Exploring Web Simplification for People with Cognitive Disabilities

Jeffrey Arthur Hoehl
University of Colorado at Boulder, jeffery.hoehl@colorado.edu

Follow this and additional works at: https://scholar.colorado.edu/csci_gradetds
Part of the Cognitive Psychology Commons, and the Computer Sciences Commons

Recommended Citation
https://scholar.colorado.edu/csci_gradetds/113

This Dissertation is brought to you for free and open access by Computer Science at CU Scholar. It has been accepted for inclusion in Computer Science Graduate Theses & Dissertations by an authorized administrator of CU Scholar. For more information, please contact cuscholaradmin@colorado.edu.
Exploring Web Simplification for People with Cognitive Disabilities

by

Jeffery Arthur Hoehl

B.A., University of Colorado, 2003
B.S., University of Colorado, 2003
M.S., University of Colorado, 2011

A thesis submitted to the
Faculty of the Graduate School of the
University of Colorado in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
Department of Computer Science
2016
This thesis entitled:
Exploring Web Simplification for People with Cognitive Disabilities
written by Jeffery Arthur Hoehl
has been approved for the Department of Computer Science

______________________________
Clayton Lewis

______________________________
David Braddock

______________________________
Leysia Palen

______________________________
Tom Yeh

______________________________
Shea Tanis

______________________________
Antranig Basman

Date _________________

The final copy of this thesis has been examined by the signatories, and we find that both the content and the form meet acceptable presentation standards of scholarly work in the above mentioned discipline.

IRB protocol #14-0269
Hoehl, Jeffery Arthur (Ph.D., Computer Science)

Exploring Web Simplification for People with Cognitive Disabilities

Thesis directed by Professor Clayton Lewis

The web has become more than a supplementary information resource but a valuable and pervasive tool for nearly all aspects of daily life including social and community participation, health promotion, creative pursuits, education, and employment opportunity. However, the web is not yet easily accessible to all people, particularly those with cognitive disabilities who encounter many challenges with access and use of the web including limited accessibility of online content and difficulty with content comprehension. Furthermore, little is documented about how individuals with cognitive disabilities who currently use the web are overcoming or being inhibited by these challenges. Much of what is documented is anecdotal or generalized as broad technical guidance rather than providing methods to empower individual end users. This research explores which websites people with cognitive disabilities use and do not use and what challenges and successes they encounter with those websites. We developed the SimpleWebAnywhere tool to address the above research needs and serve as a technology probe to determine how content simplification affects web use by people with cognitive disabilities. We explored personalizable content transformation techniques, including advertisement removal, content extraction, and text to speech, to make webpages easier to use and comprehend. We found that many people with cognitive disabilities frequently access the web for long periods of time despite popular opinion to the contrary. Web access is preferred via mobile platforms, such as smartphones and tablet computers. Users had a strong preference for entertainment content largely comprised of images, videos, and games but did not necessarily have difficulty using or understanding long, complex textual content. An intercommunity approach of combining existing open source software to provide personalized content manipulations was found to be an effective method to improve web accessibility for people with cognitive disabilities.
Dedication

To the inspirational individuals, family members, teachers, caregivers, and researchers who have welcomed me into the disability community and provided me with their insight, encouragement, and compassion all these years.

To my family and friends for their unwavering support.
Acknowledgements

My graduate school experience has provided me with the opportunity to meet many amazing people that have truly influenced my life for the better. I have been incredibly fortunate to work with my committee members and especially my advisor, Clayton Lewis, who has been an incredible guide on my journeys both figurative and literal. He has been an inspirational lighthouse as a teacher, a researcher, a thinker, a tinkerer, and as a warm, genuine person. I have the deepest gratitude for his support and wisdom over all these years. Leysia Palen has been a complement to my own personality in ways that I never knew I could learn so much from. She has always been there to provide thoughtful perspectives from novel angles and continually provided me with opportunities to grow and succeed throughout my academic career. I am also profoundly grateful to have worked with Shea Tanis who has shaped my perspectives and grown my awareness towards people with disabilities. I have been able to walk my path as a direct result of her trailblazing. I am thankful to David Braddock for his advisement and encouragement throughout the years. His stories and advice provided consistent motivation and inspiration. I am grateful to Antranig Basman for his technical guidance, thoroughness, and engaging conversation. Tom Yeh has always been able to provide insightful and analytical thought and helped to develop my ideas and work further with each iteration.

This work would not have been possible without the support of Bill and Claudia Coleman. I am grateful for their generosity, inspiration, and leadership throughout the years and their continued advocacy and involvement in the cognitive disability community. I have learned deeply from them as well as everyone at the Coleman Institute for Cognitive Disabilities who have helped support me
including Rick Hemp, Joy Wu, Laura Haffer, and Jennifer Kraft. Notably, it has been a privilege to learn from and work with Enid Ablowitz across our many roles at the institute.

It has been an honor to work with so many amazing colleagues include Jim Sullivan and Redhwan Nour who have helped me learn about this work and the communities involved. I am incredibly lucky to have met so many great students through Human-Centered Computing and Computer Science at the University of Colorado Boulder. I am grateful for the conversations, friendship, and support from them all including Ashok Basawapatna, Holger Meyers, Jane Meyers, Ben Leduc-Mills, Jason Zietz, Kyuhan Koh, Chris Schaefbauer, Kate Starbird, Halley Profita, Sophia Liu, Neeti Wagle, Lise St Denis, Jennings Anderson, Jeeun Kim, Mario Barrenechea, Marina Kogan, Melissa Bica, and Ovo Dibie. Particularly, Swamy Ananthanarayan for his inexhaustible motivation, advice, and centeredness.

The staff in the Computer Science Department have been truly terrific throughout the process and for all their help and dedication I would like to thank Jackie DeBoard, Stephanie Morris, and Rajshree Shrestha.

I am deeply appreciative of my friends and family that have supported and encouraged me throughout the entirety of this journey. E.J. Masicampo and Melissa Masicampo who have provided inspiration and strong examples to follow. David Truong, Minh Huynh, Kristen Goff, Heidi Zoellner, and Julie Morikawa for their constant friendship. Napoleon Ta and Christina Nguyen for their unwavering motivation and especially their additional encouragement near the end. My parents, Thomas Hoehl and Bok Ye Hoehl, my sister, Kim Klotz, and brothers, Jon Hoehl and Tim Hoehl, for motivating, encouraging, and supporting me not only throughout this journey but all those that came before and all those that will come after.
Contents

Chapter

1 Introduction 1

2 Definitions 6
   2.1 Intellectual Disabilities ................................................. 6
   2.2 Developmental Disabilities ............................................. 7
   2.3 Cognitive Disabilities .................................................. 8

3 Related Work 10
   3.1 Web Accessibility and Standards ...................................... 10
   3.2 Approaches to Web Accessibility ....................................... 12
      3.2.1 Technically Focused ................................................ 12
      3.2.2 Information Consumption Focused ................................. 12
      3.2.3 Information Contribution Focused ................................. 13
      3.2.4 Community Focused .................................................. 13
      3.2.5 Towards an Intercommunity Approach to Web Accessibility .... 13
      3.2.6 Historical Trends .................................................... 14
   3.3 Survey of Technology and Accessibility Issues ....................... 15
      3.3.1 Significant Economic Impact ...................................... 15
      3.3.2 Family and Caregivers as Decision Makers ...................... 16
      3.3.3 Offline Social Networks are Small ............................... 16
3.3.4 Universal Design Does Not Benefit All Users ........................................... 17
3.3.5 Small Market Demand ................................................................. 17

3.4 Survey of Guiding Principles ................................................................. 18
3.4.1 Aspirations are High ................................................................. 18
3.4.2 Functional Ability is High ............................................................. 19
3.4.3 Interdependence is Beneficial ......................................................... 19
3.4.4 Information and Communication Technologies Provide Great Opportunities . 19
3.4.5 The Rights of People with Cognitive Disabilities to Technology and
    Information Access ................................................................. 20

3.5 Cloud-Based Technology Tools .............................................................. 22
3.5.1 Advertisement Filtering ................................................................. 23
3.5.2 Content Extraction ................................................................. 24
3.5.3 Text Simplification and Summarization .............................................. 25
3.5.4 Assistive Technology in the Cloud ..................................................... 26

4 System Design .................................................................................. 28
4.1 System Architecture ........................................................................... 28
4.1.1 WebAnywhere ........................................................................... 29
4.1.2 SimpleWebAnywhere ................................................................. 30

4.2 Prototypes ...................................................................................... 32
4.2.1 Mobile Web on the Desktop ......................................................... 33
4.2.2 Iterating the Mobile Web on the Desktop Experience ......................... 36
4.2.3 SimpleWebAnywhere with Content Extraction and Simplification ........ 41

5 Evaluation ..................................................................................... 45
5.1 Recruitment .................................................................................... 45
5.2 Setting ............................................................................................. 48
5.3 Procedure ..................................................................................... 50
B  Participant Background Questionnaire  100

C  Semi-structured Interview Prompts for Interview 1  105

D  Usability Survey for SimpleWebAnywhere  106

E  Semi-structured Interview Prompts for Interviews 2 & 3  107
Table

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>List of Emulated Devices and Corresponding User Agent Strings Supported by SimpleWebAnywhere</td>
<td>35</td>
</tr>
<tr>
<td>5.1</td>
<td>Participant Demographics</td>
<td>47</td>
</tr>
</tbody>
</table>
Figures

Figure

1.1 Influence of Online Dating On How Couples Met ............................... 2
1.2 Prevalence of Cognitive Disability in the U.S. ................................. 4
3.1 Rights of People with Cognitive Disabilities to Technology and Information Access . 21
3.2 Newspaper Article Screenshot ....................................................... 23
3.3 Newspaper Article Screenshot With Advertisements Removed .................. 23
3.4 Newspaper Article Screenshot With Content Extracted Via Instapaper .......... 25
3.5 Newspaper Article Screenshot With Content Extracted Via Readability .......... 25
4.1 WebAnywhere System Design ......................................................... 29
4.2 SimpleWebAnywhere System Design ................................................. 31
4.3 A comparison of a desktop-oriented website to its equivalent mobile alternative ... 34
4.4 An early prototype of SimpleWebAnywhere that allows mobile web viewing on a
desktop browser. ............................................................................. 36
4.5 Comparison of mobile website widths on usability. ................................ 38
4.6 A revised prototype of SimpleWebAnywhere that allows mobile web viewing on a
desktop browser. ............................................................................. 39
4.7 A SimpleWebAnywhere prototype providing mobile content to the desktop. .... 40
4.8 The final SimpleWebAnywhere prototype with simplification enabled. ........ 42
4.9 The final SimpleWebAnywhere prototype with simplification disabled. ......... 43
5.1 Participant image search for “cats”. ................................. 67
5.2 Participant image search for “lamborghini”................................. 68
5.3 SimpleWebAnywhere without simplification displaying an “Al Jazeera” news article. 73
5.4 SimpleWebAnywhere with simplification displaying an “Al Jazeera” news article. . 74
5.5 SimpleWebAnywhere displaying a simplified version of the Google homepage. . . 74
5.6 Screenshot of the Wikipedia page listing “X-Men” characters. ...................... 76
5.7 Screenshot of a Barilla recipe website. ........................................ 77
5.8 Screenshot of a website showing trucks with low contrast text labels below images. . 78
5.9 Screenshot of SimpleWebAnywhere showing trucks with high contrast text labels
   below images. ................................................................. 78
Chapter 1

Introduction

The number of internet users has steadily risen over the past decade and continues to do so both in the United States and worldwide with an estimated 46.4% of the world’s population using the internet at the end of 2015 [40, 46, 52]. The Pew Research Center estimated that 87% of American adults were internet users in January 2014 [55]. The internet has become a critical component of our information gathering tools and over time has become more than just a resource for news and encyclopedic information. Increasingly, it has become a key resource for the important and sensitive aspects of our lives including social and community participation, personal healthcare, creative pursuits, employment opportunity, education, and financial management [10, 43, 67].

Socially, users are not simply exchanging information, such as pictures and updates, about their friends, families, and colleagues online but are using social networking tools to significantly supplement their offline, face-to-face relationships [43]. The Pew Research Center estimates that 73% of online adults use at least one social network while 42% use multiple social networks [54]. Not only are more users active on social networks, but they are using them more frequently. For instance, 63% of Facebook users check the site daily with 40% of users checking multiple times per day [54].

Dating highlights the impact of online tools even further. Not only are online dating sites being used to supplement offline interactions like social networks are, they are increasingly removing traditional alternatives as options altogether (Figure 1.1). This is particularly true of niche populations that exist in “thin markets” [51, 62]. The percentage of same-sex couples meeting online, for example, shows it as the predominantly favored method compared to heterosexual couples.
Other aspects of our daily lives are also becoming increasingly digitally managed. In 2013, 72% of internet users said they used the internet to gather health information primarily on “specific diseases or conditions; treatments or procedures; and doctors or other health professionals” for themselves and on behalf of others [53]. Self-diagnosis has also become a significant online activity with 35% of U.S. adults turning to the web to diagnose themselves or someone else. Of those, 35% did not follow-up with a clinician to get a professional opinion [28]. During the same year, 61% of internet users used online banking, up from 18% in 2000 [27]. In other words, critical and sensitive services that have traditionally been handled in-person by professionals are now routinely and frequently addressed initially or entirely online.

The web has become a core component of how we participate and contribute as active members to our society. However, there are worrying trends indicating that many people are not participating in these cultural changes to their full potential and aspirations, and are not benefiting equally from the prevalence of information and communication technology (ICT) available to others. Specifically, people with disabilities are part of a significant digital divide limiting their access to and participation in online activities. In 2011, only 54% of U.S. adults living with a disability reported using the internet compared to 81% of adults that reported not having any
form of disability [26]. This is a significant proportion of users given that 54 million people have a disability in the United States alone and over one billion people have some form of disability worldwide (roughly 15% of the world population) [77, 86]. Furthermore, “[r]ates of disability are increasing due to population ageing and increases in chronic health conditions, among other causes” [86]. Not only are people with disabilities part of the digital divide, but the number of people being left behind is growing [79].

The growing divide between internet users and non-users is lamentable since internet information access has clearly transitioned from being a convenient alternative to information access, to being a commonly used method (as in the case of healthcare) of access, to becoming the predominant method and displacing traditional methods (as in the case of thin market dating). The web also provides greater educational and employment opportunities which can substantially benefit people with cognitive disabilities in particular.

Cognitive disabilities include “intellectual and developmental disabilities; autism spectrum disorders; severe, persistent mental illness; brain injury; stroke; Alzheimer’s disease; and other dementias” [10]. It is estimated that 29.86 million people in the United States and over 630 million people worldwide have some form of cognitive disability, comprising over 60% of people with disabilities worldwide (Figure 1.2) [12].

People with cognitive disabilities are at lower rates of internet use due to many factors ranging from lack of access economically to poor accessibility of websites. People with cognitive disabilities are often some of the poorest in the country and have difficulty affording internet access [75, 84]. Furthermore, websites can often be difficult to use and navigate even if internet access is available. These issues do not simply create an inconvenience to users with cognitive disabilities, but rather create strong barriers to use that result in a negative spiral of digital literacy rates even when compared to those with sensory, motor, physical or other disabilities. This is in part due to people with non-cognitive disabilities and their advocates promoting the benefits and adoption of technology and information access for their constituencies more effectively than people with cognitive disabilities and their advocates. As a result, the unique needs of ICT for people
with cognitive disabilities have not been addressed or investigated as much as the needs of those with other disabilities. Furthermore, little is documented about how individuals with cognitive disabilities who currently use the web are overcoming or being inhibited by these challenges. Much of what is documented is anecdotal or communicated as impractical technical advice for content producers, and often does little to effectively empower individual end users or make progressive strides for cognitive accessibility improvement in impactful ways.

Figure 1.2: Prevalence of Cognitive Disability in the United States, 2015 [12].

Although the web accessibility community has acknowledged some of these concerns, it has done so using traditional methodologies with a strong intra-community focus. In other words, many of the suggestions for improving web accessibility for people with cognitive disabilities are the same as for physical and sensory disabilities and involve similar ideas, techniques, and practices. Pursu-
ing a focus that borrows strongly from communities outside of the mainline web accessibility field has the potential to provide significant impacts. Many web tools, such as cloud-based services and browser extensions, which do not directly address accessibility issues, have targeted very similar challenges and have potential to benefit people with cognitive disabilities as well as the web accessibility community at large. However, these tools are often overlooked, ignored, and underutilized simply because they did not originate from within the accessibility or disability communities.

This research examines cognitive web accessibility by exploring how people with cognitive disabilities use and do not use the internet and what challenges and successes they encounter in the process. We test the SimpleWebAnywhere system as a technology probe [38] and by using meta-design concepts [25] to evaluate how using cloud-based simplification software affects users’ experience of websites and determine what tools and techniques they would prefer to use and find helpful.
Chapter 2

Definitions

In this thesis we often reference “intellectual disabilities,” “developmental disabilities,” and “cognitive disabilities.” Though these three terms sound similar and are often used interchangeably with each other in common parlance, organizations and practitioners in these fields generally separate them as outlined below. It should be noted that no pure consensus exists and these terms have complex and evolving relationships with each other. In many ways their definitions overlap and are constantly changing with time as our culture and collective experiences adapt. Importantly, people with disabilities all have unique backgrounds and often fit into multiple classification categories.

2.1 Intellectual Disabilities

Intellectual disabilities (a.k.a. intellectual developmental disorder) are defined by the American Psychiatric Association in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) as a set of impairments that affects a person’s intellectual functioning and adaptive behavior [4]. Intellectual disabilities are a subset of neurodevelopmental disorders and are diagnosed via formal clinical assessment and a standardized intelligence test. The American Association on Intellectual and Developmental Disabilities (AAIDD) summarizes the diagnosis [3]:

The evaluation and classification intellectual disability is a complex issue. There are three major criteria for intellectual disability: significant limitations in intellectual functioning, significant limitations in adaptive behavior, and onset before the age of 18.

