text{total words}}{\# \text{ of complete sentences}} \right) + 100 \left(\frac{\# \text{ of complex words}}{\text{total words}} \right) \right] \quad (4)$$

Complex words refer to words with more than two syllables, but proper nouns, familiar jargon, compound words, and words with common suffixes (e.g. –es, -ed, or –ing) are not included.

Gunning Fog Index and Corresponding U.S. Grade Level	
Fog Index	Reading level by grade
17	College graduate
16	College senior
15	College junior
14	College sophomore
13	College freshman
12	High school senior
11	High school junior
10	High school sophomore
9	High school freshman
8	Eighth grade
7	Seventh grade
6	Sixth grade

TABLE 2.3: ADAPTED FROM THE GUNNING'S FOG INDEX (OR FOG) READABILITY FORMULA ("IMPACT INFORMATION PLAIN LANGUAGE SERVICES", 2004)

2.2.4 SMOG

The SMOG Readability Formula was created by G. Harry McLaughlin in 1969 through the article, *SMOG Grading – A New Readability Formula in the Journal of Reading*. The SMOG Readability Formula estimates the years of education a person needs to understand a piece of writing. A SMOG grade can be calculated by the following formula (5):

$$\text{SMOG grade} = 1.0430 \sqrt{\text{number of polysyllables} * \frac{30}{\# \text{ of sentences}}} + 3.1291 \quad (5)$$

Polysyllables are referred to words of 3 or more syllables.

2.2.5 Lexile

The Lexile Framework is an approach to measuring reading ability and the text demand of reading materials. The Lexile Framework assesses both sides of reading development – the reader and the material being read. The Lexile Framework reports a Lexile reader measure and a Lexile text measure. The Lexile reader measure describes the reading ability of an individual, and the Lexile text measure describes the semantic and syntactic features of a book, article or text (MetaMetrics, n.d.).

2.2.6 Online Readability Scoring Systems

In order to measure the readability of selected texts, our team decided to utilize a scoring system to calculate different readability scores mentioned in previous sections. There are many online readability scoring systems available, and we selected an online system to assess the readability levels of our selected passages, which is Readable.io (<https://readable.io/>). The online scoring system provides the Gunning Fog Score, Flesch Reading Ease, Flesch-Kincaid Grade Level, New Dale-Chall Score, and SMOG Index Score of a given passage. The readability tool also performed a text quality analysis which measures text by the number of syllables contained in a word or sentence. With this tool, we were able to validate the readability levels of the selected passage by using the implemented readability measurement systems.

2.3 Revised Operationalized Plain Language Rules (R-OPLR)

Operationalized Plain Language Rules (OPLR) were first created by last year's Universal Design MQP team (Daboll-Lavoie et al., 2016). Their team came up with 23 Plain Language Rules in order to simplify text for people with cognitive disabilities. This year, our MQP team decided to expand the user base to everyone using the internet. The reasoning behind this was that if something can be made simpler, it could benefit everyone. With this new goal, the team researched the latest plain language websites to see if there were any rules needed to be created or removed. We ended up with 22 Revised Operationalized Plain Language Rules (R-OPLR). The final set of rules our team prepared can be found in Appendix A. These rules were used as a guideline to simplify text manually for the dataset that we developed in this project.

2.4 Operationalized Plain Language Standards (OPLS)

OPLR developed in the 2016 MQP was further refined to Operationalized Plain Language Standards (OPLS) by our UMass Medical School (UMMS) research partners to fit the need of people with an intellectual disability. In particular, the UMSS team developed a method for applying the OPLR rules in a way to lower the reading level (e.g., simplify 10th-grade reading level to 5th-grade reading level). OPLS contains 6 simplification steps as shown in Appendix C. These steps are defined in order of importance in order to simplify a text passage in a way to achieve a lower grade level more efficiently.

III. Methodology for Developing Dataset

Developing a dataset of passages was important in order for automated machine learning algorithms to learn how to simplify text more accurately. In order to create an initial dataset, we procured several government sites with varying domains. We then simplified the original passages using IBM's Content Clarifier (contentclarifier.mybluemix.net) and UMB's Simplifier (Chen et al. 2016). A manual simplification method based on our R-OPLR was produced in conjunction with the OPLS method developed by the UMass Medical team.

These original passages and simplified pairs were added to a database with corresponding readability measurements provided by Readable.io (<https://readable.io/>). The team used Readable.io to measure the readability of the passage versions created with Content Clarifier, Simplifier, OPLS, and R-OPLR. These readability scores of the simplified passage versions were compared to readability scores of the original version.

3.1 Procedure for Data Selection

The decision to procure our sample passages from government websites was due to the requirement of those sites to be written in plain language as a result of the Plain Writing Act of 2010 (Siegel, 2010). We selected text from varying domains in order to ensure a wide range of topics were analyzed for readability and comprehension.

Each page selected had its text copied from the beginning of the topic to the end. In situations where differing topics were provided on one page, only the text passage relating to the domain was selected. In order to keep a record of our original text sources, the team cataloged each site for future reference. For example, the disability.gov social security benefits website the team retrieved text from was no longer available at some point during the study. Therefore, a cached version of the page was acquired with the help of Wayback Machine. Once we procured our website text from 17 websites with six different domains, which is shown in Table 3.1, we separated the text into smaller passages for use in our study. Below is an example of the data we collected from the government websites:

Government Website Text Sources		
Domain	Name of Site	URL
Travel	State Department Alerts and Warnings	travel.state.gov/content/passports/en/alertswarnings.html
Travel	North Korea Travel Warning	travel.state.gov/content/passports/en/alertswarnings/north-korea-travel-warning.html
Travel	How to Apply for a Passport	travel.state.gov/content/passports/en/passports/apply.html
Travel	STEP Program Main Info Page	step.state.gov/step/
Employment	USAJOBS - Management Analyst Position	state.usajobs.gov/GetJob/ViewDetails/456041900/
Employment	Federal Government Employment	www.usa.gov/government-jobs
Benefits	Apply for Unemployment Benefits	www.usa.gov/unemployment
Benefits	Disability.gov SS Benefits Info	www.disability.gov/am-i-eligible-for-social-security-disability-benefits/
Benefits	Saving for Retirement	www.usa.gov/retirement
Benefits	Getting Health Insurance for Individuals and Families in Massachusetts	blog.mass.gov/blog/health/getting-health-insurance-for-individuals-and-families-in-massachusetts/
Voting	Voter ID Requirements	www.usa.gov/election-day
Voting	How to Vote - Georgia	georgia.gov/popular-topic/voting-georgia

Voting	Voting Process - Massachusetts	www.sec.state.ma.us/ele/ele/evotingprocess/votingprocessidx.htm
Public Health	Senior Nutrition Program Overview	www.mass.gov/elders/meals-nutrition/elderly-nutrition-program-overview.html
News	US Labor Department, Amazon to establish registered apprenticeship program to train veterans for technical careers	www.dol.gov/newsroom/releases/eta/eta20170119-0
News	New Analysis: Uninsured rate for Americans with pre-existing conditions dropped sharply when major Affordable Care Act reforms were first implemented	www.hhs.gov/about/news/2017/01/05/new-analysis-uninsured-rate-americans-pre-existing-conditions-dropped-sharply-when-major-affordable
News	EDA Investment Highlights Green Innovation as Good Business	www.commerce.gov/news/blog/2016/12/eda-investment-highlights-green-innovation-good-business

TABLE 3.1: GOVERNMENT WEBSITE TEXT SOURCES

The screenshot shows the website for the Executive Office of Elder Affairs. The main navigation menu includes: Housing, Health Care, Home Care, Meals & Nutrition (selected), Caregiver Support, Service Organizations, Regulations & Statistics, and Employment & Civic Engagement. The breadcrumb trail is: Home > Meals & Nutrition > Senior Nutrition Program Overview.

