CHAPTER 11

TECHNICAL INVESTIGATION: DESIGNING A SOCIALLY-FLEXIBLE READING Widget

What is an insidious occultist without a Book of Evil? These sorcery handbooks are conduits of unbridled power . . . . The only real problem with studying your Book of Evil is that weaker minds tend to go insane upon glancing at the contents. — How to be a Villain (Zawaki, 2003, p. 108)

The previous two chapters have presented technical investigations regarding the value-based design of ATs for adults with RDs. The first reviewed the technologies currently available and identified aspects they were lacking, and the second provided general guidelines for the design and implementation of a reading widget. This chapter brings together the results of the two technical investigations as well as the other VSD investigations presented in Chapters 6–8. The resulting synthesis is a design proposal for a specific reading widget. This widget—Calico—is a platform for delivering socially-flexible reading tools that support self-advocacy in reading-disabled users while also providing normalcy and privacy management.

This chapter begins with a reiteration of the identified challenges that hinder the successful deployment and adoption of ATs for adults with RDs. Two potential solutions are then proposed and discussed. The second is then expanded upon and Calico’s system architecture is proposed. The various components of Calico are described, including its extensible layered architecture, reading tools, and meta-tools. Examples of both kinds of tools are given. Further aspects of Calico are then discussed regarding implications of its usage as well as details about its implementation.

1 Challenges and Barriers to Deployment and Adoption

The preceding chapters have shown that there are multiple dams, barriers, and obstacles to successful AT usage among adults with RDs. Some of these are value-based; others are more in line with traditional notions associated with usability, accessibility, and adoptability. At the center of these various issues is society’s adherence to normalcy and literacy. For a person with a reading disability, the desire to hide or prevent others from knowing about one’s RD limits the use of any technology in public that may be seen as “labeling” or
“stigmatizing” due to how it delivers assistance (e.g., text-to-speech). If an assistive reading device is used at all, it is only used in carefully chosen contexts that are invariably only when alone or among a few select allies. Otherwise, places such as work and school inspire stealth tactics to preserve the privacy of one’s disability.

The consequences of hiding and the preservation of a sense of normalcy among adults with RDs has direct consequences on the value of community and for the technology adoption process. Because reading disabilities are invisible, the only means of knowing if a person has an RD is if she discloses. Two people with RDs may be close friends and interact frequently but never know about each other’s disability. This hiding prevents the development of an RD community that can perform group advocacy, including demands for better assistive reading tools. Moreover, the primary driving force of technology diffusion and adoption is communication about the technology. Stealth usage and the absence of conversations among people with RDs about their RDs both hinder the spread of knowledge about assistive reading technologies.

These issues of normalcy and community are not the only factors that hinder successful AT usage among adults with RDs, however. For example, people with reading disabilities exhibit a diverse range and severity of difficulties with reading and other cognitive tasks. Thus, offering a single form of accommodation will unlikely meet the diverse needs of the user population. Unfortunately, the current AT offerings attempt to do this via such a single approach, namely text-to-speech systems. As noted in Chapter 3, Section 1.1, the benefits of TTS require strong auditory skills not possessed by all users with RDs. Moreover, several of the participants in Chapter 8 expressed negative experiences with using TTS (see Section 4.2.1 in that chapter).

Access issues are another source of problems. The pricing for ATs are often high due to the small consumer markets, thus making it difficult for some potential users to acquire an assistive device. Another access barrier is procuring digital versions of the materials to read. This is becoming less of an issue due to the growing popularity of e-book readers and our increasing transition into an information society. Some universities and schools are even moving towards only using digital textbooks due to the cost benefits (Young, 2010).

Moreover, introducing a new digital technology into an educational settings can raise concerns about honesty, cheating, trust, and fairness (Campbell, 2006). Debates about the fairness of providing accommodations to university students with RDs/LDs is already a common area of debate (Vickers, 2010). Combined, these concerns about fairness are another obstacle to successful AT deployment. Adults with RDs in college engage in reading on a regular basis, and assistive reading tools are likely to be helpful. If instructors reject the technologies due to fairness concerns, a major context and impetus for using such technologies will be lost.