The IQ test is a major tool in measuring intellectual functioning, which is the mental capacity for learning, reasoning, problem solving, and so on. A test score below
or around 70—or as high as 75—indicates a limitation in intellectual functioning. Other tests determine limitations in adaptive behavior, which covers three types of skills:

- Conceptual skills—language and literacy; money, time, and number concepts; and self-direction
- Social skills—interpersonal skills, social responsibility, self-esteem, gullibility, naïveté (i.e., wariness), social problem solving, and the ability to follow rules, obey laws, and avoid being victimized
- Practical skills—activities of daily living (personal care), occupational skills, healthcare, travel/transportation, schedules/routines, safety, use of money, use of the telephone

It is estimated that intellectual disabilities are present in 2-3% of the population and that 75-95% of all cases of intellectual disability are classified as mild (an IQ level between 50-70) [21].

### 2.2 Developmental Disabilities

Developmental disabilities are considered a broader range of impairments that may affect intellectual or physical functioning. Since a single organization does not formally “own” the definition of developmental disabilities, like the APA with intellectual disabilities, details diverge more widely including the age by which impairment appears. The AAIDD summarizes developmental disabilities as surfacing before age 22 [3]:

Developmental disabilities are severe chronic disabilities that can be cognitive or physical or both. The disabilities appear before the age of 22 and are likely to be lifelong. Some developmental disabilities are largely physical issues, such as cerebral palsy or epilepsy. Some individuals may have a condition that includes a physical and intellectual disability, for example Down syndrome or fetal alcohol syndrome.

The Arc summarizes developmental disabilities as surfacing before age 18 [71]:

Sometimes intellectual disability is also referred to as developmental disability which is a broader term that includes ASD (autism spectrum disorders), epilepsy, cerebral palsy, developmental delay, fetal alcohol syndrome (or FASD) and other disorders that occur during the developmental period (birth to age 18).
Although developmental disabilities are considered a broader or “umbrella” term, The Arc goes on to estimate that over 50% of those with intellectual disabilities do not meet the definition for developmental disability [3, 71]:

The major differences are in the age of onset, the severity of limitations, and the fact that a person with a developmental disability definition may or may not have a low I.Q. While some people with intellectual disability will also meet the definition of developmental disability, it is estimated that at least half do not meet the requirements for the developmental disability definition.

2.3 Cognitive Disabilities

The intellectual and developmental disabilities definitions address the need for formal terms that can be used in clinical and healthcare contexts. In doing so, however, they often take rigid approaches that put less emphasis on the individuals themselves. Cognitive disabilities are generally defined in a more human-centered manner and address impairments that affect a person’s quality of life. Braddock defines cognitive disabilities as “intellectual and developmental disabilities; autism spectrum disorders; severe, persistent mental illness; brain injury; stroke; Alzheimer’s disease; and other dementias” [10]. In creating the The Rights of People with Cognitive Disabilities to Technology and Information Access, the Coleman Institute for Cognitive Disabilities expands on this to include impairments that affects a person’s quality of life, and importantly, their abilities to live independently [10, 19]: I

The term “cognitive disabilities” was specifically selected to include a broad range of cognitive conditions that can impact quality of life and independent living. Cognitive disabilities include intellectual disability, autism spectrum disorders, severe, persistent mental illness, brain injury, stroke, and Alzheimer’s disease and other dementias. Technology and information access is essential for all people to live an inclusive life in our society today. People with intellectual disability and other cognitive disabilities together pose a formidable block of potential users of technology: An estimated 28.5 million Americans, more than 9% of the U.S. population, had a cognitive disability in 2012. People with cognitive disabilities worldwide are believed to exceed 630 million individuals, according to recent World Health Organization estimates (2011).

Throughout this work we prefer the term “cognitive disabilities” for its broader categorization
of abilities and impairments as well as its human-focused approach at looking at disabilities from a functional perspective in terms of quality of life and independent living.
Chapter 3

Related Work

3.1 Web Accessibility and Standards

“Web accessibility” refers to the ability for a user, regardless of physical or cognitive abilities and disabilities, to access and meaningfully use content available across the internet. This definition is deceptively simple however. The range of possible physical and cognitive abilities and disabilities is vast and any particular user could have a wide range of physical or cognitive ability within that space. Additionally, access to web-based content is inherently dependent on the devices and software platforms used by an individual. For many people with disabilities this may include non-traditional hardware, such as switch devices and screen readers, which are not always well supported by all software including web browsers or websites themselves. Web content also comes in many forms including text, images, video, audio, animations, and interactive controls. Each of these content presentations can include a number of information encapsulations. For instance, “images” may contain photographs, diagrams, graphs, charts, text, flowcharts, decorations, or any combination therein. The ability to use content meaningfully also varies between individuals as well as their physical and mental context at any given moment. Web accessibility is an incredibly wide reaching and complicated problem space with no “one size fits all” solution.

The number of individuals with physical and cognitive disabilities is staggeringly larger than most assume. A United Nations 1994 survey estimated that 15% (over 39 million) of people in the United States had some form of disability [76]. Broken up by age, the survey reveals that 38% of Americans over 60 have a disability as do nearly 12% of those from 15 to 59. Although older adults
match common stereotypes of having a higher prevalence of disability, a significant proportion of younger individuals have disabilities too. More recent estimates (2001) of cognitive disabilities in particular suggest that over 20 million Americans (over 7%) have a “substantial limitation in one’s capacity to think, including conceptualizing, planning, and sequencing thoughts and actions, remembering, interpreting subtle social cues, and understanding numbers and symbols” and the number is expected to rise rapidly as the population ages [11]. In other words, although physical and, especially, cognitive disabilities are often treated as a minor segment of the population, the research suggests that they comprise a significant proportion of it.

The large divide between web usage by people with disabilities and those without disabilities [26] highlights that decades of accessibility guidelines and standards have not made the web equally accessible to everyone. Although web accessibility standards have raised awareness and provided insight into the many challenges that people with disabilities have, the goal of equality of access still has not been met and has even retrograded in recent years [45, 78]. The World Wide Web Consortium (W3C), the main standards organization that guides web standards, published the initial “Web Content Accessibility Guidelines” (WCAG) in 1999 and released a revision, WCAG 2.0, in 2008 [15, 18]. In 1998 the United States Congress amended the Rehabilitation Act of 1973 to include the “Electronic and Information Technology Accessibility Standards,” commonly known as “Section 508.” In other words, the majority growth of the web in the everyday lives of most U.S. citizens has occurred with accessibility standards established and in place. Yet, several studies have found that even today the most popular sites often have major accessibility issues [31]. The WCAG recommendations and Federal guidelines are not meeting the needs of individuals with disabilities and/or websites are not effectively implementing the guidelines.

Several studies have attempted to tease out whether accessibility guidelines are not addressing the right needs or whether website creators are simply not following these best practices. Unfortunately, research supports both conclusions. As Hanson & Richards point out, “both topsites and government sites exhibit generally low conformance with Web accessibility standards” [31]. A study on university websites shows that the case is similar, though not as bad, for academic organi-
zations: “[w]hile some sites approach full accessibility, a large number still suffer from accessibility problems” [42]. Even the revised WCAG 2.0 has faced major criticisms by both the web developer and disability communities. As Sloan et al. point out, it is not uncommon for content that is highly usable to a wide range of people with disabilities to forego many of the guidelines and principles in the WCAG. Conversely, implementing the majority of the guidelines does not guarantee a usable webpage [66]. In other words, the WCAG are not well mapped to many end user accessibility needs.

3.2 Approaches to Web Accessibility

Web accessibility encompasses an incredibly broad range of concerns ranging from low-level technical issues to high-level usability impacts. Ensuring equal access to web content incorporates work across a significant number of technology layers and usability concerns. An analysis of work across the accessibility community yielded four predominant approaches to improving usability for people with disabilities. These included technically focused, information consumption focused, information contribution focused, and community focused approaches.

3.2.1 Technically Focused

Technically focused approaches address issues regarding webpage code (HTML, XML, CSS, JavaScript, etc.), syntax, language specifications, language feature implementations, and language enhancements. These issues tend not to be directly perceivable by the end user, but the artifacts of them are [37]. These are often referred to as “accessibility” issues more often than as “usability” issues.

3.2.2 Information Consumption Focused

Information consumption approaches focus on issues regarding the consumption and use of information at a level perceivable to the end user. These issues are often referred to as “usability” issues and quite often discussed under “holistic” approaches [65]. However, this approach addresses information to be consumed by the user and not information generated by the user.
3.2.3 Information Contribution Focused

Information contribution approaches focus on issues regarding the generation and submission of content from the end user to a website. This approach encompasses user-generated content, social networking participation, wiki editing, blog creation, and website creation [14].

3.2.4 Community Focused

Community focused approaches address issues regarding improving access throughout the web accessibility community. This approach encompasses features that allow end users to share, manipulate, and redistribute techniques, scripts, and metadata that can improve accessibility and usability to one or more websites [7, 17].

3.2.5 Towards an Intercommunity Approach to Web Accessibility

Although the web accessibility community has acknowledged new forms of web interactions and attempted to address them, there still exist several areas where web accessibility can expand and make headway. One particular area includes a stronger technical influence from communities outside of the web accessibility community. A common thread across many of the existing approaches is a strong intra-community approach; those affiliated with the web accessibility community tend to provide the vast majority of ideas, knowledge, tools, and enhancements to software targeted at people with disabilities.

However, mainstream communities that do not directly target technical features as accessibility solutions have much to offer the accessibility community and these benefits often do not end up in the hands of those who may benefit from them the most. Incorporating non-accessibility oriented technologies into accessibility software to improve web accessibility as a whole is a worthwhile and underutilized approach. This essentially involves incorporating proven ideas, techniques, and solutions from mainstream products and services into solutions targeted for those with sensory, physical and cognitive disabilities.

One example of where an intercommunity approach could benefit users with disabilities is
mobile computing. The prevalence of mobile computing has led to a surge in simplified mobile-oriented versions of websites. The mobile counterparts of many websites tend to be streamlined by removing less commonly used items, simplifying content, reducing the amount of text, reducing advertisements, and reducing available input elements and features. This often results in a simpler, less cluttered, and less distracting interface designed to fit a smaller physical screen size. Providing access to the mobile versions of sites via a standard desktop environment could greatly help users that prefer less complicated versions of websites including those with learning and attention disabilities [45]. The simplicity of the mobile versions can help users understand and navigate sites more easily and get to useful content without being as confused and making as many mistakes as might be made on a desktop-oriented version of a website. However, the simplicity may remove features that a user may want to access. In these cases, it would be advantageous to provide an alternate method for accessing the desktop version of a website on an on-demand basis.

3.2.6 Historical Trends

Overall, the world of web accessibility has changed significantly over the past several years. Major shifts have occurred moving from a traditional focus on presenting content to a user with little regard for how a user can provide information back to the web. In recent years, however, user-generated content and community sharing features have become more significant focal points of research and discussion. The shift from technical and information consuming methodologies to information contribution and community-based approaches is likely the result of the greater move and availability of Web 2.0 technologies [49]. As web applications became more dynamic and allowed for greater ability of web users to begin producing and contributing their own content, the need, usefulness, and potential of such technologies was not lost on the web accessibility community. Rather, it quickly responded by offering ways to ensure people with disabilities could participate and be an active voice in user-generated content on the internet.
3.3 Survey of Technology and Accessibility Issues

Web accessibility standards and non-compliance are not the only factors holding back internet use by people with cognitive disabilities. Researchers and practitioners largely agree that many factors are involved ranging a wide gamut including economic affordability to family or trust issues. We have formed a list of recurring key issues through meeting and speaking with researchers and practitioners ranging from academia, education, public policy, engineering, and disability advocacy organizations. A survey of major concerns and barriers to web use for people with cognitive disabilities follows.

3.3.1 Significant Economic Impact

Disability community members commonly cite the cost of devices and services as a barrier to not only internet use but technology use broadly for people with cognitive disabilities. Computing devices such as desktop or laptop computers, tablets, and smartphones are often considered to be expensive items for families and individuals with cognitive disabilities [34, 35]. Additionally, people with disabilities are often the poorest in the nation, most living in poverty, and have very limited to no financial resources to afford technology items [85]. Individuals and families that are able to afford computing devices are often concerned with technology obsolescence and worried that they will need to buy new devices too often or pay for expensive subscription-based services such as monthly internet service.

In addition to affordability, fundability and reimbursement of technology via government programs or healthcare is a major concern [34, 35]. The available options are often limited to expensive and/or functionally restricted devices for those that are able to receive financial support via healthcare related funds. For instance, individuals may receive funding for an augmentative and alternative communication (AAC) device but not a tablet computer due to the former’s specificity in use and the latter’s lack of it. AAC devices are limited in their technology capabilities to only supporting communication and are reimbursed as an aid to communication-related diagnoses.
However, since a tablet is a general purpose device capable of a wider set of functions, it can not be reimbursed in the same manner. The reimbursement system is setup with the best intentions: to prevent fraud and abuse in the healthcare system. Despite these challenges, users are still trending toward adopting mainstream technologies and rejecting custom AT due to mainstream devices fitting user’s needs better [41].

3.3.2 Family and Caregivers as Decision Makers

In many cases, lack of internet use is not wholly the decision of an individual, but involves family members and caregivers. One reason for restricting the use of technology from individuals with cognitive disabilities is to avoid potential damage to expensive devices. For instance, family members and caregivers may be afraid that an individual will drop or break a tablet computer or accidentally change its configuration in a way that they do not know how to reverse. This has slowly become a less severe issue as mobile devices become cheaper and are more easily managed, but the issue still remains noteworthy.

Another underlying issue is that it sometimes takes longer to teach family members and caregivers the benefits of new technologies and how to operate devices than the individuals with disabilities themselves [35]. The bottleneck with technology adoption and use is not always an individual with a disability as many presume, but rather those making the purchasing decisions.

3.3.3 Offline Social Networks are Small

One of the most common uses of the web today is interpersonal communication. Email, chat, social networking, video conferencing, and online telephony allow family, friends, and colleagues to communicate in real-time or asynchronously. As social networking continues to grow in popularity many have turned to it as a way to encourage those who do not frequently use the internet to increase their web usage habits [54]. However, one of the common concerns for people with cognitive disabilities is that they often do not have many close friends and thus have little motivation to get involved with online communication, including social networks. That being said, social inclusion is
still a high priority for people with cognitive disabilities and they do not want to be left behind as communication channels continue to move online further isolating them. Social inclusion is more than just having friends that one meets with in person, but rather includes having access to tools and information that allow one to live life completely and be social including online social networks and dating.

### 3.3.4 Universal Design Does Not Benefit All Users

The intent of universal design is to create physical and digital products that are accessible to the widest range of people possible, including those with physical, sensory, and cognitive disabilities. However, some experts feel that, in practice, such design still does not benefit all users, especially those with diverse needs, and that mass solutions do not work well [72]. When applied to digital interfaces, the manifestation of universal design principles is often to create a single interface that is as broadly usable as possible. Rather than focus on a one-size-fits-all approach, an inclusive design philosophy focuses on “one-size-fit-one configurations” where interfaces are designed to be flexible and adaptive and take into considerations a user’s context and needs [72, 73]. Web applications can pursue an inclusive design approach by offering end users adaptable and personalizable interfaces that support their diverse needs.

### 3.3.5 Small Market Demand

Many technology companies and developers cite a small, limited market as a prohibitive factor for assistive technology creators and vendors generally, not just on the web. There is a high cost for new innovators to get into the assistive technology market and an additional high cost to raise awareness of their products [34, 35]. The market is further limited by the inability of people with disabilities to afford high margins for technology products making longer-term sustainable business in the field difficult. Creating niche devices for a niche market is economically difficult and counter to many traditional web market models that rely on the economics of the “long-tail” where a large number of users support a large number of tastes and preferences [5]. Assistive
technology for people with cognitive disabilities further exacerbates the problem since individuals often have needs that are more unique than other disabilities. For example, a larger number of blind or low-vision users benefit from screen readers and as a whole create a large enough market for software creators to succeed [50]. However, with the unique needs of each individual with cognitive disabilities, generalized software that may help one individual will rarely help another creating a “universe of one” [16, 72].

3.4 Survey of Guiding Principles

Although there are many barriers that make it difficult for people with cognitive disabilities to access web content, there are also many misconceptions and presumptions amongst content creators that prevent them from addressing some of the concerns of people with cognitive disabilities in the first place. As such, it is beneficial to address the guiding principles that motivate why developing on the web for people with cognitive disabilities is so important.

3.4.1 Aspirations are High

Disability advocates note that a commonly held belief amongst those that do not have disability-related experience is that people with cognitive disabilities do not have the same aspirations or goals as those without a disability. Experts in the cognitive disability space often emphatically state that not only does having a cognitive disability not change a person’s goals and aspirations, but it does not change a parent’s goals or aspirations for their children either. Families want their family members with disabilities to live full, productive, and enviable lives just as anyone else would expect for all children. However, the current state of accessibility imposes that even though aspirations do not change, the number of opportunities is increasingly becoming more limited.
3.4.2 Functional Ability is High

The level of impairment for people with cognitive disabilities is often misunderstood. Most people with cognitive disabilities have mild to moderate impairment and the level of functional impairment is often very context dependent. It is also often misbelieved that a cognitive disability is directly connected to intelligence. As many in the disability field note, most people who are blind can see and most people who are deaf can hear, and similarly, most people with a cognitive disability can think independently.

Rather than think of cognitive disability in terms of one’s intelligence, one should think of cognitive disabilities as the fit between an individual’s competence and the demands of their environment at a particular time. Assistive technology should attempt to adapt and narrow the gap between a person’s abilities and the demands of the environment and highlight, as Bill Coleman notes, that “our abilities transcend our disabilities.”