Senior Nutrition Program Overview

The Executive Office of Elder Affairs Senior Nutrition Program is the largest community nutrition services program for older Americans administered by the Administration on Aging of the United States Department of Health and Human Service, through Title III-C of the Older American Act (OAA). It is the second largest program operated by the Commonwealth's Executive Office of Elder Affairs. Twenty-seven nutrition programs located throughout the state serve over eight and a half million meals to seniors each year. Meals are provided at more than 400 congregate meal sites and are delivered to frail elders in their homes. More than half of the total meals are served to homebound elders.

Nutrition Services help to address a number of problems faced by many elders, including poor diets, health problems, food insecurity, and loneliness. Key nutrition services include nourishing meals, as well as nutrition screening, assessment, education, and counseling, to ensure that older people achieve and maintain optimal nutritional status.

A major goal of the Elder Affairs Nutrition project is to provide at least one nutritionally balanced meal per day to seniors either at a congregate meal site or through home-delivered meals. People age 60 or older and their spouses are eligible to receive nutrition services. A voluntary donation is requested.

An additional goal of the Elder Affairs Nutrition Services is to assist older persons in maintaining independence so that they may continue to reside in their own homes for as long as possible.

In addition to the important dietary and social needs met by nutrition services, nutrition sites are encouraged to provide supportive services if needed and not otherwise available to participants. Such services may include information and referral, transportation, health screening, and recreation.

What is the Senior Nutrition Program?

The Elderly Nutrition Program is a federal and state funded nutrition program, administered by the Executive Office of Elder Affairs, which allows local elderly agencies to provide nutritious meals to senior citizens.

What does the Senior Nutrition Program Provide?

Meals are provided at congregate meal sites and through home-delivered meals to senior citizens (age 60 or older) and handicapped or disabled people under age 60 who live in housing facilities occupied primarily by the elderly where congregate meals are served.

Each meal contains at least 1/3 of the current daily Recommended Dietary Allowance of nutrients and considers the special dietary needs of the elderly. In addition to providing meals, the Elderly Nutrition Program also provides access to social and rehabilitative services.

What is the Congregate Meals Program?

The congregate meal program provides at least one meal per day at senior centers, churches, schools, and other locations. The congregate setting provides opportunities for socialization and companionship. It also offers programs related to nutrition education, exercise activities, health promotion and disease prevention. Some programs also offer meals on weekends. Transportation is often available for those who have trouble getting around on their own.

FIGURE 3.1: SENIOR NUTRITION PROGRAM OVERVIEW (WEBSITE)

The red box illustrates the text collected from the Senior Nutrition Program Overview website. The smaller black boxes show the passages created from the website. In this case, 9 passages were created from a website within the public health domain.

3.2 Automated Text Simplification Tools

In order to simplify the selected texts, our team used two automated text simplification tools: UMB Simplifier and IBM Content Clarifier. Both tools simplify text by applying

Artificial Intelligence technology and Machine Learning concepts.

3.2.1 UMB Simplifier

The UMB Simplifier is an automatic text simplifier which was developed to translate sentences into simpler forms automatically. It aims to reduce the lexical and structural complexity without changing or losing any important information by performing lexical and syntactic simplification. Splitting, dropping, reordering, and substitution are important processes in this simplifier (Chen et al. 2016).

3.2.2 IBM Content Clarifier

IBM Content Clarifier is a Cognitive Computing effort to perform content simplification, summarization, and enhancement. Content Clarifier is a callable API that builds upon IBM Watson's deep learning APIs to include a service that dynamically simplifies, summarizes or enhances content to increase comprehension (Content Clarifier, n.d.). There are three modes of output in Content Clarifier: Simplified, Condensed, and Ultra-Mode. Simplified mode uses lexical and grammatical manipulation to improve comprehension. Our team applied text simplification in the Content Clarifier Simplified mode. The complex words are replaced by simple and common words in the simplified version.

3.3 Manual Text Simplification Tool

3.3.1 Revised Operationalized Plain Language Rules (R-OPLR) and Operationalized Plain Language Standards (OPLS)

The team simplified the selected text manually by applying first Operationalized Plain Language Standards (OPLS) and then our Revised Operationalized Plain Language Rules (R-OPLR). In order to reduce the grade level and make the text easier to read, the complex words were replaced by more common used synonyms with less than 4 syllables. After that, the team tried to break the long sentences that contained more than 30 syllables into two or three sentences or bullet points when possible. The passive voice was also avoided. After the simplification, the average grade level went down for certain amounts.

IV. Methodology for Evaluating Dataset

After developing a dataset consisting of four versions of the same text, our team created a methodology for an online study to collect user reactions to the readability of these text passages. The four versions of text in the dataset are Original, IBM Simplified, UMB Simplified and Human/ R-OPLR Simplified.

4.1 Parts of the Online Study

Each participant will be given three survey parts to complete. In Part One, a participant will be asked to read four passages and answer three questions related to the readability of each passage. Each passage was randomly selected based on its unique ID and its version (Original, IBM Simplified, UMB Simplified, and Human/R-OPLR Simplified). Thus, each participant will see four different passages and four different versions. For example, if the first passage is original version of passage A, the second will be one of the three simplified versions of passage B. The third passage will be one of the two remaining simplified versions of passage C and last passage will be the remaining simplified version of passage D. A sample of Part One is shown below.

Passage One

Please read the following passage

This position is eligible for telework; additional requirements will be required(e.g., board approval). This position is also being announced through Merit Promotion procedures under Announcement# Isn-2017-0004. Candidates who wish to be considered under both Public(Us Citizens) and Merit Promotion procedures must apply to both reports.

Q1. I could understand this passage the first time I read it.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Q2. This passage was easy to read.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Q3. The passage was written clearly.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Next

FIGURE 4.1: EXAMPLE OF PASSAGE ONE (UMB SIMPLIFIED TEXT)

Passage Two

Please read the following passage

The EDA investment supports the accelerator. It proves that recycling carbon fiber composite scrap makes good environmental sense. Carbon fiber composite scrap makes good business sense.