### 2 Addressing the Challenges: Two Proposals

The unfortunate conclusion from all this is that technologies specifically designed and marketed as ATs for reading disabilities are unlikely to be adopted into common, widespread usage. However, this resistance does
not mean that better ATs for RDs should not be explored nor developed, though. The participants interviewed in Chapter 8 all engaged in reading in their daily lives, some even to an avid extent. They also discussed the negative implications their RDs have on their daily lives, including reading tasks. Two participants, Tara and Calvin, volunteered for the study partially in the hope of learning about new or better reading widgets that did not rely on TTS.

Although no claims can be made about the representativeness of the 10 participants relative to the the reading-disabled population, the views of these individuals is compelling. Admittedly, not every adult with an RD will engage in reading as frequently or as determinedly as do these individuals. Regardless, there is a subpopulation of adults with RDs who are underserved by the available assistive reading technologies. With these individuals in mind, I propose two solutions that can address the identified challenges to adoption.

2.1 Proposal 1: Massive Social Change

As noted, a key source of difficulty for promoting AT adoption among users with RDs is society’s role in defining what is normal. Quite simply, these barriers can be eliminated by effecting massive social change. Society’s perceptions of disability and difference need to be changed to reduce the negative implications and stigmas. At the same time, the reactions of people with disabilities to the pressures and effects of normalcy should also be tempered. Of course, changing long-entrenched values and beliefs in a society cannot happen overnight nor is it a realistic goal for a dissertation. Long-term, ongoing efforts are needed that may take decades or centuries to completely come to fruition.

Still, this proposed solution merits mentioning because the process is underway. The disability rights movement has been active for several decades now (P. Williams & Shoultz, 1982; Charlton, 1998; American Association of People with Disabilities, 2010). One major impact of those efforts has been that many governments have legally recognized the rights of people with disabilities to live productive lives just as much as the other members of a society (ADA, 1990; Disability Discrimination Act, 1995; IDEA, 1997; Special Educational Needs and Disability Act, 2001; ADAAA, 2008). The Americans with Disabilities Act itself was passed 20 years prior to this dissertation. While these laws have not solved all of the ills associated with disability in today’s society, they have brought disabilities more and more into the forefront. People with disabilities are no longer kept hidden away at home or sequestered into institutions. Increasing numbers of students with disabilities are now enrolling in college (Scott et al., 2003; Burgstahler & Cory, 2008; N. Matthews, 2009).

While these efforts have addressed disability at the societal level, there have been similar efforts targeted at people with disabilities, with two specifically focusing on younger individuals. The DO-IT program (DO-IT, 2010) has established ongoing mentoring efforts and information resources for promoting the use of ATs to increase the participation of people with disabilities in higher education and employment. By providing
knowledge, support, and encouragement about the potential helpfulness of assistive technologies, DO-IT helps students become comfortable using ATs. Project Eye-to-Eye (2010) focuses on establishing mentoring/role model relationships between elementary school children and adults with learning and cognitive disabilities. While sharing past experiences, the mentors not only provide advice and guidance, but helps the children identify and enjoy their personal strengths. In particular, Project Eye-to-Eye works to challenge the notion that literacy and school performance are the absolute measures of a person’s worth and work to broaden its participants’ concepts of self-worth and personal meanings of success. Through these efforts, both DO-IT and Project Eye-to-Eye are empowering young people with disabilities with the skills and mindsets to lead successful lives and at the same time positively influence society.

2.2 Proposal 2: Build a Better Reading Widget

Since such progress is being made with respect to the impact of disabilities in society, maybe someday the challenges identified in this dissertation will no longer be a concern. For the time being, however, support should still be given to adults with RDs. One approach would be to take the insights from the VSD investigations and design a reading widget that better addresses the challenges and barriers to successful diffusion and usage. To accomplish this, three primary design goals must be achieved:

- Provide multiple forms of reading support to meet the diverse access needs of adults with RDs.
- Recognize and support the user’s sense of normalcy and right to privacy up to and including helping to hide the presence of the RD from others.
- Establish a deployment approach that will promote diffusion and communication of the technologies.

These design goals are in line with the guidelines recommended in the previous chapter. Furthermore, a means of achieving them was suggested by an observation in Chapter 9. As noted there, most assistive reading devices do a good job at promoting access but fail at preserving privacy and normalcy. Electronic reading devices, however, poorly address access issues, but as their target population is the general populace, they are less threatening to issues of normalcy and privacy regarding RDs. Plus, diffusion of these technologies is more achievable due to the larger consumer market and greater likelihood of visual usage. What is needed is a means of combining the strengths of the assistive reading technologies and electronic reading devices to address their mutual weaknesses. This is not as simple as implementing TTS on a tablet computer, however. Text-to-speech is greatly visible when used and thus induces threats to normalcy and privacy when used in public contexts. Putting TTS on an electronic reading device will incur the same negative value impacts.