3.4.3 Interdependence is Beneficial

A common mission in the accessibility community is to increase the independent living of people with cognitive disabilities. However, the goal is not to completely eliminate interdependence on family, friends, and caregivers. Rather, the principles are to seek out independence as a choice while preserving connections between people and not treat interdependence itself as a negative value. An uncompromising move to complete independence can lead to unintentional isolation and a lowered quality of life. An aim of increasing internet use among those with cognitive disabilities is to allow families, friends, caregivers, and others to stay actively involved in an individual’s life and maintain contact as they move into increasingly independent living situations.

3.4.4 Information and Communication Technologies Provide Great Opportunities

Experts agree that information and communication technology provide great opportunities to increase the quality of life for people with cognitive disabilities. In particular, the internet and cloud computing can act as a “prosthesis for life” and deliver ubiquitous, cheap, and powerful services
This is accomplishable since services on the web are provided at increasingly large scales allowing for the cost of services to drop dramatically. Cloud-based services have shown that free and low-cost software can be incredibly feature-rich with high utility providing great opportunity to provide services to people with cognitive disabilities. However, many of the services on the web are disparate and not well integrated. As such, part of the opportunity of ICT is in combining disparate services into cohesive products that provide value in the hands of end users.

3.4.5 The Rights of People with Cognitive Disabilities to Technology and Information Access

In 2010, as a response to a question from the Coleman Institute for Cognitive Disabilities regarding whether a right to technology and information access for people with cognitive disabilities was emergent, Thomas Gilhool, who argued the seminal case in a Philadelphia Federal Court in 1971 that led to establishing the right to a public education for children with disabilities (Pennsylvania Association for Retarded Children V. Commonwealth of Pennsylvania, 1971), stated that such a right was emergent in the United States. The Coleman Institute for Cognitive Disabilities convened community and thought leaders in the fields of cognitive disabilities and technology to explore crafting such rights. In 2013 at the Thirteenth Annual Coleman Institute National Conference, the institute released a declaration of The Rights of People with Cognitive Disabilities to Technology and Information Access (Figure 3.1) [20]. As of February 2016, over 480 organizations and over 900 individuals have endorsed the declaration showing a strong and widespread belief that technology and information access is not only important but fundamental for our society to provide for people with cognitive disabilities.
The Rights of People with Cognitive Disabilities to Technology and Information Access

Whereas

• Twenty-eight million United States citizens have cognitive disabilities such as intellectual disability; severe, persistent mental illness; brain injury; stroke; and neurodegenerative disorders such as Alzheimer’s disease;
• People with cognitive disabilities are entitled to inclusion in our democratic society under federal laws such as the Americans with Disabilities Act (ADA), the Developmental Disabilities Assistance and Bill of Rights Act (DD Act), the Individuals with Disabilities Education Act (IDEA), Section 504 of the Rehabilitation Act, and under state and local laws;
• The disruptive convergence of computing and communication technologies has substantially altered how people acquire, utilize, and disseminate knowledge and information;
• Access to comprehensible information and usable communication technologies is necessary for all people in our society, particularly for people with cognitive disabilities, to promote self-determination and to engage meaningfully in major aspects of life such as education, health promotion, employment, recreation, and civic participation;
• The vast majority of people with cognitive disabilities have limited or no access to comprehensible information and usable communication technologies;
• People with cognitive disabilities must have access to commercially available devices and software that incorporate principles of universal design such as flexibility and ease of use for all;
• Technology and information access by people with cognitive disabilities must be guided by standards and best-practices, such as personalization and compatibility across devices and platforms, and through the application of innovations including automated and predictive technologies;
• Security and privacy must be assured and managed to protect civil rights and personal dignity of people with cognitive disabilities;
• Enhanced public and private funding is urgently required to allow people with cognitive disabilities to utilize technology and access information as a natural consequence of their rights to inclusion in our society;
• Ensuring access to technology and information for the 28 million people with cognitive disabilities in the United States will create new markets and employment opportunities; decrease dependency on public services; reduce healthcare costs; and improve the independence, productivity, and quality of life of people with cognitive disabilities.

Therefore

We hereby affirm our commitment to equal rights of people with cognitive disabilities to technology and information access and we call for implementation of these rights with deliberate speed.

View endorsers of this document and join us at: colemaninstitute.org/declaration

Figure 3.1: The Rights of People with Cognitive Disabilities to Technology and Information Access [20].
3.5 **Cloud-Based Technology Tools**

One of the hindrances to technology adoption for people with cognitive disabilities and their families is the cost of assistive technology. Specialized assistive technology software and hardware often come at high price points that can be prohibitive to purchase. However, as the web has grown a simultaneous shift of software from large, expensive, packaged tools to smaller, focused applications and services has taken place. This shift has also coincided with a shift from pervasive cost-per-license and subscription-based business models to alternatives such as advertisement or investor supported. These economic models have led to many web services being provided as free services to end users and third-party software developers. These services have ranged from popular, large-scale products such as web search, email, social networking, and productivity software to smaller products targeted to mainstream users but with features well-suited for people with cognitive disabilities including professionally voiced dictation of news articles [74], webpage content extraction [39, 58], and content summarization [69].

Another benefit of cloud-based services is the lack of maintenance required to keep them up to date. As developers generate enhancements, or crowd-sourced content is updated, the user usually has to take no additional actions to get newer benefits. Updates and enhancements are handled on the server-side and eliminate the need for technical knowledge to keep software running well. This can be especially beneficial when users do not view the technical maintenance of software as simply a nuisance but rather as a sufficient barrier to use. However, automatic updates can confuse users if they frequently or dramatically change familiar user interfaces and workflows, forcing users to relearn aspects of a service. Cloud-based services are most helpful when updates provide automatic maintenance for users but do not occur so frequently as to frustrate or confuse them. Allowing users to opt-out of interface changes or revert to previous versions can benefit people with cognitive disabilities by providing non-visible changes, such as security updates, while also providing time for users to learn and adapt to newer changes.

Some of the cloud-based services that offer potential to help users with cognitive disabilities
improve their experience with the web are covered below.

3.5.1 Advertisement Filtering

In many cases, the most distracting elements of a webpage are embedded advertisements that include animations, sounds, contrasting colors, and large visual spaces (Figure 3.2). Although these characteristics are often used intentionally to grab the attention of web users, they can be very problematic for those with cognitive disabilities and result in much more than a slight or temporary nuisance. Furthermore, tools that process content non-Visually, such as screen readers, must process and relay advertisements that are often not of direct use to the end user. In these cases, it can be very advantageous to remove advertisements to prevent a page from becoming overly distracting to users with cognitive disabilities, particularly attention and reading disorders, and prevent interference with automated AT agents like screen readers.

Figure 3.2: A screenshot of an article from the New York Times website before any content adjustments [47].

Figure 3.3: A screenshot of an article from the New York Times website after advertisement removal [1].
Determining which elements on a webpage are advertisements is incredibly difficult due to the large number of advertisement providers and ever changing sources of advertiser content. However, a very robust community has grown that has addressed this issue for most desktop web browsers and mobile platforms. The most popular extensions, or plug-ins, for web browsers across various platforms are utilities that filter out advertisements from webpages (Figure 3.3) [1, 2]. The filtering is based on frequently updated, crowd-sourced lists of advertiser URLs and pattern matching strings. Although the filtering is handled on the client-side by the browser, the benefit of the advertisement blocking ecosystem is the automatic retrieval and updating of the crowd-sourced lists which are hosted and managed via cloud-based services.

3.5.2 Content Extraction

Headers, footers, navigation areas, and sidebars can be distracting content for many users as well. These elements and other recurring template content can create increased visual noise and clutter to a page that detracts from the main content a user is interested in. This content is often routinely ignored or skipped by many users to reach the main content block of a page. Fortunately, several services and tools have arisen that handle main content and article extraction to separate the most desired blocks of text from auxiliary content (Figures 3.4 and 3.5). However, the focus of such projects is often not for accessibility improvements but rather for convenience in tracking and providing content for consumption at a later time. For instance, the Instapaper, Readability, and Pocket services automatically detect the main article on newspaper webpages, amongst other sources, and save the text for later reading by a user on desktop or mobile devices [39, 56, 58]. Although these services are targeted for users seeking convenience, they have great potential for helping users that find websites full of distracting or unnecessary content, including users with visual impairment, and can help users with cognitive disabilities consume content more effectively and productively.
Figure 3.4: A screenshot of a newspaper article from the New York Times website after the main content has been extracted via Instapaper [39].

3.5.3 Text Simplification and Summarization

Even after extraneous content is removed, users may still have trouble reading and understanding the content itself. For instance, text can be hard to comprehend due to uncommon words or complex sentence structure. Services like Rewordify can simplify the word choice in text to make it more comprehensible, but is limited to single word and short phrase replacements [61]. Several services are also available that automatically summarize text. Longer passages can be shortened to user-specified lengths so those with disabilities that affect reading, learning, and concentration can, potentially, more easily understand the content. However, aggressively reducing text passage length can quickly lead to content that is less comprehensible and uninformative. Services such as...
Summly had become popular for providing one to two sentence summaries, but other services such as Open Text Summarizer are more adaptable to a user’s individual needs and allow custom length summaries reducing the risk of content becoming uninformative. [63, 69].

3.5.4 Assistive Technology in the Cloud

WebAnywhere is a free, web-based screen reader designed to help users that are blind access the web when they are away from their personal computers or when in need of access to a low-cost screen reader [8, 9]. The WebAnywhere project provides an alternative to requiring that a user always have their own equipment available with expensive AT software or hardware installed. Since WebAnywhere is web-based, it requires no software installation and is available as long as a user has access to a web browser and the internet. For instance, a user with vision impairment could potentially use the web at a library that traditionally would have strict security controls preventing arbitrary software installation on their publicly accessible computers.

Although WebAnywhere was designed for and targeted towards users that are blind or have low-vision, its capabilities and features match many of the needs of people with cognitive disabilities. Many people with cognitive disabilities state that having someone, or something, read aloud as they read along is helpful for their understanding and comprehension. The ability for WebAnywhere to verbalize text on a webpage matches this assistive need well. Furthermore, as the text is verbalized aloud by WebAnywhere, it highlights the words with a yellow background color which is additionally assistive to users to help them keep track of what and where they are reading. In fact, many of the drawbacks of WebAnywhere for users that are blind make it well-suited for people with cognitive disabilities. For example, WebAnywhere’s text to speech engine speaks at an invariable rate that is quite slow for users that are blind and are accustomed to native screen readers that are often configured to read at hundreds of words per second [80]. WebAnywhere’s speed is more closely matched to those that have difficulty reading or comprehending text. WebAnywhere also requests a small number of words at a time for speech synthesis. These sentence fragments cause frequent pauses during sentence verbalization which can be frustrating for native screen reader users but are
more manageable and more appropriately suited for slower readers.
Chapter 4

System Design

To evaluate the ability for an intercommunity approach to provide useful cloud-based assistive technology for people with cognitive disabilities, we created the SimpleWebAnywhere system. SimpleWebAnywhere’s goal is to provide access to content simplification features in a minimalist interface and allows users to selectively enable the tools that would most benefit them based on their context. As we prototyped and iterated on versions of SimpleWebAnywhere we not only performed our own testing to determine how feasible technical solutions were, but also presented our interfaces to potential users, family members, caregivers, teachers, and other stakeholders to gather their feedback. Below we discuss our prototype iterations and lessons learned before exploring a final prototype further in the studies below.

4.1 System Architecture

SimpleWebAnywhere is built upon the WebAnywhere web-based screen reader project [8, 9]. The abilities of WebAnywhere to highlight text and synthesize speech are regarded as useful features not only in the blind and low vision communities but in the cognitive disability community as well. As such, it provides a good starting point to determine if web-based assistive technology can fit the needs of people with cognitive disabilities. Additionally, the architecture of WebAnywhere provides a strong platform upon which to make adjustments to web content before presentation to the user. Adapting the WebAnywhere architecture allows us to integrate, prototype, and test a variety of content manipulations to determine how viable they are in making web content easier to use for
people with cognitive disabilities.

### 4.1.1 WebAnywhere

WebAnywhere is designed to require no installation or configuration on the part of an end user other than to access it via a web browser. Like most web-based tools, it consists of two primary architectural components: client-side scripts and a server-side application (Figure 4.1).

![Figure 4.1: The system design for WebAnywhere, a cloud-based screen reader used as the basis for SimpleWebAnywhere. [8, 9]. Server-side components include a text to speech and a web proxy component that interact with a webpage and the client via the web. Client-side components include the WebAnywhere script, transformed webpage, and sound players.](image)

The client-side scripts control the application user interface, the transformed webpage, and the speech playback operations. The application user interface is comprised of a location address bar separate from that of the browser itself, a “Go” button, and a text box and associated buttons for finding text within the transformed page. The transformed webpage remains largely unchanged other than the ability for words to be highlighted in yellow text with a black background as they are verbalized. This highlighting is also used when the find feature is active. The speech playback operations simply handle audio playback via the browser’s own audio capabilities or an Adobe Flash-based player. Collectively, the client-side scripts handle the user experience of the
application but the more computationally expensive work is handled on the server-side.

The server-side application of WebAnywhere handles the text to speech operations and the content fetching operations via a proxy. The text to speech conversions are handled by a natively running instance of the eSpeak “compact open source software speech synthesizer” on the server [23]. eSpeak takes as input plain-text strings and outputs an audio file with the text as synthesized speech. These files are requested by the “WebAnywhere Script” directly from the client; i.e. it is not processed or handled by the proxy server. The proxy server handles making content requests on behalf of the user and loading the final results as part of the “Transformed Web Page.” The primary purpose of the proxy server when used by WebAnywhere is to provide a mechanism to work around browser security policies and not to manipulate or change the underlying content.

4.1.2 SimpleWebAnywhere

SimpleWebAnywhere extends WebAnywhere by adding key features targeted for use by people with cognitive disabilities and those that prefer simpler web content. On the client-side, the application user interface components remain present including the subset of web browser controls (e.g. URL entry) and the transformed content frame. Additional application user interface elements were added to allow a user to selectively choose which content adaptations they prefer and allows them to enable or disable those features easily (detailed below).

On the server-side, SimpleWebAnywhere expands upon the WebAnywhere architecture by extending the web proxy component with the ability to perform content manipulations and customized content requests to webpages (Figure 4.2). By adding this functionality, we can extend the basic features of WebAnywhere and combine them with cloud-based content manipulation services. This effectively allows SimpleWebAnywhere to access a wide range of cloud-based APIs to manipulate and simplify source content before reaching the user. Additionally, these manipulations can be chained together improving the content even further. SimpleWebAnywhere can access several services and pass to one service the output of a previously called one. This allows for SimpleWebAnywhere users to benefit from the aggregate benefits of unrelated services rather
than requiring one service to handle the full range of manipulations. For instance, it is possible
to combine mobile website requests with an advertisement blocking service and a separate word
replacement service to provide a clean version of a page with limited distractions and easy to un-
derstand language, a feat very difficult and cumbersome to do by an end user on their own. To
detail this example, SimpleWebAnywhere could pass the HTML content from an emulated smart-
phone request to an advertisement blocking proxy [57] that would remove the HTML elements of
advertisements, then take the resultant HTML and pass it to a language service to replace difficult
words with simple phrases [61], before sending the final result to the user’s browser.

Figure 4.2: The system design for SimpleWebAnywhere with alterations from the original
WebAnywhere system highlighted in red. Notably, the web proxy interacts with a cloud-based
content manipulation services component and content requests for webpages occur via customized
requests.

As each feature of SimpleWebAnywhere is enabled or disabled via the application interface,
a request is sent to the proxy server which handles requesting webpage content, performs the
requested manipulations, and sends the results back to the client to present the final content to the
user. In some cases, the webpage content requests may be manipulated such as when displaying
mobile versions of websites where the HTTP request headers are manipulated. Although a proxy has many benefits in this architecture, one notable limitation is that both WebAnywhere and SimpleWebAnywhere do not seamlessly preserve end to end security for sites that use web security techniques like secure socket layers (SSL) and HTTP over SSL (HTTPS). The proxy performing content manipulations essentially acts as a man-in-the-middle even though the tool’s intent is non-malicious. The visible effect is that sites accessed via HTTPS would warn the user of a potential security risk via the web browser or not be retrievable at all. This was an acceptable limitation for our user studies, however, if SimpleWebAnywhere is to be used for longer-term public use and include support for secure websites, some level of initial configuration will be needed to overcome security warnings. One possible solution is to configure SimpleWebAnywhere as a certificate authority (CA) that provides its own root certificate. If SimpleWebAnywhere is added as a trusted CA on each client a chain of trust can be reestablished. The major downside to this approach is that initial ease of use is lowered since security and certificate configuration would be required on each client before accessing SimpleWebAnywhere. This removes one of the major benefits of WebAnywhere and SimpleWebAnywhere as services that require no initial configuration to use. For our user studies, we chose to favor the lack of initial configuration as a priority over the need to avoid security warnings to save time and create a system that was as easy to use as possible. However, real-world use would likely require this initial configuration to mitigate security warnings that could annoy, confuse, or mislead users.

4.2 Prototypes

The expanded system architecture allows for a greater amount of flexibility in providing possible content manipulations. As we built, tested, and experimented with SimpleWebAnywhere we explored a variety of possible content adaptations to determine feasibility and effectiveness in practice. A review of our prototypes and lessons learned follows.
4.2.1 Mobile Web on the Desktop

Mobile versions of websites often provide substantially simpler versions of content than their desktop counterparts [33]. These simplified webpages are sometimes preferred by people with cognitive disabilities and screen reader users, as well as others, in part because of a decrease in the amount of content, navigation links, interactive controls, and advertisements they display (Figure 4.3). However, mobile webpages are traditionally accessed directly on mobile devices or by using various “tricks” that may only work on certain websites and require a higher degree of technical knowledge to utilize [44]. For instance, many users with vision impairments prefer using the easier to navigate, less-dynamic, mobile version of Facebook by directly navigating to the mobile URL “m.facebook.com” instead of the full-featured “www.facebook.com” URL [32]. The “m.” prefix on the URL is a common convention websites use to differentiate mobile versions of a website from the desktop versions, but not all users know to check for an alternate version and not all websites have an alternative version available. If a user is not aware or does not understand that mobile content is sometimes retrievable via a desktop browser, then their most common encounter with mobile websites is through a physical mobile device. However, accessing content on a mobile device constrains the user in other ways including smaller screens and smaller buttons which can be problematic visually and physically, especially for those with motor impairments [64].