Q1. I could understand this passage the first time I read it.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Q2. This passage was easy to read.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Q3. The passage was written clearly.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Next

FIGURE 4.2: EXAMPLE OF PASSAGE TWO (R-OPLR SIMPLIFIED TEXT)

Passage Three

Please read the following passage

Qualifying specialized experience must demonstrate the following:

- Experience developing and implementing policies, methods or procedures to improve strategic work for planning and integrated learning system.
- Experience providing advice, guidance, and career counseling to employees.
- Experience providing data in preparation of program and budget goals.

There is no substitute of education for specialized experience for the GS-14 position.

Q1. I could understand this passage the first time I read it.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Q2. This passage was easy to read.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Q3. The passage was written clearly.

- Strongly Disagree
- Disagree
- Neither agree not disagree
- Agree
- Strongly Agree

Next

FIGURE 4.3: EXAMPLE OF PASSAGE THREE (ORIGINAL TEXT)

Passage Four

Please read the following passage

Unemployment benefit programs pay money to workers who:

- Become fired through no fault of their own.
- Meet sure eligibility requirements as determined under state law.

Q1. I could understand this passage the first time I read it.

- Strongly Disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly Agree

Q2. This passage was easy to read.

- Strongly Disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly Agree

Q3. The passage was written clearly.

- Strongly Disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly Agree

Next

FIGURE 4.4: EXAMPLE OF PASSAGE FOUR (IBM SIMPLIFIED TEXT)

Participants will then complete a Part Two. They will be shown each possible version of the four passages they just evaluated. They will be subsequently asked to rate four versions of four texts they read in the Part One in corresponding order. The rating criterion will be listed as easiest, moderated, less hard, and hardest. Below is a sample of Part Two.

Compare Passage One

Please read the following passages

<p>Text 1:</p> <p>This position is eligible for telework; additional requirements will be required(e.g., board approval). This position is also being announced through Merit Promotion procedures under Announcement# Isn-2017-0004. Candidates who wish to be considered under both Public(Us Citizens) and Merit Promotion procedures must apply to both reports.</p>
<p>Text 2:</p> <p>This position is eligible for telework; additional criteria will be required (e.g., supervisory approval).</p> <p>This position is also being announced through Merit Promotion procedures under Announcement #ISN-2017-0004. Candidates who wish to be considered under both Public (US Citizens)and Merit Promotion procedures must apply to both announcements.</p>
<p>Text 3:</p> <p>This position is eligible for telework; additional criteria will be required (e.g., supervisory approval).</p> <p>This position is announced through Merit Promotion procedures under Announcement #ISN-2017-0004. Applicants who wish to be considered under both Public (US Citizens) and Merit Promotion procedures must apply to both announcements.</p>
<p>Text 4:</p> <p>This job is legal for telework; additional criteria will be required (e.g., superior approval).</p> <p>This job is also being announced through Merit Promotion procedures under Statement #ISN -2017 -0004. Candidates who bid to be considered under both Public (US Citizens) and Merit Promotion procedures must apply to both announcements.</p>

Readability Easiness	Texts
Easiest	Text 2
Moderate	Text 3
Less Hard	Text 4
Hardest	Select Text

Next

FIGURE 4.5: AN EXAMPLE OF THE FIRST PAGE OF PART TWO. PASSAGE ONE'S OTHER VERSIONS ARE PUT ON THE SAME PAGE FOR USERS TO COMPARE THE DIFFERENT VERSIONS.

Part Three required participants to complete a demographic survey (e.g., information about age and education level as the last part of the online study).

Demographics Questions

Q1. Please enter your age.

Q2. Are you a student?
 Yes
 No

Q3. What is the highest degree or level of school you have completed? If currently enrolled, highest degree received.
 Some High School, no diploma
 High School Graduate/ GED
 Associate's Degree
 Bachelor's Degree (currently pursuing)
 Bachelor's Degree
 Master's Degree
 Doctorate Degree
 Other

Q4. Is english your native language?
 Yes
 No

Next

FIGURE 4.6: AN EXAMPLE OF THE LAST PAGE

Demographics Questions

Q1. Please enter your age.

Q2. Are you a student?
 Yes
 No

Q3. What is the highest degree or level of school you have completed? If currently enrolled, highest degree received.
 Some High School, no diploma
 High School Graduate/ GED
 Associate's Degree
 Bachelor's Degree (currently pursuing)
 Bachelor's Degree
 Master's Degree
 Doctorate Degree
 Other

Q4. Is english your native language?
 Yes
 No

If not, What is your native language?

Next

FIGURE 4.7: AN EXAMPLE OF THE LAST PAGE WHEN THE USER SELECTS "NO" FOR QUESTION 4.

4.2 Preliminary Study to Test Methodology

Our team recruited 40 participants in total to conduct a preliminary study. In the preliminary study, each participant was given four passages to read, and they answered questions pertaining to readability for each passage in Part One. There were four versions of passages tested, which consisted of Original, IBM Simplified, UMB Simplified, and R-OPLR Simplified passage versions. Each participant read a passage version at random, with the text number also selected randomly.

In order to randomly select the four passages for each participant, the team wrote a python script that generated 40 discrete numbers for every ten participants. These 40 numbers represented the passage indexes from our *Text* database. Each team member used the python script to generate 40 random passage index numbers, and selected four index numbers from the random number list to look up for corresponding passages in our *Text* database.

In Part One, each participant was shown one version of a passage every time, and was asked three questions related to the readability and comprehension of the passage (questions are shown in Section 4.1). In Part Two, each participant was shown the same passage from Part One with all possible passage versions next to it. They were then asked to rank the passage versions based on ease of reading (the question is shown in Section 4.1). In Part 3, the participants were asked demographic questions.

Our team gathered 40 participants' answers and demographic information, and analyzed the data. The data analysis results will be discussed in Section 5.1 and Section 6.1.

V. Results

Our team created a dataset of 103 original text passages. For each original passage, three different simplified versions were created (two were automatically created using IBM and UMB tools and one was created manually using R-OPLR). Each text passage includes an entry for readability measurements determined by Readable.io.

The data in our dataset are stored in two databases: *Text* database and *Text Analysis* database. The *Text* database contains the original version of the selected texts and different simplified versions that were generated. For each selected text passage, there are four versions of text included in the database: Original, IBM, UMB, R-OPLR, which were generated by utilizing the two automated text simplification tools and applying R-OPLR simplification rules with the help of OPLS. The information in the *Text* database was used for the preliminary study.

The *Text Analysis* database contains readability information of each text version. Our team used online readability scoring system to measure and collect readability information. The readability information includes:

- Flesch-Kincaid Grade Level
- Gunning-Fog Score
- SMOG Index
- New Dale-Chall Score
- Number of sentences that contain more than 30 syllables
- Number of sentences that contain more than 20 syllables
- Number of words that contain more than 4 syllables
- Number of words that contain more than 13 letters
- Passive voice count
- Adverb count

Besides the readability information collected from the online scoring system, we recorded the average readability grade level for each text version in the database as provided by the online readability tool.