The unfortunate truth is that any assistive reading tool will be potentially labeling and stigmatizing. Different ATs do differ in their visibility, and what ultimately matters is the user’s degree of comfort in regards to those different visibilities. One person with an RD may be comfortable using in public a colored text background mimicking an overlay. Another person may be worried about people asking why the e-book
device’s display is tinted purple. Each individual may react in a different way as it is ultimately a personal choice. The most direct means of recognizing and supporting this diversity of stigma concerns and reactions is to implement multiple assistive reading tools on a reading widget like a tablet and then let the user choose what assistance is active in specific contexts. This way, every user can select the tools that he or she feels most comfortable using in that context.

There is still a problem with this approach, however. A reading device loaded with many assistive options is unlikely to be perceived as a device for the general population. By providing a large number of built-in features that provide assistance to users with RDs, the design of the device implies that the primary user population are people with RDs and not the general population. The problem here is how the features are presented. Including assistive features in a device does not automatically signify it as a device for people with disabilities. The Amazon Kindle (2010) has a built-in TTS option, but the device itself is marketed and largely viewed as a technology for everyone (Siegel & Gallaga, 2009). The Intel Reader (Intel, 2010a), however, is also a portable reading device with TTS but is marketed and targeted to users with disabilities.

The distinction here is that the Kindle’s TTS feature is not presented to the user as the device’s most important, beneficial aspect. From a certain perspective, one could characterize that the main problem with most ATs for people with RDs is that the tools they provide are specific to providing assistance for people with RDs only. Instead, what if a reading device provided other forms of reading help that were not limited to just RD-related difficulties? A reading device that provides customized support for multiple reading tasks and issues faced by all types of readers could be construed as a general purpose device and not just an AT meant only for people with RDs. As first proposed in last design recommendation (Section 2.10) in the previous chapter, this universal design approach is the basic idea behind the proposed Calico system.

3 The Calico Reading System

Although the intent of Calico is to provide help for people with reading disabilities, the primary universal design goal of the Calico1 system is to provide support for the reading needs of all readers, not just those with RDs. Promoting the successful adoption of assistive reading widgets for people with RDs is achieved as a consequence of the design of Calico. Its design is relatively simple: a software application purposed for displaying and reading text on a variety of digital devices. This includes e-book devices, PDAs, and all computer form factors: tablets, laptops, and computers. As shown in Figure 11.1, Calico consists of three components: the document viewer, reading tools, and meta-tools. Each component is described below.

3.1 The Basic Document Viewer

The first and primary component of Calico is its basic document viewer. True to its name, this viewer can load documents from files, display them, and perform simple navigation such as turning a page or going to a
specified page. Given that Calico is meant to provide support for a variety of reading needs, this functionality may seem inadequate. However, the simplicity of the basic document viewer’s design is intentional as Calico is based on a multi-layer interface design.

Shneiderman (2003) proposed the multi-layer interface as a means of supporting novice users in mastering complex software applications. Modern word processing software comes with multiple features and tools, ranging from basic font manipulation to design templates for letters and fax cover sheets. This array of choices can be intimidating to a beginning user. A multi-layer interface scaffolds the learning by controlling the number of features at one time. Starting with a basic version of the application, interface features are added with the addition of new “layers.” Continuing with the example of a word processing application, the base of a multi-layer word processor would contain only features that are absolutely necessary: load a file, save a file, and print. The next layer may add a few simple features such as boldface, italics, and spell checking. With each additional layer, the application grows in complexity as more and more features are added. Although this description might suggest that layers come in strict, hierarchical orders, Shneiderman suggests that layers can also branch in order to provide modular functionality in order to provide features more specific to certain tasks. For example, letter and fax templates would be features in a layer for office assistants, while equation and chart editors would be included in a layer for scientists and researchers.
The key aspects of a multi-layer interface design are that the application starts off with a simple, easy-to-grasp interface with limited functionality and new features are only added when necessary. One of the open questions about multi-layer interfaces is determining when new feature levels should be introduced. Another question is which features belong in which levels. For the most part, Calico sidesteps these questions by leaving these choices to the user. New features are only added by the user through the deliberate installation of extensions known as reading tools.