By providing an easily accessible way to browse mobile content on a desktop browser, users can gain the benefits of a simpler website while preserving the physical benefits of a desktop computer including larger displays and better hardware support, particularly for assistive technology. The simplicity of mobile websites can help users understand and navigate sites more easily and get to useful content without being as confused or making as many mistakes as might be made on a desktop-oriented version of a website. However, the simplicity may remove features that a user may still want to access. In these cases, it is advantageous to provide a method for accessing the desktop version on an on-demand basis.
The first prototype of SimpleWebAnywhere allowed users to access mobile websites via the desktop browser by emulating mobile device requests. Although many mobile websites can be accessed via the aforementioned URL edit of changing the prefix/subdomain to “m.” this was found to be an unreliable approach. An automated system would have to test for a proper response after requesting a “m.” subdomain to see if it was a valid URL and many sites do not provide a graceful fallback if the request fails (e.g. issue a redirect to the main site). Some sites will redirect to error pages or the homepage of a site without taking into account the webpage path of the original URL forcing the user to land on an unintended page. In effect, the system would think that it was serving valid webpages, but the user would be stuck in a loop where all links and content requests would constantly return them back to the homepage. More importantly, the number of websites that supported the “m.” subdomain are relatively rare, so more often than not an error would occur or the standard content would be presented providing little utility to the user.

An approach that followed more common conventions was to adjust the “User-Agent” string in the HTTP request header. The user agent string is used to voluntarily identify the hardware and software used to issue a HTTP request. This information is generally automatically generated and provided by the web browser sending the request and is more informative than the URL alone.
(though by no means is it considered an untampered or secure piece of data). In practice, using the user agent string to retrieve mobile websites was found to be more effective than adjusting the subdomain alone. Additionally, using the user agent string provided a more graceful fallback in the case of errors; rather than redirecting to error pages or homepages, websites typically served the standard version of a site if a mobile version was not provided.

Table 4.1: List of Emulated Devices and Corresponding User Agent Strings Supported by SimpleWebAnywhere

<table>
<thead>
<tr>
<th>Device</th>
<th>User Agent String</th>
</tr>
</thead>
<tbody>
<tr>
<td>iPhone iOS 3.0</td>
<td>Mozilla/5.0 (iPhone; U; CPU like Mac OS X; en) AppleWebKit/420+ (KHTML, like Gecko) Version/3.0 Mobile/iC25 Safari</td>
</tr>
<tr>
<td>iPhone</td>
<td>Mozilla/5.0 (iPhone; U; CPU iPhone OS 4.3 like Mac OS X; en-us) AppleWebKit/533.17.9 (KHTML, like Gecko) Mobile/8F190</td>
</tr>
<tr>
<td>iPad</td>
<td>Mozilla/5.0 (iPad; U; CPU iPhone OS 3.2 like Mac OS X; en-us) AppleWebKit/531.21.10 (KHTML, like Gecko) Version/4.0.4 Mobile/7B314 Safari/531.21.10</td>
</tr>
<tr>
<td>Android</td>
<td>Mozilla/5.0 (Linux; U; Android 2.1; en-us; Nexus One Build/ERD62) AppleWebKit/530.17 (KHTML, like Gecko) Version/4.0 Mobile Safari/530.17</td>
</tr>
<tr>
<td>BlackBerry</td>
<td>Mozilla/5.0 (BlackBerry; U; BlackBerry 9800; en-US) AppleWebKit/534.8+ (KHTML, like Gecko) Version/6.0.0.466 Mobile Safari/534.8+</td>
</tr>
</tbody>
</table>

Since websites predominantly serve optimized content or redirects based on the user agent string, our prototype allowed the user to choose user agents to emulate from a list of common devices that were available on the market at the time (Table 4.1). The user agent selection was controlled by the end user so they could find a mobile alternative that best fit their needs since mobile websites are sometimes optimized to specific mobile hardware. For instance, some websites provide less content for requests made by mobile phones than for tablet-sized devices due to their relative physical screen sizes, so we provided an option to emulate an iPhone as well as an iPad. Additionally, websites could optimize their content and scripts for the browsers making the request. We found that in some cases, using the desktop equivalent of a mobile browser for a platform provided better support and fewer problems than crossing platforms. For example, using the Safari
desktop browser to access SimpleWebAnywhere and emulate an iPhone or iPad (which run Safari mobile browsers) could fix issues that would appear if SimpleWebAnywhere emulated an Android device while using Safari on the desktop.

Figure 4.4: An early prototype of SimpleWebAnywhere that allows mobile web viewing on a desktop browser. The dropdown list to the right of the URL field allows a user to select a mobile device to emulate. Large UI elements made it difficult to enter and manipulate text in the application controls at top.

4.2.2 Iterating the Mobile Web on the Desktop Experience

WebAnywhere was designed for users who are blind or have low vision and the application user interface elements were intentionally created to be large with large text labels. This reduced the amount of space available to display the URL, webpage path, and keywords for the find tool, however, which made text input and manipulation difficult. Once the user agent selection box was added, the application UI became cluttered to the point that it was difficult to see and edit the
URL and webpage path, especially on narrower window sizes (Figure 4.4). To counteract this, we decreased the font size for UI elements and increased the text field sizes to make the URL data easily readable and editable. We intentionally placed the user agent selection box between the URL field and the “Go” button to provide a visually linear workflow for users to enter a destination, pick their device emulation, and activate the SimpleWebAnywhere tool (Figure 4.6). The background color for the SimpleWebAnywhere controls was also changed from a neutral gray to a blue gradient to make the separation of the controls from the actual webpage content more apparent.

A drawback of providing mobile content on a desktop display became obvious after adding the user agent emulation feature. Most mobile-focused content is designed to take up the entire width of a window to maximize the typically small screen size on mobile devices. However, at desktop display widths elements will expand so wide that it makes them more difficult to read and understand. For example, when the window is widened further than in Figure 4.4, the yellow “Add to Shopping Cart” and “Add to Wish List” buttons become so stretched that they lose their perceived affordance of being clickable buttons [48]. Text that would normally wrap into easy to read paragraphs would also extend as a straight line reducing their readability and visual clustering.
To combat the issue of wide window sizes detrimentally affecting website design cues and making web controls harder to intuit, a “Width” control slider was added that would manipulate the size of the transformed webpage’s content container without affecting the SimpleWebAnywhere application user interface. The width slider could adjust the transformed webpage’s width from 1-100% in 1% increments.

A common observation while testing the system was that the synthesized speech was played at a high perceived volume relative to other system sounds and notifications. This was often jarring and became annoying to users so a “Volume” slider was added to control the synthesized speech independently of the system volume setting.

Figure 4.5: A comparison of the Amazon mobile website at a wide width, left, and a narrow width, right. Wide content decreased perceived affordances of UI elements and made some text more difficult to read.
Figure 4.6: A revised prototype of SimpleWebAnywhere that allows mobile web viewing on a desktop browser. UI elements were resized to allow more of the URL to be legible and two new controls, “Volume” and “Width”, were added.

Using SimpleWebAnywhere with mobile device emulation worked for viewing several popular websites we tested such as Google News, Amazon, and the New York Times (Figure 4.7). We were able to adjust the user agent string and were served back optimized, mobile-specific pages with less miscellaneous content and fewer advertisements that made clear differences in the amount of information presented to the user. The mobile version would appear and render with most content intact and verbalizable by the application. Overall this largely achieved the goal of simplifying webpages and providing easier to use and easier to comprehend content on the desktop.

The presentation of mobile content on the desktop did result in some errors however. In both desktop and mobile versions, content sections would sometimes have missing content errors (e.g. the “Not Found” in Figure 4.6). Additionally, some of the interactivity and navigation on a webpage broke. As part of the mobile optimization performed by websites, the scripts being served sometimes had device-specific code that did not always work correctly with desktop browsers. For
instance, the mobile versions of websites would listen for events handlers on swipe gestures, taps, or double-taps for parts of their interactivity. These gestures did not always work with their desktop equivalents like click-and-dragging, clicking, or double-clicking. Without the use of many buttons, controls, and widgets, some pages became largely non-functional other than to provide the main static content of the website. Mobile content requests were thus useful for converting individual pages of content to a simple desktop version once they were accessed, but did not usually help simplify or maintain the level of difficulty of navigating through a website simply due to broken interactions. The de facto workflow while testing this feature was to initially navigate and interact with a website using a desktop browser user agent then transition to a mobile user agent when particular content wanted to be transformed, such as a news article one would read or a product description page one wanted to navigate.

Figure 4.7: A SimpleWebAnywhere prototype screenshot providing the mobile version of a New York Times article to a desktop browser.
**4.2.3 SimpleWebAnywhere with Content Extraction and Simplification**

Although mobile device emulation via SimpleWebAnywhere generally worked well, often the resulting webpages still had lots of controls and miscellaneous content that were not related to the main content of the page. With the additional burden of needing to toggle the user agent on and off to ensure interactivity and navigation worked well, we decided to pursue a prototype with which desktop websites are used for most navigation tasks and the main content was extracted on-demand via a button. This would allow users to have a usable experience to find and retrieve information and content they were interested in consuming and then activating a simplified view to read the content.

Another observation we made in the mobile emulation prototype was how the “Volume” slider was used in practice. While developing, testing, and initially experimenting with this prototype of SimpleWebAnywhere, we noticed that the volume slider was rarely used to change the volume of the text verbalizations to something comfortable or better suited for the environment. Rather, it was used to turn off the voice altogether by lowering the volume to its lowest value which effectively muted the text-to-speech feature. In other words, the addition of the volume slider let us discover early on that users were not likely to adjust the volume but simply wanted to have control over whether content was being vocalized or not.

Lastly, the find controls in the main application were rarely used while navigating and reading content. These controls were potentially helpful in the WebAnywhere version since it would allow blind and low-vision users to find specific content on a page and control verbalizations from that focus point onward. However, for sighted users the usefulness of this feature was not significant enough for users to use it frequently.

Taking these early prototype findings into consideration, we chose to remove the non-essential functionality and further simplify the interface to meet the needs of our target user audience (Figure 4.8). We disabled the find functionality, volume controls, user agent selection box, and width control since mobile content was no longer being retrieved. The controls were replaced with two
buttons. The first button controls whether SimpleWebAnywhere performed content extraction on the requested page and indicated its state via text and color. Enabling the button would display “SIMPLIFY PAGE: ON” with a green background while disabling the button would display “SIMPLIFY PAGE: OFF” with a red background. The second button controlled the text to speech and highlighting functionality and displayed “SPEAK ALOUD: ON” in green when enabled and “SPEAK ALOUD: OFF” in red when disabled. Lastly, we added a text field for a “Participant ID” which would allow us to track different participant’s patterns in log file analysis as discussed in section 5.4.6. We made the participant ID field large and apparent to act as a cue that the use of SimpleWebAnywhere was part of an active research project and that the websites users visited were being tracked and analyzed.

Figure 4.8: The final SimpleWebAnywhere prototype screenshot providing simplification on the University of Colorado Boulder Human-Centered Computing website.
Figure 4.9: The final SimpleWebAnywhere prototype screenshot without providing simplification on the University of Colorado Boulder Human-Centered Computing website.

Content extraction was performed using the cloud-based tool Readability [58]. Readability is a user-facing service that allows users to save links and build reading lists from content around the web. When a user visits their reading lists and clicks a link to read, they are presented with a minimalist view displaying only what Readability determined to be the primary content of the page. For example, if a user saved a newspaper article for reading later, only the article would be
shown without any other website content from the original source (Figure 3.5). Readability exposes their content identification and extraction via their parser application programming interface (API) [59]. The API takes in a URL and returns structured metadata about the contents of the page. For the purposes of SimpleWebAnywhere, we use the auto-detected title, author, date, and content fields to create a minimalist view of any webpage.

The Readability parser API also returns a confidence score for its analysis which reflects how well the algorithm thinks it classified the original content. This score could potentially be used to automatically simplify a page if the content extraction confidence score was over a minimum threshold. This would alleviate the need for a user-facing button to turn simplification on or off. However, in testing a wide variety of websites and webpages, it was determined that the confidence score was not accurate and always returned a value of “0.5” making it indiscriminate in whether it was providing content extraction accurately or not. Accordingly, we ignored this value and chose to expose the simplification button to the user.

By combining several cloud-based tools that are freely available, the final prototype of SimpleWebAnywhere provided an easy to access tool that initially required no installation or setup to support website simplification for users with cognitive disabilities or anyone that wanted a simpler view of web content. The design and interface were made to be as clear and simple as possible while preserving the ability for the user to control the core functionality to best suite their needs.
Chapter 5

Evaluation

To explore web use by people with cognitive disabilities we performed a multi-session study using surveys, semi-structured interviews, and the SimpleWebAnywhere tool as a technology probe. Three sessions were planned for each group of participants. We present the procedure, observations, and discussion of this study in this chapter.

5.1 Recruitment

A focus of our research was to determine how people with cognitive disabilities are currently using the web and in what ways we could improve that experience. As such, we aimed to recruit adult participants that self-identified as having an intellectual or developmental disability and actively use the web (Appendix A). We kept the requirements for participation intentionally broad for two primary reasons. First, recruitment in this field is notoriously difficult and imposing restrictions on diagnoses or abilities would have unnecessarily restricted our participant pool. Second, we wanted to explore a wide space of potential participants with a wide array of concerns, needs, and ideas. Previous work done in the field has targeted specific diagnoses or intellectual abilities but we wanted to compare and contrast the needs of people from diverse cognitive abilities and backgrounds. One of our guiding principles for this research is that users on the web should not be categorized or catered to specifically based on their disability labels. Additionally, individuals that do not have named disorders may still identify as having a cognitive disability and should not be excluded on that criterion alone. We wanted our participant pool to reflect these ideologies and
engage a wide audience to see what tools and features can help people broadly rather than for a particular need.

To respect the privacy of people with cognitive disabilities and their families we passively recruited through organizations in the cognitive disability space throughout the Denver and Boulder, Colorado areas. We sent contacts at several organizations a flyer asking for participation from their members or people they provided services to along with our contact information and asked them to give the information to anyone they thought would be willing to participate. This is in contrast to active recruiting in which we would have asked for a list of people we could directly contact to participate. We avoided the latter approach as we felt it removed the choice of the individuals and families to disclose whether they had a cognitive disability and we wanted to be sensitive to such privacy and disclosure concerns. We received replies and references from three disability organizations: The Association for Community Living (ACL), The Developmental Disabilities Resource Center (DDRC), and The Arc – Jefferson, Clear Creek & Gilpin Counties. By receiving referrals through these organizations we verified that each participant had been diagnosed with some form of cognitive disability and was receiving support or services from the referring organization. After a referral reached out to us to participate in the study, follow-up communication took place over the phone or by email to schedule sessions.

All participants in the study were high-functioning with mild to moderate levels of cognitive disability. We wanted to ensure that each individual understood the risks, benefits, and procedures of the study and could provide their own consent. In cases where this may have been unknown or ambiguous, we asked the parent if the individual was able to provide their own consent. The study did not include any individuals with severe or profound cognitive disabilities to prevent possible or mistaken coercion or potential harm to any participants.

Limiting the study to participants with mild to moderate levels of cognitive disability also limits the direct applicability of our findings to similar populations. Although we hope that our results will help inform progress in the field of web accessibility for people with cognitive disabilities broadly, we recognize that individuals with severe or profound diagnoses and disabilities tend to
have unique challenges that were not represented in our target population. In particular, those with more severe levels of cognitive disability are often focused on basic technology access, if any technology access is a goal at all, and have individual needs that may require specialized software and hardware combinations specifically adapted for an individual. As the level of cognitive disability increases for an individual, more holistic approaches to technology access are necessary. Similarly, although we aimed to be inclusive of addressing reading, learning, and attention disabilities, we recognize that as the severity of such disabilities increases, the effectiveness of our approach diminishes as non-technical and physical factors become increasingly influential. Addressing increasingly severe levels of disability requires more individualized and nuanced adaptations than our approach offers.

We recruited 13 participants total; of those 8 participants had a cognitive disability, 5 were parents, and 3 lived independently. Of the 8 individuals with a cognitive disability, 2 were male and 6 were female with ages ranging from 18-53 (M = 31.13, SD = 14.59). Of the 5 parents, 1 was male and 4 were female. We refer to an individual with a cognitive disability as a “primary participant” throughout this study and an independent primary participant or a primary participant and their parent collectively as a “participant group.”

Table 5.1: Participant demographic information. Odd numbered participants are individuals with a cognitive disability. Even numbered participants are the parents of the preceding number.