5.1 Preliminary Study Results

Our team analyzed the results of the preliminary study. As mentioned in section 4.1, each participant answered three questions after reading a text passage and each question had five options in Part One. To analyze the data provided by participants, our team counted how many times a particular answer was selected by participants for each question. Our team performed the analysis for each text version. For example, Table

5.1 shows the number of participants who chose a particular option in each question for original texts. Tables for other text versions can be found below:

Original	First Read Comprehension	Ease of Reading	Clarity of Writing
Strongly Disagree	0	2	1
Disagree	4	2	4
Neither Agree or Disagree	12	6	8
Agree	21	23	22
Strongly Agree	5	9	7

TABLE 5.1: NUMBER OF SELECTIONS FOR READING QUESTIONS (ORIGINAL)

IBM	First Read Comprehension	Ease of Reading	Clarity of Writing
Strongly Disagree	3	3	2
Disagree	7	10	10
Neither Agree or Disagree	19	13	16
Agree	6	8	10
Strongly Agree	4	5	1

TABLE 5.2: NUMBER OF SELECTIONS FOR READING QUESTIONS (IBM)

UMB	First Read Comprehension	Ease of Reading	Clarity of Writing
Strongly Disagree	4	3	4
Disagree	11	10	5
Neither Agree or Disagree	17	14	18
Agree	5	7	8
Strongly Agree	2	5	4

TABLE 5.3: NUMBER OF SELECTIONS FOR READING QUESTIONS(UMB)

R-OPLR	First Read Comprehension	Ease of Reading	Clarity of Writing
Strongly Disagree	1	0	0
Disagree	4	1	0
Neither Agree or Disagree	6	5	6
Agree	18	18	25
Strongly Agree	11	15	9

TABLE 5.4: NUMBER OF SELECTIONS FOR READING QUESTIONS (R-OPLR)

As shown in Figure 4.5, which is the Part Two of our study, participants were then asked to rank all four versions for each text passages they had seen in the Part One of our study. The team also compiled some statistics to build following tables. Each table represented the counts for each version of the text classified by ranking number. “Rank No.” stated the readability easiness from easiest to hardest. In other words, Rank No. 1 indicated that a specific text was easiest one to read and Rank No. 4 indicated that a specific text was hardest one to read. For example, Table 5.5 indicated that original text versions had been rated by participants as the easiest one to read for 63 times among all four versions.

Rank No. 1	Count
Original	63
IBM	1
UMB	0
R-OPLR	96

TABLE 5.5: NUMBER OF A TEXT VERSIONS RANKED NO.1

Rank No. 2	Count
Original	86
IBM	5
UMB	10
R-OPLR	59

TABLE 5.6: NUMBER OF A TEXT VERSIONS RANKED NO.2

Rank No. 3	Count
Original	10
IBM	74
UMB	73
R-OPLR	3

TABLE 5.8: NUMBER OF A TEXT VERSIONS RANKED NO.3

Rank No. 4	Count
Original	1
IBM	80
UMB	77
R-OPLR	2

TABLE 5.9: NUMBER OF A TEXT VERSIONS RANKED NO.4

We then graphed overall responses by text version to see how our participants felt about the passage version in terms of Comprehension of First Read (CoFR), Ease of Reading (EoR), and Clarity of the Text (CoT). As EoR was one of the biggest factors for our project, a trend line was created to highlight the differences in the evaluations. The trend line in the graph serves to show how overall respondent perception was in agreement or disagreement to the EoR for each text version. After graphing the survey data, our team started to see different trends occurring based on the text version evaluated.

The original version of the texts (shown below in Figure 6.1) showed a positive trend towards agreement in the CoFR, EoR, and CoT. The EoR trend line had a positive slope, indicating an agreement towards the text being easy to read.

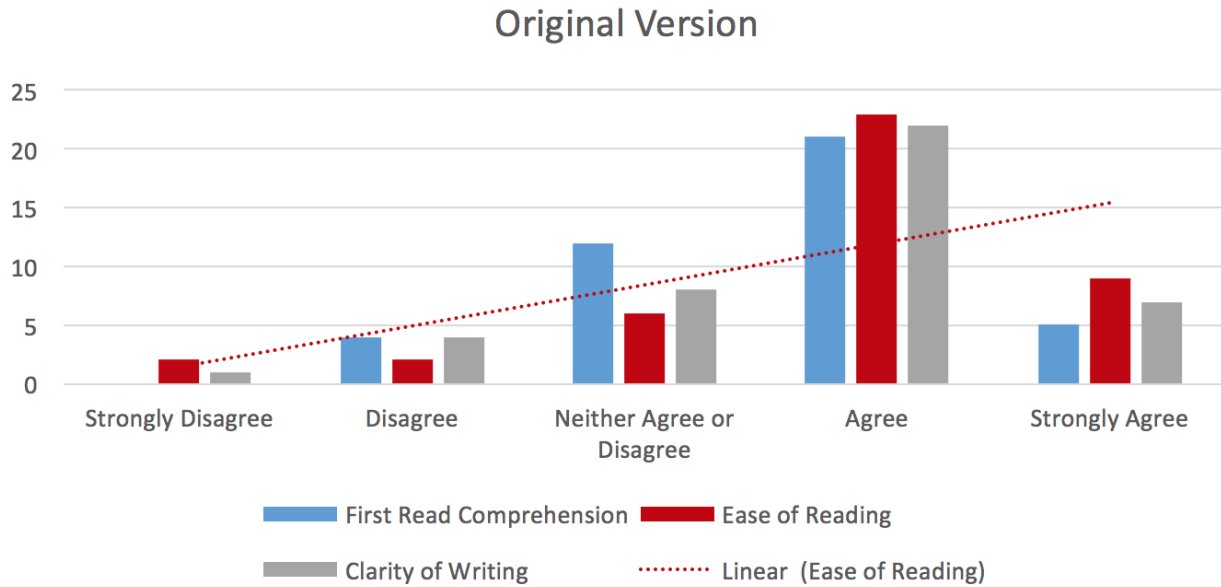


FIGURE 6.1: ORIGINAL VERSION TEXT CHART

The R-OPLR version of the texts (shown below in Figure 6.2) had shown an even greater positive trend in agreement in the CoFR, EoR, and CoT. An increase in EoR was clearly visible with the positive slope of the trend line. This led our team to believe that respondents mostly agreed that R-OPLR was easy to read.