3.2 Reading Tools

To achieve its goal of meeting the reading needs of a diverse set of readers, Calico must recognize the multiple forms that literacy can take and provide means for supporting them. This viewpoint is taken from the theory of multiliteracies (New London Group, 1996) in that reading skills and tasks differ across genres, fields, and purposes. Reading a physics research paper invokes different practices than reading a scholarly law article. Both are different from reading a short story as well as biographies, romance novels, and user manuals. These various reading tasks all share some elements of the reading process but also bring in their own cognitive demands. Calico’s purpose is to provide support for all of them.

Reading tools are installable extensions to Calico that provide additional functionality. The features added by extensions help streamline Calico to meet the explicit needs of its user. If a person is using Calico to read medical articles, extensions can make Calico into software specialized for reading medical articles. If a person reads primarily news articles, the tools can be focused towards that purpose instead. Moreover, these tools are composable. This means that multiple tools can be running and interacting at the same time. As an example, a person with an RD could be using a personalized typographic rendering, a text window, and on-demand TTS. Calico’s design allows these three different reading tools to interact seamlessly.

This composable extension framework is based on the one used by the Mozilla Firefox web browser (Mozilla Foundation, 2010). Firefox provides the standard functionality needed for navigating the web but also offers extensibility through extensions called add-ons that are available for download online. Add-ons can be for general purposes such as blocking advertisements on websites or can be specialized tools such as real-time currency conversions, online shopping support, and integration with social networking sites. Importantly, Mozilla is not the sole developer of these browser add-ons. By providing tools and programming languages to build add-ons, Mozilla has enabled a community of Firefox users to develop the tools that they want and need. The usage of community developers is also seen with the applications built for Apple’s iPhone and iPad. Such efforts promote user self-advocacy by as they provide the means users to develop extensions desired by the various user communities. For Calico, the same approach is used. Reading tools (and meta-tools) are available for download online, and interested users with the necessary skills are able to implement their own tools as well for use by others.
3.2.1 Examples of Tools Unrelated to Reading Disabilities

A demonstration of the potential diversity of reading tools is shown in Table 11.1. The tools listed are not specific to reading disabilities but address both general and specific reading needs. Search, dictionary lookup, notetaking, and annotation tools are examples of features already available on many electronic reading devices (Amazon, 2010; Apple, 2010a). One means of enhancing dictionaries would be to search a subject-specific dictionary such as a medical or a French-to-English dictionary. Depending on the setup, the dictionary could be accessed online or installed on the device. The latter is how the Kindle provides its dictionary features.

Table 11.1 also provides two examples in which a reading tool uses network access to provide specialized support to the user. The first is a tool for a person working in investment and finance. When reading an article that mentions a company that she is unfamiliar with, the Investment Lookup tool would access records from the NYSE or NASDAQ to provide information about the company and its economic performance. While this is an example of a tool for non-fiction reading, the Potter Pensieve is an example of providing support for fiction reading. The Harry Potter series by J. K. Rowling is an example of a fictional universe encompassing multiple characters, terminology, trivia, and history that is distributed across multiple books. As keeping track of every tidbit of knowledge can be difficult, therefore some fans created online resources with information about the series. The Pensieve would be a tool created by this fandom to connect to these online resources.

Moreover, reading tools can do more than simply looking up information from other sources. The last two examples in Table 11.1 manipulate document content to aid the reader. Both tools help prevent the need to repeatedly flip back and forth across pages in order to find some information. For example, when reading Chapter 6 of this dissertation, a reader would likely need to refer back to Figure 6.1 several times. The Information Clip tool would allow the user to select a section of the document (Figure 6.1) that would be stored as a thumbnail on a tool bar for later access as shown in Figure 11.2. This usage of clipping to isolate specific information for more convenient access later is derived from the WinCuts (Tan, Meyers, & Czerwinski, 2004) and Clipping Lists (T. Matthews, Czerwinski, Robertson, & Tan, 2006) interfaces.