<table>
<thead>
<tr>
<th>Participant ID</th>
<th>Pseudonym</th>
<th>Age or Parent</th>
<th>Gender</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Oliver</td>
<td>19</td>
<td>Male</td>
</tr>
<tr>
<td>P2</td>
<td>David</td>
<td>Parent</td>
<td>Male</td>
</tr>
<tr>
<td>P3</td>
<td>Jacob</td>
<td>30</td>
<td>Male</td>
</tr>
<tr>
<td>P5</td>
<td>Emily</td>
<td>41</td>
<td>Female</td>
</tr>
<tr>
<td>P6</td>
<td>Elizabeth</td>
<td>Parent</td>
<td>Female</td>
</tr>
<tr>
<td>P7</td>
<td>Samantha</td>
<td>18</td>
<td>Female</td>
</tr>
<tr>
<td>P8</td>
<td>Victoria</td>
<td>Parent</td>
<td>Female</td>
</tr>
<tr>
<td>P9</td>
<td>Eleanor</td>
<td>53</td>
<td>Female</td>
</tr>
<tr>
<td>P11</td>
<td>Madison</td>
<td>18</td>
<td>Female</td>
</tr>
<tr>
<td>P12</td>
<td>Lily</td>
<td>Parent</td>
<td>Female</td>
</tr>
<tr>
<td>P13</td>
<td>Abigail</td>
<td>49</td>
<td>Female</td>
</tr>
<tr>
<td>P15</td>
<td>Zoey</td>
<td>21</td>
<td>Female</td>
</tr>
<tr>
<td>P16</td>
<td>Karen</td>
<td>Parent</td>
<td>Female</td>
</tr>
</tbody>
</table>
5.2 Setting

Since many people with cognitive disabilities have limited access to transportation resources, interview sessions were offered to take place at the participant’s home or at the University of Colorado Boulder. We also offered to meet elsewhere at a location chosen by the participant if the participant had any privacy or safety concerns with the preferred options. It was our expectation that most participants would choose to have the interview sessions at their homes since it was likely the most convenient location for them. Several participants lived significantly far from the university (greater than 20 miles), so we clearly stated that they did not need to travel to participate. As researchers we were inclined to hold the interview sessions at each participant’s home to get a richer context for how they use their own personal technology in their everyday life and learn more about their daily habits generally. However, we ultimately left this decision up to the participant.

Of those that lived independently, none had a driver license and were all dependent on public transportation services, family, or friends for transportation. Of the participant groups with accompanying parents, time, effort, and parking fees all seemed like inhibiting factors to visiting the university campus. Despite what logistically seemed like the most convenient choice, the majority of participant groups (n=6) actually chose to hold the sessions at the university and 2 participants that lived independently chose to hold the session in their own homes.

Since the desire to hold the sessions on the university campus surprised us, we asked several participants why they chose to come to the university rather than have the researchers visit them in their home. Rather than citing privacy, safety, or convenience concerns, most participants actually stated that it was interesting to them. They were excited and looking forward to visiting the university, seeing the labs, and exploring the spaces. It was also seen as being a good change of pace from the regular routines that many participants had. For them, it was nice to have a reason to leave the house and go somewhere that was not part of their typical daily schedules. As we later discovered in the background questionnaire, many participants had little or no education beyond high school so the university campus and lifestyle were novel and interesting. Oliver, Samantha,
Madison, and Zoey in particular were all of college age, and although some had experienced certain college classes or programs none were enrolled full-time in a college.

Jacob traveled for several hours on a public bus to get from his home to the university campus, then walked across the campus from the bus stop to the research lab. Jacob has a physical disability that requires him to use arm crutches to walk and the distance across campus was a challenge for him requiring several breaks to take a rest. After mentioning that I could have made any of several accommodations, Jacob noted that he actually preferred this approach. By taking the public bus and visibly walking across campus, he saw himself as a self-advocate publicly showing others that people with physical and cognitive disabilities exist and are part of the community. He intentionally wanted people to see him take the bus, walk with his arm crutches, and struggle at times to make the journey. From his perspective, the more times he could take such trips, the better, since it would increasingly bring more awareness to those along the way.

Abigail also traveled for several hours on a public bus to arrive in Boulder and arrived at the downtown bus station. We accommodated her by providing transportation to and from the bus station and the university for each session. When asked why she was willing to travel so far when we could have easily visited her, she mentioned similar rationale to most other participants; it was worth the time to change up an otherwise repetitive daily routine and gave her a reason to visit and explore Boulder afterward.

Overall, the participants found that participating in university research was rewarding to them individually not only because it “gave them something to do,” but because it offered them something that felt socially rewarding and beneficial to society. It was a positive reason to break daily routines and explore the university, visit Boulder, and promote disability awareness. We feel that it is important to not only pursue research for people with disabilities, but to continue to push for more opportunities for participants to be visible and active in their communities via research studies.
5.3 Procedure

For each participant group, we aimed to hold 3 interview sessions each 3 weeks apart. The first session lasted 2 hours while the second and third sessions were 1 hour each. In the first session, we introduced the research project, went through a background questionnaire, held a semi-structured interview about the participant’s current web use, introduced and evaluated SimpleWebAnywhere, and performed a system usability scale (SUS) questionnaire on SimpleWebAnywhere. For the second session, we reviewed the participant’s use of SimpleWebAnywhere between the first and second session and performed a second semi-structured interview on their web use with more informed context. The third session was similar to the second session with participants also evaluating other web simplification methods such as advertisement blockers, screen readers, and other browser extensions.

In total, 19 sessions were held with all 8 participant groups completing the first session, 6 participant groups completing the second session, and 5 participant groups completing all three sessions. Madison and Lily cited a lack of interest when we contacted them to confirm the second session and chose to no longer participate further. Samantha and Victoria had to stop participating for external factors due to a significant accident in their personal lives after the first session. Casey and Cathy were not able to be contacted to confirm their third session and were considered to have left the study after several attempts to contact them were not returned.

Sessions were recorded using a video camera as well as screen-recording software that additionally recorded an internal webcam feed and audio. The video camera provided a wider view of the participants and often caught interactions between a primary participant and their parent or the primary participant and the researcher. The webcam view was exclusively a view of the primary participant. We ensured that all participants were aware they were being recorded, but still took measures to reduce “performance” or “freezing” behaviors [22]. The video camera was placed as far as possible from the participants to limit discomfort and was usually placed across a large table or across the room. The screen recording software was relatively discrete with the laptop
webcam light indicator being the main physical indication the user was being recorded. Although
the video camera was physically present and the webcam indicated it was active throughout the
sessions, participants did not seem to engage in “performance” behavior that could be isolated to
the use of recording equipment.

During the first session with each participant group, we gathered background information and
demographics via a questionnaire that was completed verbally and by hand (Appendix B). The
questionnaire was modeled after a nationwide technology use survey for people with intellectual and
developmental disabilities [70]. The goal of the questionnaire was not to measure and calibrate the
specific needs or abilities of the participants via a trained professional like the Supports Intensity
Scale (SIS) [82]. Rather, the survey allowed us to gather general background information and
get a broad sense of how each primary participant viewed their own abilities and their everyday
technology use. The background questionnaire covered general demographic information, education
history, employment status, living status, disability information, and technology use.

At the end of the first session, each participant group also completed a usability survey for
the SimpleWebAnywhere software (Appendix D), although Abigail was not able to complete the
survey due to time constraints. The system usability scale (SUS) was designed to be “an extremely
simple and reliable tool” to gather a basic quantitative sense of a system’s usability [13]. This
survey was chosen in large part due to its simplicity and ease of understanding for people with
cognitive disabilities.

During each session, hand-written and typed notes were taken as we spoke with partici-
pant groups and performed the semi-structured interview. Afterward the notes and video were
transcribed and analyzed in tandem to develop an understanding of our participants and isolate
patterns, commonalities, and points of individuality.

Throughout the study, web server logs were created for any use of SimpleWebAnywhere. The
logs recorded typical web server statistics as well as specific data for SimpleWebAnywhere including:
date and time of access, source IP address, URLs accessed, participant ID (user inputted), state of
the simplification feature, and state of the text to speech feature.
5.3.1  Guidance for Future Researchers

As we conducted our interview sessions we learned a number of techniques that improved the research process for both individuals with cognitive disabilities as well as their families and the researchers involved. The following is a short discussion of techniques we found helpful for conducting interviews and research with this population.

As noted above, many of our participants were excited about the opportunity to visit the university campus and participate in their community. We encourage future researchers to provide more opportunities to have people with various disabilities engage in their community through research. This not only includes inviting participants to university labs but also increasing exposure of self-advocates in their community by simply being visible and active. Our participants generally noted that there were limited reasons to leave their homes so providing chances to do so was valued. We ask future researchers to offer to hold interview sessions at locations that participants would not normally visit or rarely get the opportunity to visit whenever possible.

Before conducting this research, we were warned that individuals with cognitive disabilities could be potentially difficult to work with, and many parents had similar concerns, especially for long session durations. However, we found that all of our primary participants were very pleasant throughout the interview sessions, even those that lasted over two hours. One technique that worked well was to begin each session with a questionnaire to help “break the ice.” As part of going through the questionnaire we intentionally asked lots of questions about the individuals themselves to get to know them better. In particular, asking about hobbies and interests tended to put the participants at ease, help the researchers learn more about them, and became useful later in the process for idea generation on which websites to visit.

Given the nature of this study, we were also able to have primary participants visit webpages and view images and videos they were personally interested in. In doing so, the participants were entertained for a large portion of the study session which helped them participate for hours without complaint, getting irritable, or getting easily distracted. This surprised many of the parents who
were concerned they may need to leave the session early. Moments when the primary participants were watching online videos also provided spontaneous opportunities to gather detailed information and hear additional stories from the parents themselves which provided valuable insights. Participant fatigue across sessions was more noticeable than within sessions. Being asked about the same types of issues and getting into finer detail and nuance about behavior was increasingly less interesting for primary participants. As such, we suggest that researchers remain flexible and dynamic throughout their interview sessions to keep the interest of the participants as high as possible.

It was also noted before the study began that individuals with cognitive disabilities have a high likelihood to acquiesce to the researchers’ requests and to answer in what they perceived as expected rather than truthful ways. We observed this behavior but also noticed that parents had a bias toward this behavior as well. In many cases, parents were more likely to perform this way than their children or encourage their children to respond in particular ways. We encourage future researchers to be aware of these patterns and interpret their data with these biases in mind.

Another bias we were warned about was the likelihood of participants to “perform” if cameras were used to record the interview sessions. To mitigate this, we used the most discrete and smallest cameras we could to record the sessions and intentionally placed them as far away from each individual as possible. In particular, built-in laptop webcams worked well because they only provided a single light as an indication they were being recorded and remained discrete the entire session. Overall, we did not notice any behavior that led us to believe our participants were acting unnaturally at all, but steps to reduce such behavior are still recommended for all future researchers.

By following these techniques we were able to conduct sessions that did not seem to overly tire, bore, or bias our data beyond a reasonable expectation. Parents were generally surprised and appreciative of how smoothly the interviews went without needing to react to emotional or physical distress. Self-advocates were also appreciative of the ability to be visible in their communities and participate in socially significant work.
5.4 Results and Discussion

5.4.1 Demographics

Of the 8 primary participants we interviewed, several trends were apparent and matched other observations and research in the field. All primary participants had completed high school but only Abigail and Eleanor had completed any formal post-secondary education. Abigail had completed a 4-year college program with study in Political Science and Eleanor had completed a 2-year program for becoming a certified nursing assistant. Others were interested in continuing their post-secondary education endeavors and began, but did not finish, their pursuits. Zoey (21yo) had completed 3 semesters of college in a program designed for students with special needs but left following a traumatic experience. Oliver (19yo) had participated in some college programs including a summer drama class, but had not officially matriculated in a college or university program. Overall this matched other research indicating the relatively low rates of post-secondary education for people with intellectual and developmental disabilities as compared to the general public and people with other disabilities [30].

Participation in post-secondary education did not imply long-term success or ease in accomplishment. Eleanor no longer worked as a nursing assistant and had trouble with state board exams initially:

I went to college; I went to nursing school. That was 2 years for that. I was a certified nursing assistant for a while, not anymore ... Those state boards are tough, I blew it the first time.

We also noticed low rates of employment and income. The majority of primary participants (n=7) reported an income below $10,000 a year, our survey’s lowest income category, and the remaining primary participant reported an income between $10,000 and $20,000, our second lowest income category. None of the participants reported having full-time employment, 3 reported having part-time employment, 1 was self-employed at home, and the remaining 4 all reported having no employment but actively volunteering at organizations they were personally interested in. Of
particular note, although none of the participants worked full-time, none chose to be unemployed and inactive in the community either. Rather, every primary participant had some active role in the community, whether paid or unpaid, that they chose to participate in usually on at least a weekly basis.

None of the younger participants (ages 18-21) lived independently; they all lived with family members in a single family home and all participated in the study along with one of their parents who were their primary caregivers. Of the remaining primary participants all those that participated individually lived in an apartment independently with the exception of Emily who lived in a single family home independently, although her mother, Elizabeth, lived nearby and visited frequently.

Abigail was the only primary participant to have been previously married but is now divorced. All other participants have never been married and no primary participants have any children. This may be in part due to the age of several of our primary participants, four participants being 21 years old or younger. Although all participants were over 18 years old there was still a sentiment to delay interpersonal relationships to a later age:

[After being asked his marital status]

Oliver: Nope I'm not part of that yet. I'm too young for that. Maybe when I’m 24 of course.

David (Father): No rush.

Transportation dependencies and resources were quite consistent. Nearly all participants (n=7) mentioned utilizing the public bus system (RTD) as a major provider of transportation and also utilized family or friends when available (n=8).

5.4.1.1 Discussion

One of the important pragmatic lessons we learned was using the questionnaire as an informal tool early in the sessions allowed us to “break the ice,” build a rapport, and learn about the personal interests of the participants without the distraction of observing their technology use right away. The participants and their parents seemed quite accustomed to answering surveys about their
demographics and disability backgrounds, so this phase of the session was familiar to them and seemed to help everyone “settle in” to the interview. It also provided an opportunity to digress in conversation and learn about the personal interests and hobbies of the participants which helped guide the system testing later on. By discussing participants’ hobbies and interests early, we were able to generate ideas to later test while observing web use and SimpleWebAnywhere use. Participants often had difficulty with idea generation when put on the spot later in the session (for instance when we asked what types of sites they visited at home) so referencing ideas they brought up organically earlier in the session was a nice method to fallback on interests they were known to have. We recommend that future researchers in this space offer a method to help ease participants with cognitive disabilities into the study without making them feel “on the spot” immediately and a simple survey on personal backgrounds worked well for this purpose.

As noted in previous research, we often observed inclinations towards acquiescence by our participants [24]. We attempted to avoid this by asking open-ended questions, going through the survey interactively, and reading all options aloud before asking for a response to multiple choice questions. We also noticed that it was not just the primary participants that had a strong tendency to acquiesce to questions. In several instances, the primary participant would answer what we presume was honestly (often a neutral answer) and the parent would interject and give a stronger response, or lead the primary participant to give a strong response, that catered to what they thought we wanted to hear as researchers. This was often obvious after we clarified that we were not necessarily trying to categorize individuals to any particular metric. However, we stress that we do not consider the survey data to be precise or perfectly representative of our participants. Our intention was to use the survey as a platform to interact with our participants, discuss aspects of their lives, and gauge their technology use in daily life. In this regard the survey seemed to do quite well. It spawned a great deal of useful conversation, help put participants at ease, and illuminated their lives and backgrounds as individuals rather than purely data or numbers. Unexpectedly, it also opened up the ability for many of the participants and their parents to interact with each other and discuss stories in depth. We found this to be a particularly helpful aspect of the study. By
asking many of the survey questions and letting both parents and children discuss examples and stories, we found that they themselves would begin telling details, asking questions, and providing insight into aspects of their lives in a mutual, organic way that shed more light on topics than the survey would have alone.

5.4.2 Disability Backgrounds

We asked each primary participant about their disability background from two perspectives (Appendix B). The first was to determine generally which categories of disability they self-identified as having and the second was split up by disability category with specific options of abilities and disabilities. This turned out to be a beneficial approach since a few of our primary participants self-identified inconsistently on these questions. For instance, in response to “Do you have any of the following disabilities?” both Oliver and Eleanor responded that they did not have any cognitive or learning disability. Emily responded that she did have a cognitive disability, but when asked what cognitive and learning impairments she had both her and her mother indicated that Emily had no major functional limitations. Emily was able to read content she wanted to, using a dictionary when necessary, and was able to use a calculator for math problems, and did not encounter many roadblocks in her daily life. However, by receiving supports from their referring organizations we knew all the primary participants were already verified as having a cognitive disability and all acknowledged having a disability in conversation at some point before or after these questions were asked directly.

A tangential conversation we had with Oliver and his father before we arrived at this section of the survey provides some clues to the confusion in their particular case:

David (Father): We’re doing the 21 mile ride and I guess that’s, I guess that’s geared because of the trisomy 21. I think that distance was...
Oliver: Which I don’t have trisomy 21 disability.
David: Uhh.. well we keep talking about that. You, you, um, your genes, your cells have it.
Oliver: But I don’t have trisomy 21 though.
David: Well, ok. Well, we’ll keep discussing.
Oliver: Sweet.
David: You’ve worked really really hard to overcome some of the issues in trisomy.
Oliver: Yeah, it looks like you and I are entering a debate here.
David: We’re not gonna, no. We’re not gonna debate. Nothing to debate. You’re a rockstar.

As active advocates in the field of intellectual and developmental disabilities, Oliver and David had a progressive view on defining disabilities. From Oliver’s understanding and his father’s explanation, he himself did not have trisomy 21, rather his cells had it. Thus, when asked if he, as a person, had any cognitive disability he did not identify as such.

Self-identifying with other disabilities was generally individualized with speech concerns being the second most common response (n=4), and mobility/physical disabilities (n=2) and psychological/emotional disabilities (n=2) being the third most common responses.

5.4.2.1 Discussion

The inconsistency in self-identifying as having a cognitive disability and what skills and abilities each individual had caught us particularly by surprise. Given that our participants were recruited via disability support organizations, did not have severe or profound disabilities, and were adults that had completed high school, we expected all primary participants to readily identify as having a cognitive disability. In fact, part of our system design for SimpleWebAnywhere is predicated on this notion. As a web-based service, one aspect of our goal was to see if it would be a viable solution “in the wild.” However, that assumes that individuals would at some point seek out the tool or recognize how its features would benefit them. If a significant population of people with cognitive disabilities that could benefit from the tool do not identify themselves as benefitting from it, they would simply never use it. In other words, the limiting factor for use would likely not be awareness of the tool, but rather not identifying that its features are useful to one’s needs. The evolution of labeling in the cognitive disability space has been a storied one and we appreciate the move from medical labels and overt stereotypes (e.g. “mentally challenged”) to
people first language (e.g. “a person with a cognitive disability”) to nuanced language (e.g. “my cells have trisomy 21”), but it is clear that this progression presents practical challenges beyond communicating with respect.