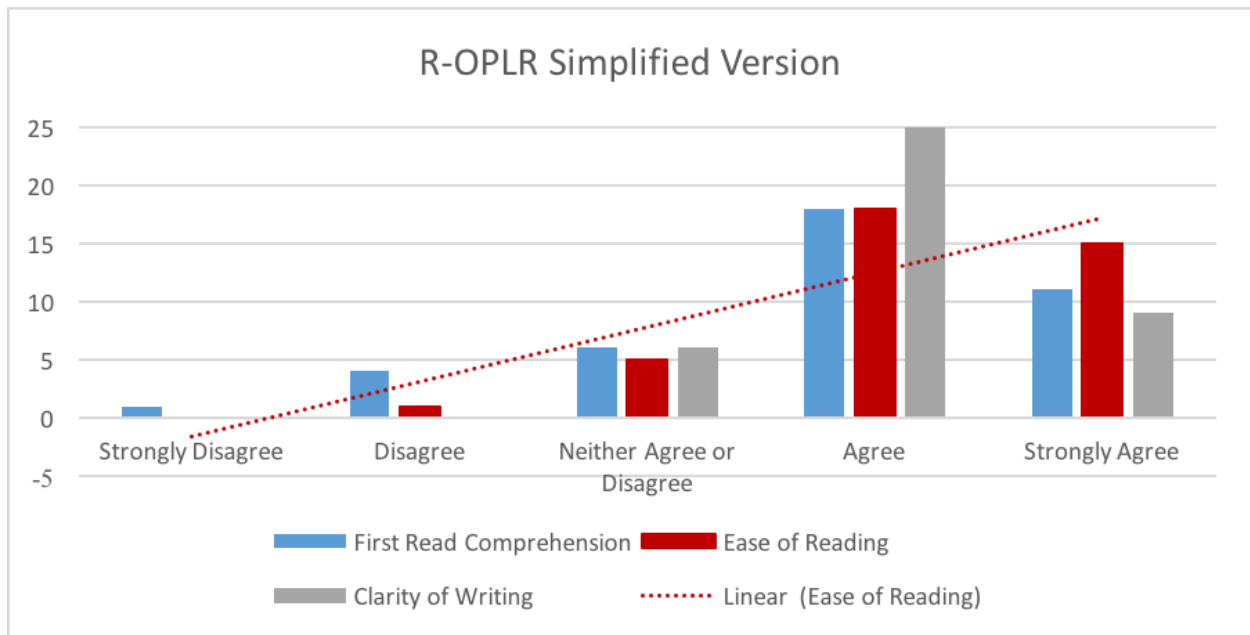


FIGURE 6.2: R-OPLR SIMPLIFIED VERSION TEXT CHART

Interestingly, both the IBM and UMB automated simplifications (shown below in Figure 6.3 and Figure 6.4) had shown a mixed response with no greater agreement or disagreement to the CoFR, EoR, and CoT. The EoR trend line shows a near flat slope, indicating an uncertainty in agreement or disagreement over the readability of the texts. This led our team to believe that although the texts were not interpreted as hard to read, the texts were not shown to be as easy to read.

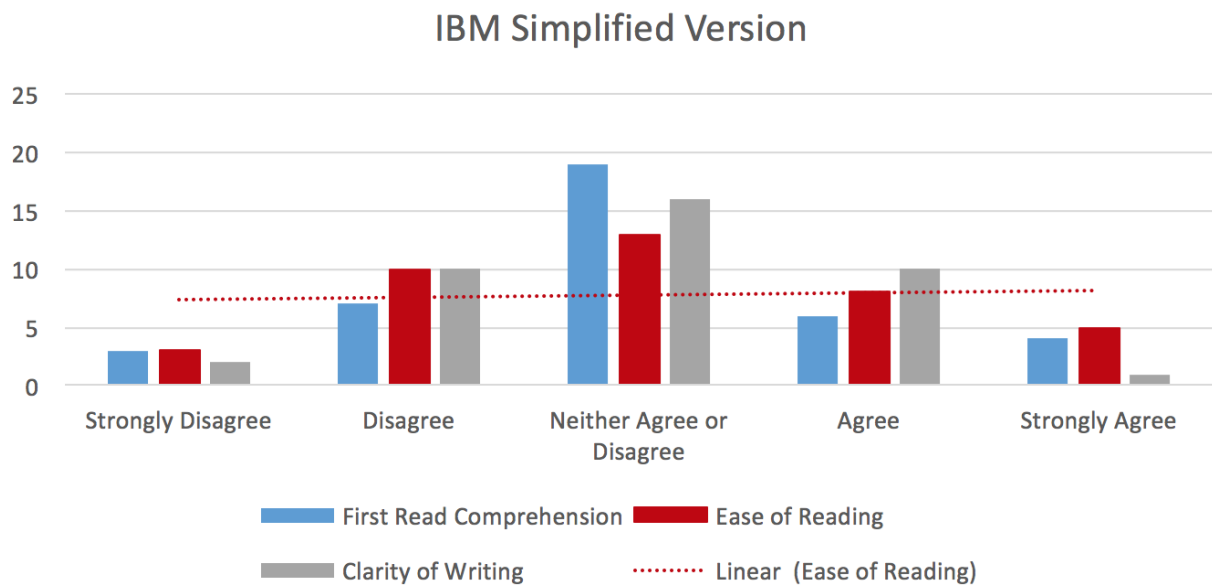


FIGURE 6.3: IBM SIMPLIFIED VERSION TEXT CHART

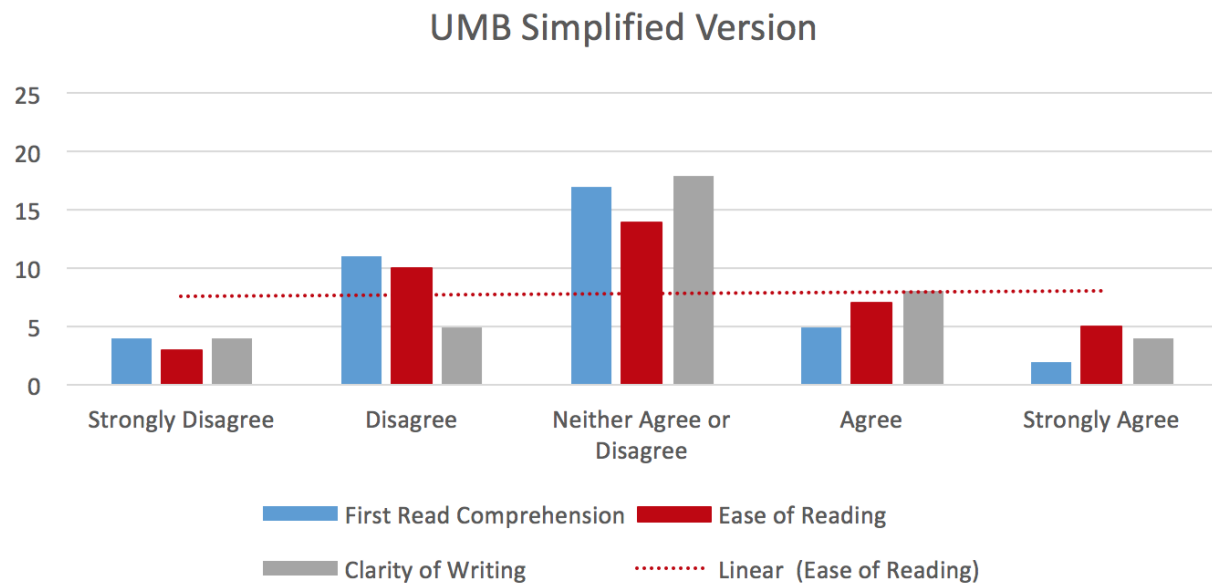


FIGURE 6.4: UMB SIMPLIFIED VERSION TEXT CHART

The team then graphed the rankings of text versions shown as part of the passage comparison section in which each evaluated text version was shown next to all permutations (Original, R-OPLR, IBM, UMB) of the text. In order to score the assigned rankings, we assigned quality points based on how each text version was ranked by a respondent. Text deemed the “Easiest” to read (Rank No.1) received 4 quality points per ranking, “Moderate” received 3 quality points per ranking, “Less Hard” received 2 quality points per ranking, and “Hardest” to read received 1 quality point. Tables 6.1-6.4 below show the quality points that were used to create a visualization of the rankings.