Bibliographies and endnotes can be another cause of readers flipping back and forth between pages. To read a note or identify what paper is being referenced, the reader has to mark his current reading location, flip ahead in the document, read, then return to where he was. This can be a tedious effort.\textsuperscript{4} The Reference/Endnote Fetcher simplifies this effort by identifying footnotes and paper references and then retrieving the text when requested. An example of this is shown in Figure 11.3. In the figure, the document being read is Deibel (2008), which uses a bibliography format in which numbers represent the cited papers. The fetcher tool recognizes the format of an in-text reference, associates it with the corresponding entry in the bibliography, and provides that entry when requested by the user. The success of this tool is contingent on having an algorithmic process that can correctly identify and map references to their later entries. This can be achieved by using
Table 11.1: Examples of Calico reading tools unrelated to reading disabilities.

<table>
<thead>
<tr>
<th>TOOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Search</td>
<td>Find all instances of a given text in the current document.</td>
</tr>
<tr>
<td>On-Demand Dictionary</td>
<td>Get the meaning of the selected word from a general purpose dictionary.</td>
</tr>
<tr>
<td>On-Demand Medical Dictionary</td>
<td>Get the meaning of the selected word or phrase in a medical dictionary.</td>
</tr>
<tr>
<td>Margin Annotations</td>
<td>Allow the user to write or type notes to be stored as notes in the margins.</td>
</tr>
<tr>
<td>Underliner / Highlighter</td>
<td>Mark text that the reader indicates as important and allow the user to control</td>
</tr>
<tr>
<td></td>
<td>the style and visibility of the markings.</td>
</tr>
<tr>
<td>Investment Lookup</td>
<td>Retrieve information about a company’s current and past stock performance.</td>
</tr>
<tr>
<td>Potter Pensieve</td>
<td>Look up selected text on an online encyclopedia about the Harry Potter</td>
</tr>
<tr>
<td></td>
<td>Universe (<a href="http://harrypotter.wikia.com/">http://harrypotter.wikia.com/</a>)</td>
</tr>
<tr>
<td>Information Clips</td>
<td>Select a portion of a page to keep as a readily retrieved thumbnail, allowing</td>
</tr>
<tr>
<td></td>
<td>ready access to tables, figures, and other frequently referred to items.</td>
</tr>
<tr>
<td>Reference / Endnote Fetcher</td>
<td>Retrieve the text of a footnote or reference without having to move to the page</td>
</tr>
<tr>
<td></td>
<td>location of the footnote or reference.</td>
</tr>
</tbody>
</table>

Figure 11.2: Example usage of the Information Clips reading tool. (a) The clip bar at the bottom contains two previously clipped items. (b) The user selects a clip thumbnail for re-viewing.

Figure 11.3: Using the Reference / Endnote Fetcher to retrieve a bibliography entry in Deibel (2008).
the by-example data scraping approach in the reform web enhancement system (Toomim et al., 2009). By having the user provide a few examples from the document of what a reference looks like and the mapping between these references and the later entries, this properly trains the machine learning component sufficiently to ensure high classification accuracy.

3.2.2 Examples of Tools Addressing Reading Disabilities

Although the majority of reading tools in Calico are not expected to specifically concern reading disabilities, such tools would also be available. Table 11.2 lists several reading tools that address some of the various difficulties experienced by people with RDs. As can be seen, many of the assistive technologies discussed in Chapter 3 can be implemented in Calico. Some of these are direct replications, such as recreating the SeeWord project (Dickinson et al., 2002; Gregor et al., 2003) with the Personalized Digital Typography tool. Overlays, TTS, and highlighting are also included in the table. The text window is also replicated but improved upon. As shown in Figure 11.4, the opacity of the window frame can be adjusted to obscure but not hide the surrounding text. In this example, the surrounding text is lightened, but other approaches (e.g., blurring or distorting) could also be implemented. This approach addresses some of the concerns about windows hindering reading comprehension due to its suppression of information about the overall text layout and formatting.

Some of the reading tools in Table 11.2 are new applications of computer science research, particularly natural language processing. Research on reading level detection and text simplification (Schwarm & Ostendorf, 2005; Petersen & Ostendorf, 2009) drive tools that simplify or summarize selected sections of text. Another example is the Smart Dictionary. This tool is an advanced version of the On-Demand Dictionary reading tool in that it uses word sense disambiguation to return the most appropriate definition/word sense (W. Kintsch, 1998; Navigli, 2009). For people with RDs, having to sift through several returned definitions and identify the best one can be a source of difficulty as well as a marked increase in the amount of text needed to be read. By providing the most appropriate definitions first, these issues are addressed.