We found this to be an interesting counterpoint to the needs of the low-vision and blind users on the web. Although many blind users are comfortable to very comfortable allowing for a website to detect whether they are using a screenreader or not [80], many vocal advocates believe this to be a bad idea largely in part because it exposes their disability in a way they feel is unnecessary [81, 87]. For many blind users, there is a refreshing sense of equality knowing that websites can not easily detect and adapt themselves for screenreader usage. A major difference between the two populations is that by definition a screenreader user has identified a tool to assist them with their particular needs and is choosing to use it to get to the point where equality is possible (i.e. accessing a website via a screen reader). We originally designed SimpleWebAnywhere with a similar principle. We would offer the tool to users and they could choose to use it to more easily access websites, but the destination site would not know the end user had any particular disability. However, if many users do not identify as having a cognitive disability or do not realize how certain tools can help them, then we miss a potentially significant number of users that could benefit from the tool simply because they would ignore its benefit to themselves.

5.4.3 Technology Use

We found that the primary participants in the study used computing devices quite frequently and with little need for support. Every primary participant stated that they have access to a computer which fit our expectations given that our recruitment guidelines specifically asked for users that “currently use the web for basic tasks such as performing an online search.” The need for support was low with most participants needing no regular assistance (n=7) and only one requiring “less than 30 minutes” of support each week, our second lowest category, with only monitoring or verbal prompting was needed. When in need, most participants indicated that a family member or friend was available to help them. Jacob additionally mentioned that the Information Technology
(IT) team at his work would help with issues if he had them. Sharing a computer or tablet was largely split based on an individual’s living circumstances. For participants that lived alone personal devices that were not shared, while participants that lived with family members shared devices with other family members though each had at least one device that was predominantly “owned” by them, e.g.:

Researcher: Do you have your own computer?
Oliver: Well I have an iPad, but, my dad broke it.
Researcher: So you have your own iPad?
Oliver: Yeah, my own iPad. And it’s mine. So I treat it with respect and he treats it with violence.

Emily was the only participant to use a computer to budget money which was a result of her running her own home business (cosmetic sales) which was managed on her desktop computer. Most primary participants used a computer for work (n=5) as well as to play games (n=7). Nearly all primary participants learned how to use a computer or tablet via a family member or at school (n=7) while Jacob stated he was self-taught but could not remember how exactly he became familiar with computers in general.

Five of the primary participants had a smartphone and regularly used it, with one wanting one but not being allowed by his parents, and one citing that she could not afford one. Nearly all participants had a tablet (n=7) with most being an iPad and one being a Windows tablet. The only participant without a tablet stated that she wanted one and expected she would use it frequently but could not afford one.

5.4.3.1 Frequency of Computing Use

The majority of our primary participants used a computing device such as a desktop, laptop, or tablet computer “hourly or more frequently” (n=6), our survey’s highest frequency category, while the remaining participants used it “at least once a day” (n=2), our second highest frequency category. The majority of primary participants that owned a tablet used it for at least several
hours a day, if not the majority of the day, on a daily basis. This amount of use was perceived quite differently from individual to individual and parent to parent. In Jacob’s mind, he used it often but self-regulated from using it all day since he thought it would not be healthy: “would that include my iPad too? [Yes] I would say maybe six to eight hours a day. I try to not be on it all day long because it’s not good for you.”

In Oliver’s case, the tablet began to significantly interfere with his daily life. David, Oliver’s father, mentioned that over the course of several weeks Oliver was slowly becoming more irritable during the day and more difficult to work with. He was tired throughout the day, talking back more often, becoming non-compliant, and generally becoming much more emotional and moody. At first he and his wife thought Oliver was going through a developmental change. However, one night David woke up to a noise in the middle of the night and noticed a glowing light emanating from Oliver’s room. He discovered that Oliver was watching videos and playing games on the iPad in bed and had been doing so for the past several weeks. At that point he realized the family had purchased the iPad just a couple of weeks before they first began to notice the behavior change. Oliver was staying up all night and discreetly watching videos and playing games, only to be tired with a bad temperament throughout the day due to lack of sleep. To Oliver, this was uncontrollable, so his father had to begin intervening:

Oliver: At night, I might wake up and the iPad sort of calls to me. It calls to me in my sleep. So when I wake up I go to it. And it finds me.

. . . .
Researcher: So the iPad calls to you at night, and tells you to use it?
Oliver: Yes.
David (Father): That’s why we hide it at night.
Oliver: That’s because you don’t.
David: You’d never sleep if we didn’t.
Oliver: It’d be really great if I sleep with my iPad.

This did not ultimately change his behavior however, and David began unplugging the wireless router at night as well to inhibit Oliver from using any devices at night.
To Emily and Elizabeth long periods of video watching were a welcome behavior during the day that filled her time. Emily watched soap operas everyday as one of her main pastimes and discovered how to schedule and record them on her tablet when she missed them on broadcast television due to other activities. Between watching soap operas live on TV, recorded via the tablet, or via a network TV app on the tablet, she would spend most hours most days watching TV. At times, the cable TV would go out but the internet would still be available so she would switch to watching on her tablet. At other times, the internet would go out, but the TV signal would remain, so she would watch on her TV. Elizabeth mentioned that she was a bit nervous when she went on a recent vacation because the TV signal was not working and she knew that if the internet went out, Emily would begin calling her constantly. Having at least one of the two services available ensured that Emily’s time was comfortably occupied and she would be self-sufficient during that time.

Overall, most participants echoed similar patterns of use for computing devices but not always to the same amount everyday. Nearly all participants would spend several hours per day, usually in the evening or at night, using a tablet or computer for entertainment purposes. Videos, movies, and TV shows were the most common entertainment source (see section 5.4.4) with gaming being popular as well.

5.4.3.2 Gaming Use

Using computing devices for gaming was quite common but not as ubiquitous as watching videos or browsing webpages. Most participants played games daily and often for hours per day (n=5) while one participant only played “a tiny bit” and two largely avoided it. Similarly to the number of hours spent using a device, the participant’s attitudes towards gaming varied significantly. Eleanor tried actively to play a lot of games and had a variety she was interested in ranging from bowling to image hunts to Scrabble. Abigail and Oliver were both big fans of the “Angry Birds” series of games and played them extensively. Of those that played games, all mentioned at least one puzzle game that they played often. Jacob, however, mentioned that he stopped playing games altogether:
I mean, I used to because I remember when I was younger I’d play games all the time, I’d get computer games constantly and now since I’m older it’s like I just use [the computer] for you know, research purposes or job hunting right now.”

Notably, Oliver seemed to be particularly good at a complex numbers-based puzzle games called Numbrix and Pente. David noted that:

[Oliver] does these faster than I can. This is one of the mystifying, mystical kind of things, he’s a savant in figuring this stuff out.

....

He can, look, he just did one what seven, eight steps ahead ... it’s just an example of how technology reveals strengths as well as therapy and teaches new skills.

David saw puzzle games like this as “cognition stretching games” that he had been using to teach Oliver new skills from “early on.” David liked using the tablet, and any apps on it, to either empower Oliver or help him develop cognitively in any way possible. They were also users of Duolingo, a foreign language learning app that incorporated gamification principles into its design. David pushed Oliver to use “cognition stretching games” as much as possible but admitted that it was not worth fighting entirely against other types of entertainment that were less educational or mentally stimulating.

Across participants, gaming was viewed with many different perspectives. Opinions varied between treating it as an active hobby, a childish behavior, and even as therapy and education.

5.4.3.3 Discussion

We found the prevalence of tablet computers and access to smartphones quite surprising. After speaking to numerous people in the cognitive disability space, especially teachers and educators, one of the most cited ways to improve technology access for people with cognitive disabilities was to make tablet computers more widely and cheaply available. Although the primary participants had a low annual income, access to different computing devices did not seem to be a major concern. Most participants had at least a tablet computer and most had easy access to a laptop, desktop, or smartphone. Although the sample size was relatively small, the proportion of participants that
owned a tablet was still quite high. This is perhaps due to relative market saturation of tablets in recent years and possibly a wider availability of older and alternative tablets. For example, one participant mentioned that the tablet she was responsible for was formerly a family member’s.

No participants mentioned having difficulty using computing technology as a whole; all primary participants stated that they needed little to no assistance to accomplish their main goals in everyday use. In fact, many parents often cited that their child knew more about the technology than they did and could figure out minor problems more easily than themselves. Oliver even mocked the question and stated that the most difficult part about using Netflix on his iPad was dealing with his parents (who often controlled when he could and could not use it). The issues that did arise were usually not at a user interface or technical level but often stemmed from a more social or interpersonal interaction. Parents mentioned that they would supervise to let their children know “what not to do” or only need to intervene when major issues surfaced. For example, Emily was able to handle most technical problems herself but could not understand her internet service provider’s phone support so her mom would have to call on her behalf when the service no longer worked. Other issues tended to be at a value system level. Parents would try to help their children regulate what a “healthy” or safe amount of usage was per day or ensure that good habits were being followed such as the case in Oliver and David’s interaction over iPad use above. Many times, it was simply that the primary participant often had lower self-control and would use technology excessively so it became a family values concern to help decrease the overall amount of technology use. It should also be noted that technology helps highlight where an individual’s strengths and prowess may exist. Many treat people with cognitive disabilities as having practical abilities below those without disabilities across many dimensions. However, as Oliver’s skill in math-based puzzle games shows, people with cognitive disabilities may actually excel beyond people without cognitive disabilities in particular skills and abilities and this should not be neglected due to other traits.

The rationale and values behind the amount of technology used and games played in each participant group continued to highlight the distinct needs that each participant group had as individuals and independent families. Even though trends and commonalities in behavior existed
superficially, much of the rationale and belief systems behind those behaviors varied and should be taken into account as researchers continue to design and create systems for this population. Behaviors that are ostensibly similar may have very different motivations ranging from feeling safe and comfortable at home to lacking self-control and giving into impulse. These nuanced backgrounds are important to discuss, understand, and inform future work in this area.

5.4.4 Web Use

All of our participants had internet access at home while the majority also used the internet at a secondary location such as work, school, or a local public library (n=5). The frequency of internet use matched the frequency of computer use for each participant. Those that used a computer at least once an hour also used the internet once an hour and the same for those that used it at least once a day. Accessing the internet was the predominant reason to use any computing device for each participant. Most participants did not need any support or assistance to use the internet (n=6), while the remaining 2 mostly required monitoring by parents to control access and posting to social media (e.g. Facebook) and to avoid accessing “inappropriate sites.”

The majority of participants used a computer or tablet to write and communicate with friends and family and predominantly used Facebook (n=7) and email (n=8). One participant preferred communication over texting and usually used her phone instead of Facebook or email. Computers were also used to complete homework, write speeches, create and keep lists, fill out job applications, update resumes, write letters, write books, and maintain contacts. Most textual work was quite varied and inclusive of many tasks that are common.

All participants were familiar with and comfortable using a web browser. No participant had any significant struggle using Google Chrome, Mozilla Firefox, or Microsoft Internet Explorer on a laptop or desktop. They were familiar with the layout, controls, and general behavior of what a web browser does and how to use it. Participants that owned iPads and iPhones also mentioned not only being familiar with but often using Safari to browse the web from their mobile device. Furthermore, participants did not discriminate between browsers. Participants mentioned using
whichever browser appeared as a consequence of an action they took and did not try to switch to another browser or change the default browser preference in any way, and this was observed during the sessions. This pattern also determined which websites were often visiting including search engines. Abigail mentioned using Yahoo, Google, and Bing to perform searches based on whichever one simply appeared with the results of a query, which was essentially device dependent based on the default settings of the environment.

5.4.4.1 Online Video

The most common use of the web by participants was to watch online videos. Every participant mentioned watching online videos predominantly on a tablet, if owned, or on a desktop or laptop computer. Online video usage was almost exclusively for entertainment and often was an on-demand supplement to a participant’s other interests in mainstream media or pop culture. For instance, Zoey was a fan of the “Pretty Little Liars” television show and often used YouTube to watch content related to the show including clips, interviews, fashion analysis, etc. Oliver was a fan of the “Glee” television show and watched many clips of the show, particularly the musical and dance excerpts. Jacob was a sports fan and often watched game highlights, analysis, and industry clips. The variety of mainstream media related content was diverse too. Participants mentioned watching TV episodes, clips of TV shows and movies, promotions for TV shows and movies, old versions of TV shows and movies, music videos, etc. However, viewing was not limited to content connected to mainstream media. The types of videos also diversified to include video game walkthroughs, fan-made animated shows, and fan-made tribute videos or cover songs. Netflix was also a popular choice for TV episodes and movies as were network sites (e.g. abc.com) and other streaming providers (e.g. Hulu).

A common feature that was well liked by primary participants was the ability to find and immediately play related content after a video clip finished. This avoided the need for any participants to have to restart their content seeking workflow to find another clip to play. However, a couple of parents were displeased with this feature as it made it too easy for the primary participants to
spend hours upon hours watching videos without doing much else which led to fixation behaviors.

5.4.4.2 Websites and Browsing

The most common methods for navigating to and around websites was search and image clicking. At some point in the study, every participant used a search engine to find a website they were interested in or find content they were interested in. The most common approach was to type a non-fully-qualified domain name into the browser address bar (a.k.a. omnibox) and then find the best match in the resulting links. Several participants also preferred to use Google’s Image Search feature to look at a large amount of content that matched their query. In particular, Abigail preferred this approach to search for “cats” which she did often and frequently (Figure 5.1). Samantha used image search for most of her queries including for cars (Figure 5.2), trucks, and boats.

![Figure 5.1: Participant image search for “cats.”](image-url)
Generally, anything that interrupted a participant’s workflow became a relatively big error to overcome. For instance, any participant that wanted to sign-in to a website during the study had a difficult time remembering the email address and/or the password they used for that website. Additionally, interstitial interruptions would either confuse the primary participant or cause them to quickly return to the page that came before. In one instance, Oliver was trying to show us a game he liked to play and clicked the logo for it from the software developer’s website. However, a full window interstitial advertisement popped-up and Oliver almost immediately clicked the back button and started looking elsewhere for the game. As soon as Oliver saw the advertisement he thought that the wrong destination had been reached and navigated backward rather than looking for a way to dismiss the advertisement and continue on to the desired content. This interruption in his workflow, however, was never recovered from and he never found the game he wanted to play. This also occurred with YouTube advertisements that appeared before the video clip participants wanted to view.
5.4.4.3  Online Shopping

None of the primary participants or their parents were very comfortable with online purchasing by the primary participant. In most cases, the participants simply did not make purchases online. However, Jacob mentioned he had on occasion purchased sportswear online, albeit reluctantly, to send to family, as well as DVDs for himself. Elizabeth provided Emily with a debit card to use for small purchases on Amazon, but checks the balance frequently and ensures all the charges are valid. Elizabeth once noticed a charge for a $99 Amazon Prime account which she knew was unintentional and had to call customer support to get it reversed. Although she mentioned the process was relatively easy, it reinforced her desire to oversee and supervise the transactions made by Emily on a regular basis. All participants were concerned about fraud, security, and privacy violations as their major deciding factors for not allowing or supporting online purchases.

Several participants also mentioned that they simply enjoyed going to a physical store more than shopping online. They liked the experience of leaving the house, going to the store, and being part of the community. This was also a large motivator for not shopping online. Some participants, like Jacob, saw this as part of their advocacy goals, but others, like Abigail, simply enjoyed the experience and preferred physical stores to online ones.

5.4.4.4  Discussion

Although our participant groups had a diverse set of cognitive disabilities, a few commonalities in web usage patterns became clear throughout the study. Participants often discussed only a few websites that they frequented often rather than a large number of websites that they visited as needed. Often, these sites provided a wealth of content and were relatively well known. YouTube was popular amongst all participants, and Zoey, for example, frequented a small number of fashion sites including Seventeen Magazine and Twist Magazine. Abigail and Samantha frequented Google Image Search quite often, which would often lead to a much wider variety of websites in general, but their starting point was relatively consistent.
It was also clear that nearly every primary participant preferred images on websites and was visually-oriented while reviewing the content. Often if a page did not have images or videos the participant became quickly disinterested. Complementarily, websites with lots of images and videos were highly engaging and the participants focused on and discussed the images far more than the text. Many of the sites that participants mentioned frequenting a lot (e.g. Seventeen Magazine, Twist Magazine, YouTube, Pinterest, Instagram, etc) are notably all very visually-oriented sites with many pictures and little text. Text-based sites were visited occasionally, but overall visually-oriented sites accounted for most web use.

Search features that worked well were also critical to successful use of a website by nearly all participants. Often the search engine each participant used would take them directly to content, however, in instances where participants used a search engine only to get to the root of a website, they often looked for a search box as their first destination thereafter. This was particularly prevalent on YouTube for instance. Not only were search boxes important, but every participant used the autocomplete suggestions to finish their queries rather than completing their own. Search boxes with autocomplete seemed like the best navigational feature to have in order to avoid workflow interruptions and allow each user to get to the content they were seeking as quickly as possible.

The lack of online shopping use supported other observations that we had of our participants. Often our participants mentioned that they are not busy and have lots of free time, hence the ability to spend lots of time online. Shopping physically in local stores not only offered what was perceived as a safer, less fraudulent, and more secure way to purchase goods, but also a worthwhile task that took up time and gave participants a purpose and goal for the day. It essentially provided an opportunity to stay active in the community and thus provided a strong counterpoint to the use of online shopping which provides convenience and time savings as goals.