Rank No. 1 “Easiest”	Count	Quality Points (x4)
Original	63	252
IBM	1	4
UMB	0	0
R-OPLR	96	384

TABLE 6.1: “EASIEST” QUALITY RANKING TABLE

Rank No. 2 “Moderate”	Count	Quality Points (x3)
Original	86	258
IBM	5	15
UMB	10	30
R-OPLR	59	177

TABLE 6.2: “MODERATE” QUALITY RANKING TABLE

Rank No. 3 “Less Hard”	Count	Quality Points (x2)
Original	10	20
IBM	74	148
UMB	73	146
R-OPLR	3	6

TABLE 6.3: “LESS HARD” QUALITY RANKING TABLE

Rank No. 4 “Hardest”	Count	Quality Points (x1)
Original	1	1
IBM	80	80
UMB	77	77
R-OPLR	2	2

TABLE 6.4: “HARDEST” QUALITY RANKING TABLE

Based on the respondent rankings and quality points assigned, we were able to visually see how each text version had fared in terms of ease to read (Shown below in Figure 6.5 and 6.6). R-OPLR scored the highest with 569 quality points, with the original text close behind with 531 quality points. Both the UMB and IBM versions scored lower based on respondent rankings with scores of 247 and 253 respectively. Similarly, Figure 6.6 shows that R-OPLR was considered easiest by most participants and the automated versions were considered hardest to read. This data corresponds to the trends shown in Part One with R-OPLR performing slightly better than original with the automated versions not fairing as well.

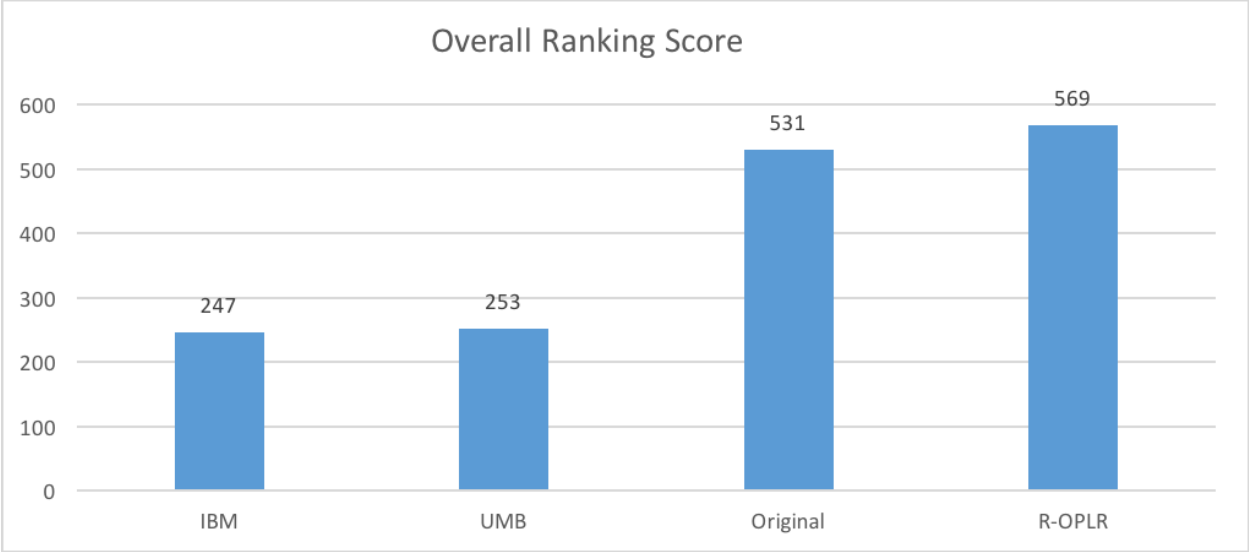


FIGURE 6.5: OVERALL RANKING SCORE CHART

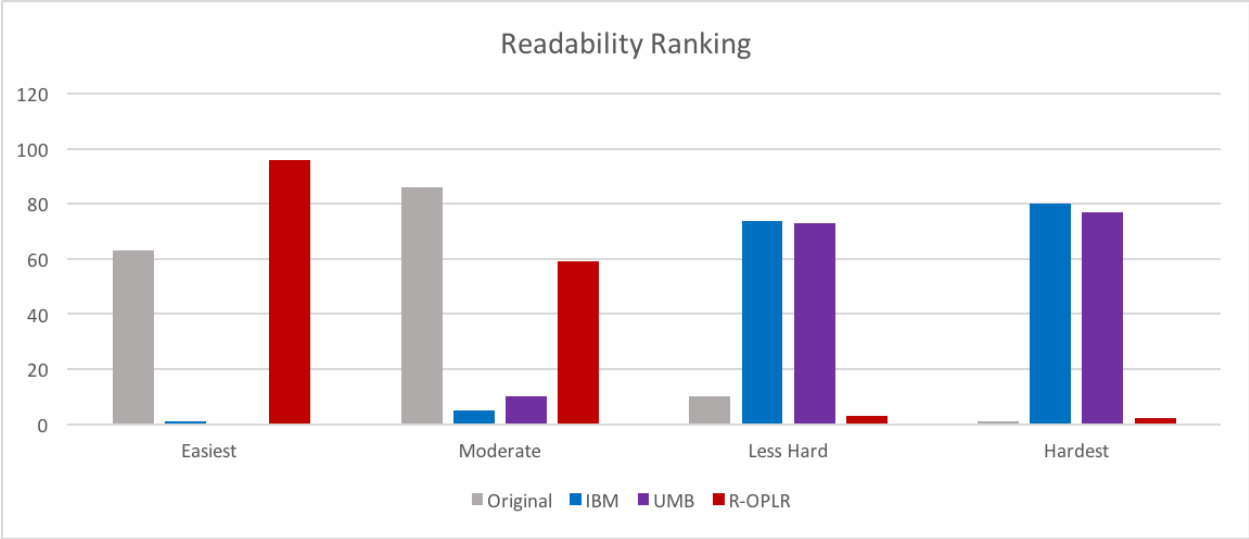


FIGURE 6.6: READABILITY RANKING CHART

As part of our study (Part Three), our team collected demographic information from our survey respondents. Based on the responses, most respondents are 18-23 years old, students who age from 18 to 23 and currently pursue Bachelor Degree. Around half of the respondents are native English speaker and rest of them speak Turkish, Chinese, or Spanish. Following figures represented the data that collected in the study.

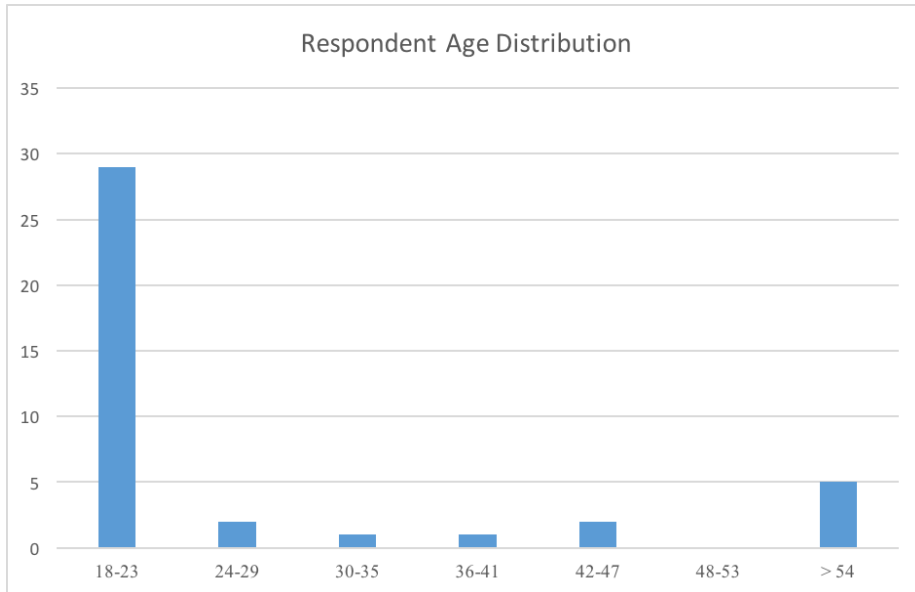


FIGURE 6.7: RESPONDENT AGE DISTRIBUTION

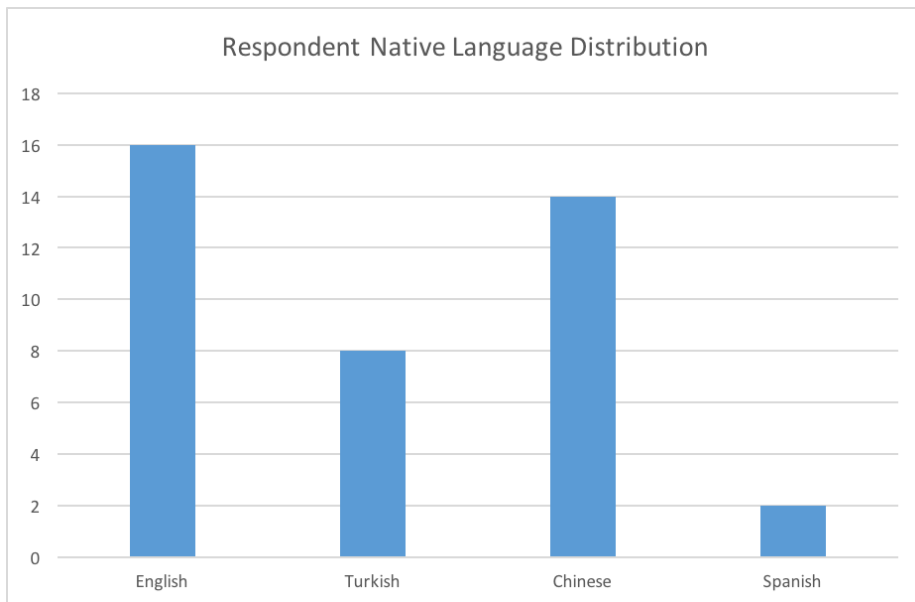


FIGURE 6.8: RESPONDENT NATIVE LANGUAGE DISTRIBUTION

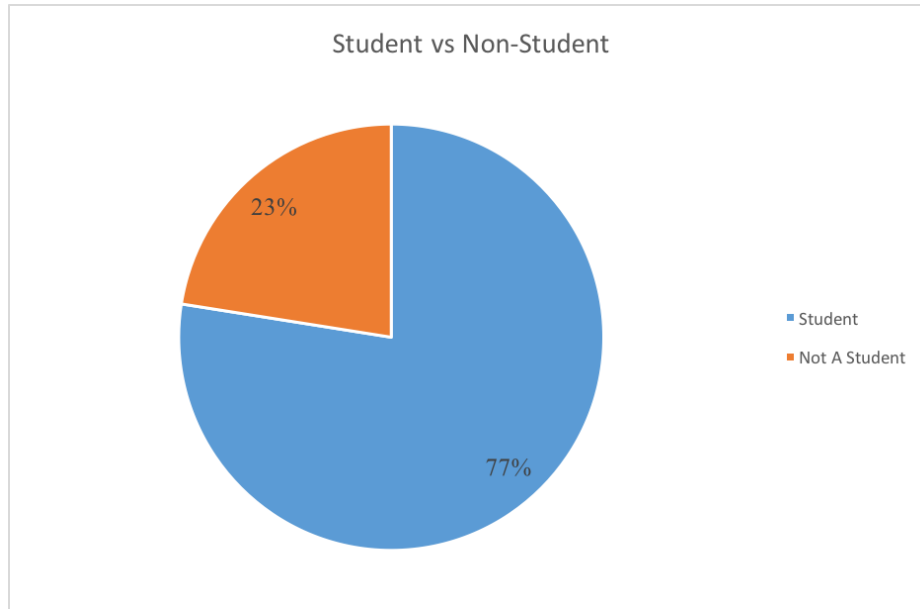


FIGURE 6.9: STUDENT VS. NON-STUDENT

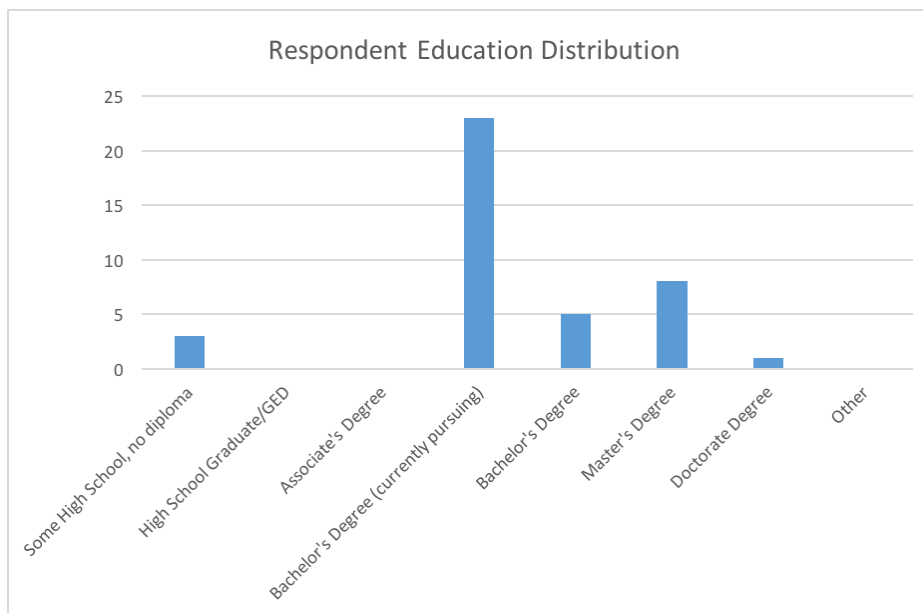


FIGURE 6.10: RESPONDENT EDUCATION DISTRIBUTION

VI. Discussion

The main purpose of the study was to test our methodology for large data collection. Our results show that our methodology can accurately measure the responses of users. We purposely designed the experiment in a way to cover as much as possible evaluation for the text passages in the dataset. A total 160 text passages (4 different versions of 40 text passages) were evaluated by 40 participants. Hence, care must be taken when interpreting these results. For example, the responses displayed in Figure 6.1-6.4 refer to different text passages. Because content can impact readability care must be taken when looking at these results and their trends. The results displayed in Figure 6.5 and 6.6 show how the various versions of each passage were ranked. These figures show that manually simplified text was ranked as easiest to read. The automatically simplified text, however, was ranked the hardest to read. These results together suggest that the dataset generated in our project would be useful for machine learning algorithms to learn from. The more “easy to read” data is provided for a machine learning system, the better the system can simplify the text. Again, we need to emphasize that the purpose of the project was not to compare the readability of the different versions of the text, rather provide various versions of the same text with different levels of readability to develop a rich paired text dataset. Our preliminary analysis shows that we were able to do so.

6.1 Limitations and Future Steps

Through the project, our team was able to create a database for selected texts and different simplified versions of each text passage. However, there were certain limitations in the project. First, all the text passages were selected from the government website, and some content was related to legal terms and specific government programs or departments. Original texts that contain reserved government names and program information still had a high grade reading level after performing simplification. Second, the readability evaluations in our study came from a small number of participants. We need much larger pools of participants to determine the overall readability of the text passages. Additionally, most participants were recruited from Worcester Polytechnic Institute (WPI). To generalize the results we need to collect information from different populations.

For future steps of our project, researchers could utilize our methodology to expand the text database and to provide a richer dataset for future deep learning applications of automated text simplification. Also, the R-OPLR and OPLS rules reported in the Appendices could be used to simplify texts manually. These rules also serve as a suitable guideline to write text in plain language.

VII. Contributions

The Internet is a major resource of information in our everyday life. Everybody uses it to find information no matter the age, gender, education level, etc. Therefore, the creation of simple texts can benefit everybody. Simplified text shortens the time to comprehend a text and makes it easier to find information. Our team contributed to the text simplification project by updating last year's OPLR/OPLS rules and by creating an initial paired text passage dataset (400 text passages). We also developed and tested a methodology to collect user evaluation of readability of text passages in our dataset.

VIII. Conclusion

Our MQP was a research collaboration between IBM, UMASS Boston (UMB), and UMASS Medical School (UMMS). IBM and UMB were the experts in machine learning, in particular, automatic text simplification. UMass and WPI worked on manual text simplification. A major objective of our MQP was to develop an initial database of various versions of the same text generated through manual and automatic text simplification, and their reading level scores via the online readability tool (Readable.io). This dataset which will be populated with more data over the years will be used to improve automatic text simplification in the future. We also developed a methodology to collect user evaluation of readability of text passages in the dataset and tested our methodology with 40 participants. This research project required us to learn about leading-edge machine learning tools for automatic text simplification and rules for manual text implication. Also, it provided an outstanding interdisciplinary learning experience integrating various knowledge generated by various research organizations (WPI/MIS, UMMS/ Index Program, UMB/Data Science, IBM Watson/Accessibility Group).