5.4.5 SimpleWebAnywhere Analysis

After observing how participants used the web using default software and web browsers, we introduced them to the SimpleWebAnywhere tool. We explained what the tool was, how it worked,
and gave a quick demonstration of its abilities. Afterward, we allowed each primary participant to choose a site and use SimpleWebAnywhere. We were quickly able to learn what aspects of the tool worked well and did not work well for people with cognitive disabilities. More importantly, however, we were able to observe more subtle nuances and behaviors about what can improve web accessibility by observing what went right and what struggles were encountered.

One of the most noticeable and pervasive issues with SimpleWebAnywhere was that it depended on many disparate systems causing very slow and irregular response times. This was almost immediately noticeable by users. Participants would type in a destination URL and would often need to wait several seconds before any visual changes were made to the screen. It was clear that all of our participants were accustomed to much faster response times. Several participants attempted to click the “Go” button again while others begin fidgeting and wondering if something was wrong until the researcher explained that it was a slow system and we needed to wait. Overall, most participants quickly adapted to the slower speeds and were patient, but it was clear that this was a major issue with usability. Abigail in particular was annoyed by the long wait times and brought it up as a flaw several times. Karen noted that Zoey would also likely not be able to use it: “that will be a problem for [Zoey] . . . she won’t [use it] right now, given her situation, she’ll start to dissociate and is just not engaged.”

The text to speech engine that SimpleWebAnywhere used garnered very mixed results both across participants and within participants. The default configuration for SimpleWebAnywhere was to automatically begin reading the text on a website immediately after it finished loading the page. At first, most users liked the voice and enjoyed it, but this impression quickly faded and most users found it “annoying” or “weird,” often in less than 30 seconds of use:

Eleanor: “Oh this makes it easier, it talks! Oh, a lot better.”
17 seconds later: “Shoosh (clicks button to disable speech).”

Zoey: “The voice is good, it has a certain ring to it. I do like it.”
Karen: “Really? Are you being nice? Because it was talking when we had it on that website this morning and you were annoyed and I was annoyed.”
Zoey: “I was annoyed.”

Most primary participants and parents liked the idea of having text to speech and highlighting easily available but quickly brought up several concerns. Having the voice run all the time was simply too annoying for most participants. Having an on-demand voice would likely work much better, for instance if words were spoken on hover or on selection by the mouse. The voice itself was also too artificial and unnatural sounding which put off most participants. In later sessions, we demoed modern, smoother text to speech engines (specifically those included in the ChromeVox screenreader extension [29]) to much more praise and less annoyance. Participants enjoyed not only the smoother speech but noticed that the pronunciations were more accurate, particularly for foreign or hard to pronounce words such as “pecorino cheese” which caused David to exclaim “Wow, the quality of that is really good!” Lastly, the speed at which SimpleWebAnywhere was able to retrieve and playback verbalizations was far too slow. Participants found it distracting to wait for several seconds to have highlighted text verbalized, particularly in the middle of sentences since verbalized phrases were not segmented at the sentence level but rather were chunked with several words at a time.

The other major component of SimpleWebAnywhere was the content extraction feature, labeled simply as “Simplify Page” in the interface. This relied on the Readability API to extract main content text [59]. Although the Readability API suggests that it would work on a variety of content, our experimentation found that it really only benefited a small group of webpages. Particularly, those that modeled news or encyclopedic articles. As such it worked well on mainstream news sites like “The New York Times” and “Al Jazeera” (Figures 5.3 & 5.4) as well as Wikipedia. With articles and long-form text, it worked quite well and users saw several benefits. They liked the reduced number of visual elements, wider text layout, and lack of distracting content as we expected. However, it often removed images that were relevant to the story and produced a text-oriented rather than multimedia presentation. Given the very visually-oriented preference of the participants, as discussed above, the was largely a regression in usefulness. Additionally, the con-
tent extraction was often aggressive on sites that lacked any form of article content. For instance, participants that used the system early in the study were greeted with an over-simplified page for google.com that was completely unusable (Figure 5.5). To workaround the over-simplification of sites that were critical to participants’ workflows we modified SimpleWebAnywhere to have a whitelist of domains that were never simplified and populated it with the major search engines which helped future participants in the study.

![Figure 5.3: SimpleWebAnywhere without simplification on an “Al Jazeera” news article.](image-url)
A downside to using a third-party component for a portion of the system was the lack of control and visibility into its behavior. The Readability API cached results to queries for content extraction. However, these caches were often significantly out of date or incorrect and caused a great deal of confusion. Abigail attempted to simplify the msn.com homepage and ended up with...
a cached page that was not only from a previous year, but was customized to have regional results from Virginia rather than Colorado, where the study took place. Jacob also encountered cached results on a sports website that fit the article format more closely, yet that content was over two years old.

Another component of SimpleWebAnywhere that made it difficult to use was not something that it did, but rather something it did not do. As noted above, it was quickly discovered that most participants rarely entered a fully qualified domain name into the URL bar of a browser. The same was true for SimpleWebAnywhere which expected a resolvable URL. Participants would enter search queries into the URL bar and expect it to return a search results page for the URL or autocorrect into a valid URL. Since this functionality did not exist, it often threw error messages. However, this state did provide us more time to observe how participants began to overcome this error state. It was very apparent that all primary participants had difficulty at this point. A combination of poor spelling skills, difficulty controlling the mouse and keyboard cursors, and not fully understanding URL formatting requirements caused URL correction tasks to be very difficult. It usually took several attempts before a primary participant was able to correct a misspelled or incorrectly entered URL into one that worked despite assistance from either a parent or a researcher.

Despite some major usability issues, participants were quite tolerant of SimpleWebAnywhere and generally liked the results when they worked well. Additionally, most participants liked the ideas the system was presenting and wanted a similar system that was simply more robust and error tolerant but with similar features. Parents in particular liked the system, despite thinking it would get low usage in its tested state.

5.4.5.1 Discussion

The intent of building the SimpleWebAnywhere system was not to build a perfect system that worked flawlessly, but rather one that was underdesigned and an early prototype to help receive feedback from users about what potential tools could help them access the web more easily. In those goals, the system generally succeeded despite participants experiencing major usability issues. By
testing the system with users with mild to moderate cognitive disabilities we were able to gather several insights that were not visible in the earlier prototyping phases.

One of the most valuable insights we gained from testing SimpleWebAnywhere was that many participants did not, in fact, always prefer less content or simpler content presentations. Rather, most participants actually preferred each webpage to have more content rather than less, especially if it included any images or videos. This was particularly salient with Oliver who expressed that he really liked the Wikipedia page listing “X-Men” characters (Figure 5.6) [83]. This Wikipedia page has over 20,000 words listing characters and their details and notably only 1 picture, at the very top of the page. When asked what he liked about the page, Oliver stated that he liked “all this information.” He seemingly enjoyed getting immersed in reading all the details and minuitia of the page rather than being put off by it. The same was true of Oliver and recipe websites. One of his favorite activities was to read recipes aloud from online pasta manufacturer websites (Figure 5.7). Oliver particularly enjoyed having the newer text to speech engine from ChromeVox read through these recipe sites as well.

Figure 5.6: Screenshot of the Wikipedia page listing “X-Men” characters.
Oliver was not the only one that preferred complex, content heavy sites however. Abigail particularly liked information dense sites, but she attributed that to her being on the Autism spectrum. Jacob also preferred high information density, particularly for sports since he was a big sports fan. Zoey also preferred content heavy sites, but preferred them to have lots of images rather than text.

Another surprising finding was that the particular modifications SimpleWebAnywhere made that users benefitted the most from were simple text formatting changes. Nearly every participant mentioned that they liked that the simplified version of pages had larger text that was more legible. They also liked that the text was not constrained to a narrow column in the middle of the page but rather stretched the whole screen. These two modifications made the text feel and look much easier to read. The simplification also made labels with low contrast ratios easier to read and stand out. Zoey and her mom actually did not notice that the original version of a page they were viewing had text labels under each picture until they simplified the page (Figures 5.8 & 5.9).
Figure 5.8: Screenshot of a website showing trucks with low contrast text labels below images.

Figure 5.9: Screenshot of SimpleWebAnywhere showing trucks with high contrast text labels below images.

The larger and clearer text raised a concern with David that was also unexpected. David was quite concerned with Oliver’s posture and ergonomic position when using smaller computing devices like a tablet or laptop. He noticed this both with websites and sites like YouTube:
You know we didn’t talk about display and graphics size, you know, font size and magnification. He’s got a bad habit of (gestures hand very close in front of his face) getting real close and he doesn’t think to do a display adjustment. He’ll do that with even YouTube. You know it pops up in a small window. He knows how to [enable full screen], he’s so driven by accessing the video that he won’t take the time to do it. So, I don’t know if there’s, if your end product will place a cookie that would remember what an ideal size is and try to manage things toward that.

While testing SimpleWebAnywhere, we noticed that Oliver did move his head farther back from the screen when larger text was present. For David this was promising, he realized that he could perhaps improve Oliver’s posture and ergonomics by adjusting the content size both for videos, which Oliver watched for long periods of time, as well as text, which Oliver liked to get as close as possible to on the screen, especially when reading recipes.

Between study sessions, we mentioned to David that there were extensions to handle both the YouTube video size as well as text content size. During the third session, we asked why he had not installed these tools to which he responded:

Anything nowadays, to somebody who’s not into computers, it’s just overwhelming. And I’m reasonably [computer] literate. And also changes come so quickly ... and being a parent, the spectrum of quality as to whether or not this thing really works. Then you have to think, ok, one of these things is supposed to work and it’s not supposed to slow your computer down, the other one is supposed to be better but it slows your computer down, you know all these kinds of things. So there’s an intimidation factor just because I don’t who you can trust. And then there’s stuff you keep thinking how much of it sounds good but it really is just either flat out a virus or a vehicle or spyware. So it’s kind of hard to know to do that.

This intimidation and frustration that David is feeling shows part of where SimpleWebAnywhere can help parents that do not feel they have the time to cull the software that is available online. By providing a safe, secure, stable system upon which they can enable various adaptations that address their needs, a system like SimpleWebAnywhere can provide a great deal of utility.

Overall it was clear that robustness and quality is important if a tool to help people with cognitive disabilities is developed for long-term public use. The cumulative effect of many small issues and even some large issues led to a system that users were willing to tolerate in a research setting, but likely not willing to tolerate long-term. However, some participants did keep trying
and testing the system throughout the study and afterward showing their interest in the system.

### 5.4.6 SimpleWebAnywhere Log File and Maintenance Analysis

One measure we used to evaluate the utility and efficacy of SimpleWebAnywhere was whether participants were using the system outside of scheduled testing sessions. If participants were sufficiently motivated to use SimpleWebAnywhere on their own, then we believed that the features were of sufficient interest and use to the cognitive disability community and provided reasonable value. While introducing SimpleWebAnywhere to participants, we informed them that any use of the system would be tracked in the form of web server log files that we would analyze throughout the study. Furthermore, we discussed with participants the purpose of the “Participant ID” field in the SimpleWebAnywhere interface and how it could be used to voluntarily identify that they were using the system. Since SimpleWebAnywhere was also publicly reachable there was potential that users that were not part of the study could use the system. Since public users would not have valid participant IDs, the field also provided a mechanism to quickly determine how many public users were interested in SimpleWebAnywhere’s functionality in addition to our main study participants.

SimpleWebAnywhere tracked several common data fields on the web server including each requests’ date and time, originating IP address, and URL. In addition we tracked SimpleWebAnywhere data such as the aforementioned participant ID and booleans for whether a user had the simplification feature enabled and the text to speech feature enabled.

Overall we expected the usage of the system to be low outside of the scheduled sessions. However, after running the system for several weeks, we noticed that we were receiving increasing amount of web traffic in the order of hundreds of thousands of requests. Since this seemed high for an unadvertised system, we investigated the log files and determined that many of the requests had source IP addresses from China and were owned by the Baidu search engine [6]. The Baidu search engine was crawling the SimpleWebAnywhere webpage, however, since SimpleWebAnywhere used a proxy behind the scenes the number of possible webpages to crawl and index was indeterminate. Essentially, SimpleWebAnywhere was providing a mirror of all webpages it could access and masked
them under its own domain name thus creating a virtual replica of the public internet to the web crawler. To avoid this situation, we had previously annotated the SimpleWebAnywhere site to not be indexable by web crawlers via the “robots.txt” file. However, Baidu did not seem to respect that configuration. As a workaround, we chose instead to reject all requests coming from the Baidu IP addresses as they were negatively impacting the performance of the SimpleWebAnywhere system which solved this particular problem.

After the in-person participant sessions were completed, we chose to leave the system running in perpetuity. We wanted to allow participants to continue to use the system if they found it valuable but also leave it open for public use if others found it useful too. Approximately twelve months after the end of the in-person sessions, the web hosting provider of the servers running SimpleWebAnywhere contacted us indicating that we had vulnerable software running on our servers that was actively being exploited. To avoid further incidents we chose to disable the SimpleWebAnywhere system and make it publicly inaccessible. Investigating the log files showed that over the course of SimpleWebAnywhere’s lifetime it had served nearly one million requests. We analyzed the data further and determined that the vast majority of these requests were from various insecurities and exploits and were predominantly used to serve spam emails. Using the “ReputationAuthority” website we found that the majority of the requests served came from a known Chinese spam producing bot with a reputation score of 95 out of 100 (higher values indicate more malicious reputations) [60]. Overall, most requests to SimpleWebAnywhere were by bots, crawlers, or other automated systems. After removing automated systems, we were left with slightly over 10,000 requests we were confident were legitimate versus the over 990,000 we accumulated over the lifetime of SimpleWebAnywhere.

During the second and third sessions with participants, we verbally asked if they had used the system in the time between sessions. Although most participants had not, several users did report using SimpleWebAnywhere in the interim. Generally this was motivated by participants preparing for an upcoming study session or evaluating the system soon after a session. In other words, they wanted to try the system on their own so they could be better prepared to discuss and
provide feedback. Usually these types of usage occurred within 48 hours of a scheduled session. To determine whether participants had used the system based on intrinsic motivation outside of session preparation, we evaluated the log file data and removed entries on a per-participant basis that occurred within 48 hours of a session for that participant. Interim use of SimpleWebAnywhere occurred 18 times by 4 participant groups. Five of those occurrences were within our 48 hour window, leaving 13 instances of use that did not seem related to preparing for a user study session by 3 participant groups. Analyzing the URLs and queries, we found that most of the interim use was similar to that which we observed during our in-person interviews providing consistency to our participants’ stated use of the web. Overall, interim usage included retrieving content for news and current events, entertainment, images, games, hobbies, social networks, and email. Website domains and queries were mostly consistent with in-person observations, though there was some noticeable branching out that included additional hobbies users were interested in and looking up movie listings and times.

5.4.6.1 Discussion

The use of SimpleWebAnywhere outside of the in-person lab sessions highlights that there seems to be value in providing tools that can help people with cognitive disabilities simplify their web experience. Our participants were motivated to try the system at home both in preparation for future sessions and for their own personal use. Although many of the same technical challenges were cited as frustrations at home as well as in the lab (e.g. slow response times), users still tried broadening the range of sites they wanted to use the system on. We believe that these results further support the validity of the approach and the need for more systems like SimpleWebAnywhere to be created, released, and maintained to support people with cognitive disabilities.

By exposing SimpleWebAnywhere publicly and allowing it to run for a period of time that far exceeded the in-person study’s timeline, we were able to gather further insight into the risks and costs of producing web-based assistive technology. An unexpected but significant challenge for creating web-based assistive technology is simply the maintenance of any solution over time. In our
case, a significant amount of time went into managing the accidental and purposeful exploitation of the system by automated software. It should be noted that releasing cloud-based AT alone is not enough, the configurations of the system as well as software patches, updates, and performance updates must all be accounted for in the long-term planning of the system. Many aspects of online hosting are constantly in flux ranging from the software running on the servers to the standards determining how browsers communicate. Keeping track of and ensuring proper functioning of all the software is a significant cost associated with online tools, some of which is immutable. Overall, however, we feel that cloud-based assistive technology and an intercommunity approach has shown itself to be very useful to users, has lots of potential for growth, and worth the related maintenance costs.
Chapter 6

Conclusion

We were surprised that while much of the demographic information we collected matched our expectations going into the study, the information we collected on technology use, web use, usability challenges, and usability success stories did not match our expectations. Cognitive accessibility for the web has often been framed in terms of simplifying the user interface and reducing complexity in terms of user interface components, content length, and content reading difficulty. Suggestions such as content summarization, content extraction, word simplification and replacement, and text to speech have all been offered as potential aids to increase the ability for people with cognitive disabilities to use the web. As such, we predicted that our primary participants would perform basic tasks successfully but would likely encounter fundamental barriers with user interfaces and content that would limit their use of the internet overall in their daily lives. What we found, however, was that many of these assumptions were not validated and likely apply to a smaller set of populations than originally believed. We discuss these assumptions as well as implications for cognitive accessibility tools for the future below.

6.1 Technology and Web Use is Higher Than Expected

We found that technology and web use was high within our participant group, both in frequency and duration. All of our participants used a tablet or computer to access the internet at least once a day, and usually many times a day, for several hours throughout the day. Additionally, very little active assistance was needed. Most of our participants used the internet without
supervision the majority of the time and only required monitoring to avoid excessive technology use, incorrect purchases, and some inappropriate content. In other words, supervision was not needed to overcome technical or user interface challenges but rather only behavioral challenges. This generally contradicts the common messaging within the cognitive disability community which asserts that internet use is quite low in this population. We recognize that our recruitment focused on individuals that have mild to moderate impairments and may be restrictive in generalizability. Individuals with severe to profound cognitive disabilities likely have lower rates of internet use than we found. However, we feel that our findings are an indicator that both technology and internet use may be higher than realized for those with mild to moderate impairments and that the real world barriers to become daily technology users is lower than expected for many people with cognitive disabilities.