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IX. Appendices

9.1 Appendix A - Revised Operationalized Plain Language Rules (R-OPLR)

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" v.s. "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 as much as possible (avoid "don't" or "didn't")
9. Avoid multiple negatives ("don't forget to not...")
10. Explain all acronyms/abbreviations, 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)
 - a. Pointing Words: This, that, these, those, and the
 - b. Echo Links: Words or phrases that echo a previously mentioned idea
 - c. 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
20. Avoid contraction (Use "Do not" instead of "Don't"; Use "I will" instead of "I'll")
21. Illustrations (pictures, tables, anything that helps reader to understand better)
22. Reserve 50% for white space of each page

9.2 Appendix B - Operationalized Plain Language Rules (OPLR)

The rules below were created by last years MQP Team in “Universal Design, Improving User Experience for People with Cognitive Disability” paper (Daboll-Lavoie et al., 2016).

1. Stick to the point; Avoid slang, jargon, colloquialisms, non-literal text tangential, extraneous, or non-literal text, and jargon
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

9.3 Appendix C - Operationalized Plain Language Standards (OPLS) for People with Intellectual Disability, John Rochford, UMASS Medical School

Goal: Reduce reading level to one easily understandable by a target population, e.g, of lower-secondary education level, or of 5th-grade reading level.

Procedures:

- Apply rules in order. (The numbering of the rules signifies the order in which they are implemented.)
- After each rule is applied, check reading level of text with the tool <http://www.webpagefx.com/tools/read-able/>.
- If the reading level is:
 - at target or lower, stop applying rules.
 - higher than target, apply the next rule.
 - higher than it was when the previous rule was applied, do not apply the rule, and move to the next rule.

Current Set

1. Rule 1: Use short, simple words.
 - a. Replace 3+ syllable words with ones that have 1 or 2 syllables, and that are commonly used.
 - b. To identify complex words and simpler, common alternatives, use a tool such as: Thesaurus.com (Check "Common" checkbox.)
findcomplexword.mybluemix.net (created by Fei Wu).
2. Rule 2: Write short sentences. Be succinct.
 - a. 10 words or fewer should be the average sentence length.
 - b. Divide long sentences into shorter sentences without losing information or changing meaning.
3. Rule 3: Avoid using acronyms and abbreviations.
 - a. The first time an acronym or an abbreviation is used, state the whole term completely, followed by the acronym or the abbreviation in parentheses. For subsequent instances, use the acronym or the abbreviation alone.
 - b. Example: "United States (U.S.)"
 - c. If readers should be familiar with an acronym or an abbreviation, especially if they are likely to be unfamiliar with the spelled-out version, use it instead of the spelled-out version
 - d. Example: "MRI" instead of "Magnetic Resonance Imaging"
4. Rule 4: Use an active voice in the present tense
 - a. Do not implement if new information is introduced.
 - b. Example: If the actor/subject of a passive-voice sentence is unknown, don't create an active-voice sentence with the new information of a

guessed actor/subject.

5. Rule 5: Use correct grammar and spelling.
 - a. Use an automated grammar and spelling checker, such as the one built into Microsoft Word.
6. Rule 6: Remove proper nouns (a name for a person, place, or entity, and spelled with initial capital letters, e.g., Larry, Mexico, Boston Red Sox).
 - a. After the proper nouns are removed, test the reading level of the text without them.
 - b. If the reading level is lower, reinsert the proper nouns, but use the reading level achieved without them.