6.1.1 Entertainment is the Primary Use Case

The main use cases for computing devices amongst our participants were for entertainment purposes. Video watching, image viewing, and gaming were all quite common across our participants with few barriers encountered in these tasks. Although many researchers focus on productivity and educational aspects of technology and how they can benefit people with cognitive disabilities, it is important to recognize that entertainment plays a very large role in technology use today. By acknowledging how common entertainment use is and what features make it particularly engaging (e.g. recommended videos to watch next), we can inform future work in cognitive accessibility tools and interfaces to improve engagement, education, and productivity across many domains beyond entertainment alone. In particular, the engagement observed with highly visual content suggests that we should push to include more videos, images, and interactive content on websites to increase cognitive accessibility. Furthermore, a larger focus should be placed on creating content that is immersive and interesting rather than sacrificing these traits for the sake of simplicity.
6.1.2 Games Can Highlight Extraordinary Abilities

It is also notable that the games that participants played were mainstream, relatively popular, and not targeted specifically to people with cognitive disabilities. In some instances, the primary participants were significantly better at playing games than their parents or peers without a cognitive disability. This highlights that certain games revealed extraordinary cognitive abilities rather than impairments and opens up possibilities to discover individual strengths in users and adapt content toward those strengths. In addition to focusing on cognitive impairments for accessibility, we should also take into account that many individuals have increased abilities in other areas of cognitive processing and leveraging those abilities may be able to compensate for an impairment in powerful ways.

6.1.3 Online Shopping is Not Frequently Used

One area where web use was lower than expected was online shopping. None of our participants felt entirely comfortable and secure shopping online and preferred visiting physical stores as a component of being part of their community. This finding highlights that many of the barriers to increased web use are not related to the user interface directly but rather the perception and context around web use. Currently, online shopping is still viewed as somewhat risky to individuals with cognitive disabilities and their families which is the limiting factor rather than the user interface itself. Thus cognitive accessibility in this domain incorporates managing the impression of safety and risk rather than the ability to complete a workflow. It is also important to note that shopping physically in a store was a core aspect of community participation to many of our participants. Although we view the web as a powerful tool to increase the productivity and convenience of many daily tasks, it is worth noting that providing mechanisms for individuals to stay connected, visible, and participate in their physical communities is of high value and importance. Ostensibly, providing convenient services to people with cognitive disabilities that allow individuals to stay at home may seem like a great idea, however, providing more opportunities for individuals to leave
the home and be active community members should likely be prioritized as well.

6.2 Efficacy of Adaptations

6.2.1 Content Adaptations

One of the common recommendations from the cognitive accessibility community is to keep content as simple and short as possible to help the widest range of abilities and disabilities. Specifically, long-form content is often described as being hard to read, hard to comprehend, and can be overwhelming. Although we acknowledge this recommendation is helpful for many users, we were surprised to find that the opposite is true for many cognitive disabilities too. Several of our participants strongly preferred content that was long, detailed, and complex. Seemingly, this content was found to be immersive and captivating. Our participants had little trouble navigating and exploring complex content that was presented in an organized manner, likely because they found it personally meaningful and interesting. This finding highlights that often cognitive disability recommendations are focused more on the presentation of the content rather than the relationship of the content to the user themselves which may be a stronger influencer on their overall ability to consume and enjoy the content. We suggest creating immersive, relevant content that is more meaningful to a user will increase its inherent accessibility and usefulness.

6.2.2 Interface Adaptations

The cognitive accessibility community recommends that user interfaces focus on simplicity and minimalism to increase usability, but often do not give direct suggestions for how to accomplish this leaving many technologists to be interested in improving the state of cognitive accessibility but lacking clear guidance. Simple, clean, interfaces with few controls and few miscellaneous elements are often said to be preferred by people with cognitive disabilities, however, we did not observe a strong preference for cleaner, simpler interfaces from our participants. Rather, the main visual changes that participants seemed to prefer were larger text, higher contrast ratios, and
wider presentation of text on screen. Providing more control for a user to increase text and content size would be beneficial, but even when such controls are available, users often do not use them (e.g. zoom and full screen support on videos). Most participants left most settings on their devices, browsers, and in applications at the default settings. As such, we believe that tools that automatically or more intelligently increase text and content size would be the most beneficial to people with cognitive disabilities. If tools to automatically increase content size are not available, we recommend technologists and content creators simply focus on increasing all content on their websites to be as large as possible. As direct, actionable advice, we recommend increasing font sizes, raising text contrast levels, increasing video and image sizes, and widening webpages as easy, yet incredibly powerful, cognitive accessibility improvements.

6.2.3 Interaction Adaptations

Difficult interactions are not restricted to particular elements or pieces of a static user interface. One observation we found was that major barriers and confusion appeared during transitional moments in a workflow rather than on content itself. For example, if a user clicked on a thumbnail, they generally expected to see the image they clicked on in a larger format or have related content appear instead of unrelated interstitial advertisements. Participants also had difficulty with entering correct and well-formatted URLs and finding the current websites when domain names were not obvious. We believe that unexpected content during transitions should be avoided and expectations should be matched as closely as possible to improve accessibility. Furthermore, transitions as a whole should receive more focus as a space to increase accessibility. Our participants had the most difficulty with workflows, transitions, and slow responsiveness rather than with the complexity of the content itself.

6.3 Intercommunity Approach

Following an intercommunity approach wherein we combined several open-source tools into SimpleWebAnywhere’s personalizable interface was generally well-received. Participants liked the
flexibility of easily being able to toggle specific features on and off and liked the compound effect of having multiple content adaptions running on top of each other. Even though our primary participants did not have major difficulty using sites, we received positive feedback regarding having the flexibility to enable text to speech and content extraction when desirable. However, having content adaptions running for long durations was generally disliked. Participants found that having the text to speech feature run all the time was simply too annoying and the content extraction broke too much webpage navigation. Generally, an intercommunity and modular approach to improving web accessibility is promising, though efforts to succeed in this space must be robust, error tolerant, and have good performance.

6.3.1 Intercommunity Approach on Mobile Devices

Although SimpleWebAnywhere provided positive value for desktop-based web browsing, the majority of our participants preferred accessing the internet via their mobile devices. Since web access is more commonly mediated via apps on mobile devices, SimpleWebAnywhere provides less value and utility on mobile platforms since it’s ultimately tied to a web browser interaction model. For mobile platforms, an intercommunity approach can still be used to provide assistive technology that would be helpful for people with cognitive disabilities by using a proxy-based solution instead of a website-based solution. Each mobile device could be configured to speak to a proxy server that would manipulate content requests to provide the requested accessibility features seamlessly without a user interface to use or anything to remember to activate. A major downside to this approach is that each mobile device would have to be individually configured to use the proxy initially. Maintenance of the system would be easier since a public facing website is not required and would thus avoid complications of web crawlers accessing the site and removes the website exploitation risk entirely. That being said, regular security updates and software version upkeep would still be required to maintain and operate the proxy service. Additionally, any APIs that are depended upon will need to be regularly tested and supported as the APIs are modified.

The proxy-based solution would, in effect, perform many of the duties the proxy component
of SimpleWebAnywhere performed. Based on participant feedback, a useful feature would be automatic and seamless advertisement removal via a proxy-based approach like Privoxy instead of a web browser extension [57]. This would effectively eliminate advertisements from websites as well as many interstitial advertisements and in-app advertisements. Other features like automatic word replacement and text summarization could also be integrated into the system. However, given the lack of user interface, features such as text to speech would no longer work like they did in SimpleWebAnywhere. One suggestion participants recommended was that words only be verbalized when highlighted. Instead of the proxy handling text to speech features, an accessibility service on the device could be created to allow users to highlight text and have the text be verbalized akin to how VoiceOver on iOS works or TalkBack on Android devices. Using native text to speech engines would also provide an additional benefit by providing smoother voices with better pronunciation. It should be noted that services running on the device will also require their own set of maintenance requirements. Although the risk of security exploits is lower, maintenance will be needed to test and ensure the service works with operating system and application updates over time.

Since proxy server and accessibility service configurations are setup in the mobile device’s operating system settings, an initial configuration is necessary. However, once the initial configuration is complete, all apps and browsers on the device would benefit from the accessibility features seamlessly. This approach allows us to provide accessibility support to people who do not self-identify as having a cognitive disability since they would not need to perform any additional actions or workflows after the initial configuration (with the exception of the on-demand text to speech example above). In SimpleWebAnywhere’s case, users that did not self-identify as having a cognitive disability were unlikely to visit the website. However, as long as a mobile device is configured once by a caretaker or family member, there is no longer any particular action to remember to enable the proxy-based features.
6.4 Closing Remarks

Although people with cognitive disabilities face many struggles in their daily lives and have many barriers to accessing information online, it is clear that many are active web users and contribute greatly to the online community. Though their needs are often neglected in terms of web accessibility, we hope to have shined a bit more light onto what can help make the web easier to use for individuals with a range of abilities and disabilities. Our goal is to increase access to the wealth of online information available for all people which will ultimately benefit society as a whole.
Bibliography


[38] Hilary Hutchinson, Wendy Mackay, Bo Westerlund, Benjamin B Bederson, Allison Druin, Catherine Plaisant, Michel Beaudouin-Lafon, Stéphane Contrys, Helen Evans, Heiko Hansen, Nicolas Roussel, and Björn Eiderbäck. Technology Probes: Inspiring Design for and with


[74] Umano. Umano. URL: http://www.umano.me.


Appendix A

Participant Recruitment Flyer

Research Study on Simplifying Web Content

Researchers at the Computer Science Department at the University of Colorado Boulder and the Coleman Institute for Cognitive Disabilities want to study the usability of a tool that simplifies web content. The objectives of the study are to gather information about the experience of using the web by people with cognitive disabilities and determine how that experience may be improved using software. We want to conduct interviews to determine how people with cognitive disabilities currently use the web and what challenges and successes they encounter. We will also test the usability of an online software system that modifies the presentation of websites.

Research participation is voluntary.

Would this study be a good fit for me?
This study might be a good fit for you if:
  • You are 18 years old or older
  • You have an intellectual or developmental disability
  • You can currently use the web for basic tasks such as performing an online search

What would happen if I took part in the study?
If you decide to take part in the research study, you would:
  • Answer questions about yourself and how you use the web now
  • Test out a software tool that simplifies web content and let us know what you think
  • Test the tool over 6 weeks and let us know your thoughts over 3 interview sessions
  • You can stop participating at any point during the study

To take part in this study or for more information, please contact Jeffery Hoehl at:
  Email: jeffery.hoehl@colorado.edu
  Phone: 303-720-6191
Participant ID: __________________________

**Background Questionnaire**

The purpose of this questionnaire is to provide us with some background information about yourself and your experience with technology.

The answers you give here and anywhere else in this study are confidential and are not tied to your identity. No one but the researchers in charge of this study will know what answers you put for each question.

**About You**

Age: ____________

Gender: ____________

**Education Level:**

Years of Education completed (circle the highest number of years completed)

| 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22+ |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|
| Elementary/Primary School       | Middle/High School | College/University | Graduate School |

**Work Status:** (check all that apply)

- o Not Working
- o Part-Time
- o Full-Time
- o At Home
- o On-Site
- o Self-Employed
- o Volunteer
- o Job Title (if working): __________________________
Income: (check one for the past 12 months)
- Less than $10,000
- $10,000 - $19,999
- $20,000 - $29,999
- $30,000 - $39,999
- $40,000 - $49,999
- $50,000 - $59,999
- $60,000 - $100,000
- More than $100,000

Current Living Situation: (check one)
- Apartment (alone)
- Apartment (w/ others)
- Single Family Home (alone)
- Single Family Home (w/ others)
- Group Home
- Assisted Living
- Nursing Home
- Other ______________________

If you live with others, whom do you live with?: (check all that apply)
- Family
  - Parents
  - Brothers
  - Sisters
  - Other ______________________
  - Number ______________________
- Friends
  - Number ______________________
- Roommates
  - Number ______________________

Marital Status: (check one)
- Never Married
- Currently Married
- Separated
- Divorced
- Widowed
- Cohabitating

Number of Children: ____________

Do you have access to transportation resources?
If so, please describe: ____________________________________________
Disability Information

Do you have any of the following disabilities?: (check all that apply)
  o Cognitive/Learning
  o Mobility/Physical
  o Speech
  o Hearing
  o Vision
  o Psychological/Emotional
  o Other ______________________

Cognitive & Learning:
  o No Cognitive Concerns
  o Some Impairment
  o Has Difficult With
    o Reading
    o Writing
    o Math
    o Listening
    o Remembering, Memory
    o Paying Attention
    o Other ______________________

Mobility:
  o Walks Independently – No Mobility Concerns
  o Walks With Assistance
  o Uses a Wheelchair

Fine Motor Skills – Use of Hands:
  o Good Hand Skills; No Motor Skill Concerns
  o Some Difficulty With:
    o Eating
    o Personal Care
    o Using Phone
    o Writing or Drawing
    o Using Computer
  o Limited or No Use of Hands

Speech & Communication:
  o Speech is Easily Understood; No Speech Concerns
  o Speech is Difficult to Understand
  o Unable to Speak Functionally – Non Verbal
  o Uses a Communication Device
  o Walks With Assistance
  o Uses a Wheelchair
Hearing:
- No Hearing Concerns
- Decreased or Hard of Hearing
- Unable to Hear – Deaf
- Uses ASL or Interpreter

Vision:
- No Vision Concerns
- Wears Glasses
- Visually Impaired or Blind

Technology Use

1. Do you have access to a computer? Yes No
   If so, how often do you use it?
   - None or less than monthly
   - At least once a month, but not once a week
   - At least once a week, but not once a day
   - At least once a day, but not once an hour
   - Hourly or more frequently
   How much support do you need to use it each week?
   - None
   - Less than 30 minutes
   - 30 minutes to less than 2 hours
   - 2 hours to less than 4 hours
   - 4 hours or more
   What kind of support do you need?
   - None
   - Monitoring
   - Verbal/Gestural Prompting
   - Partial Physical Assistance
   - Full Physical Assistance

2. Do you share computer access with others? Yes No
   If so, with whom? ________________________________
<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Do you have access to the internet?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If so, where from?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Home</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- School</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Library</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Other ______________________</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How often do you use it?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- None or less than monthly</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- At least once a month, but not once a week</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- At least once a week, but not once a day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- At least once a day, but not once an hour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Hourly or more frequently</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How much support do you need to use it each week?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Less than 30 minutes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 30 minutes to less than 2 hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 2 hours to less than 4 hours</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- 4 hours or more</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What kind of support do you need?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- None</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Monitoring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Verbal/Gestural Prompting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Partial Physical Assistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Full Physical Assistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Do you use a computer to write things?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Do you use a computer to budget your money?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Do you use a computer in your work?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Do you use a computer to send/receive email?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Do you use a computer to play games?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Who first taught you to use the computer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- A family member</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Support staff</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Someone at work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- No one</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- School or computer class</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Do you have problems with your computer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Do you have someone to help you use the computer if you need help?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Do you use a digital camera?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Do you use a cell phone (not a smartphone)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Do you use a smartphone (ex. iPhone, Android)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Do you use a tablet computer (ex. iPad)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix C

Semi-structured Interview Prompts for Interview 1

The following questions and prompts will be used to guide an interactive discussion and demonstration of a participant’s web use.

Questions and Prompts for Initial Session (Interview #1)

1. Please tell me about how you use technology in your daily life.
2. What types of computer and devices do you use?
   a. How do you choose between them?
3. What do you do on your computers and devices?
4. Do you use the internet and web?
   a. How often do you use the web?
   b. What types of things do you do online?
   c. What websites do you visit regularly?
   d. What websites have you visited recently?
5. What types of tasks do you perform online?
   a. Do you read news online?
   b. Do you shop online?
   c. Do you find health information online?
   d. Do you use search engines?
   e. Do you find information on hobbies or interests?
   f. Do you use email or social networking?
6. What works well for you while using technology or the web?
7. What does not work well for you while using technology or the web?
8. What would make the web easier/simpler to use for you?
9. Can you show me how you use the web now? Please pick a website you go to often.
   If the participant cannot think of a task to complete, use the following options:
   a. Find a book you are interested in and add it to your shopping cart on Amazon.com (do not complete the purchase; remove it from the cart before moving forward)
      i. Find the book: The Lorax by Dr. Seuss, and add it to your shopping cart on Amazon.com (do not complete the purchase; remove it from the cart before moving forward)
   b. Look up the latest news for your favorite sports team
      i. Look up the latest news for the Denver Broncos
   c. Find which movies are playing this weekend and at what times

[Configure and perform a demonstration of the SimpleWebAnywhere system and show how it manipulates webpage content]

10. What did you think of SimpleWebAnywhere?
11. What did you like about the system?
12. What did you not like about the system?
13. Do you think you could and would use this system?
14. Can you repeat the task we did earlier using SimpleWebAnywhere? (from question 9)
Appendix  D

Usability Survey for SimpleWebAnywhere

Usability Scale for SimpleWebAnywhere
The following questions are to be completed cooperatively with the participant during each visit (Interview #1, 2, 3).

Please circle how much you agree or disagree with each statement regarding SimpleWebAnywhere:

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Neither Agree or Disagree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I think that I would use this system frequently</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I found the system unnecessarily complex</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I thought the system was easy to use</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I think that I would need the support of a technical person to be able to use this system</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I found the various functions in this system were well integrated</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I thought there was too much inconsistency in this system</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I would imagine that most people would learn to use this system very quickly</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I found the system very cumbersome to use</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I felt very confident using the system</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I needed to learn a lot of things before I could get going with this system</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
Questions and Prompts for Follow-Up Sessions (Interview #2, 3)

1. How much have you used the SimpleWebAnywhere system since the last session?
2. What do you think of SimpleWebAnywhere so far?
3. What do you like about the system?
4. What do you not like about the system?
5. Do you think you could and would continue to use this system?
6. Can you show me an example of a time you have used it and what you did?
7. Has the way you use your computer or the web changed at all since the last session? If so, how?