This approach of using composable extensions is a direct means of addressing the diversity of reading disabilities as directed by the design recommendation in Section 2.3 of Chapter 10. The list of tools in Table 11.2 addresses many of the RD-related difficulties described in Chapter 2. The user can choose tools that address her reading weaknesses or augment her reading strengths while ignoring tools that are ineffective. This level of choice in assistive tools was rarely seen in the technologies reviewed in Chapter 9. Kurzweil 3000 was the rare exception, but the multiple forms of assistance it offers are fixed options built-in to the system itself. If a tool is not helpful, a Kurzweil user’s only option is to disable the tool. Unlike with Calico, alternative forms of help cannot be added to Kurzweil.

Calico’s ability to provide alternative versions of assistance is also a means of addressing concerns about stigma and normalcy. With Calico, several reading tools can provide essentially the same form of assistance
Table 11.2: Examples of Calico reading tools addressing reading disabilities.

<table>
<thead>
<tr>
<th>TOOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smart Dictionary</td>
<td>Get the most likely meaning of the selected word using word sense disambiguation.</td>
</tr>
<tr>
<td>Translucent Text Window</td>
<td>Simulate a text window of configurable size and transparency.</td>
</tr>
<tr>
<td>Automated Highlighting</td>
<td>Provide an automated moving word and line highlighting.</td>
</tr>
<tr>
<td>TextLens</td>
<td>Use a fisheye lens to reduce visual clutter around the text currently being read similar to the idea behind TableLens (Rao &amp; Card, 1994).</td>
</tr>
<tr>
<td>Intelligent Bookmark</td>
<td>Remind the user of the last page, line, and word read by requiring the user to move a pointer (e.g., stylus or finger) across the text when reading.</td>
</tr>
<tr>
<td>Personalized Digital Typography</td>
<td>Let the user select how the text should be rendered: font, sizes, line spacing, colors, etc.</td>
</tr>
<tr>
<td>Virtual Overlays</td>
<td>Change the background color of the displayed text as a replication of the effects of a color overlay.</td>
</tr>
<tr>
<td>Text Simplification &amp; Summary</td>
<td>Provide an easier-to-read summary of a selected section of text.</td>
</tr>
<tr>
<td>Outside the Lines Skimmer</td>
<td>Provide support for the text skimming practices suggested by Mooney and Cole (2000) for college students with RDs/LDs.</td>
</tr>
<tr>
<td>Text-to-Speech</td>
<td>Read the text aloud.</td>
</tr>
<tr>
<td>Word Aloud</td>
<td>Replicate a reading by reading only small selections of text aloud.</td>
</tr>
<tr>
<td>Phonetic Respeller</td>
<td>Provide a phonetic respelling of the selected word.</td>
</tr>
</tbody>
</table>

Figure 11.4: Demonstration of the Simulated Text Window tool using translucence to obscure but not hide the surrounding text.

Figure 11.5: Using the Phonetic Respeller to get a phonetic spelling of the word ‘photograph.’
but differ in the visibility of their usage. For example, the last three tools in Table 11.2 all address difficulties related to the phonological processing defect that impacts word recognition. Text-to-Speech is the standard approach, but as previously noted, listening to an entire text can attract undesired attention. Reading pens allow the user to be more selective and minimize the amount of text that is read aloud, thereby incurring less risk of being noticed. The Phonetic Respeller further reduces threats to normalcy by eliminating the speech component. Instead, as shown in Figure 11.5, this tool transcribes a selected word into a more easily parsed phonetic spelling. The respeller does require the reader to still visually parse text as opposed to completely bypassing the phonological processing deficit by hearing the word. However, the assistance offered by the respeller requires a brief moment to use and is less likely to disturb others and attract their attention. Thus, the likelihood of the respeller being adopted into regular use is higher. Even if the assistance provided is less effective, this is of course far better than receiving no assistance due to the tool being rejected outright.

3.2.3 The Consequences of Too Many Reading Tools

Although this approach to providing reading tools allows Calico to successfully meet the first two design goals on page 206, the multitude of reading tools introduces problems for achieving the third goal of promoting diffusion. Foremost among these issues is the vast number of reading tools that might be available for Calico. Consider that the perceived visibility and stigma threat of using a reading tool likely differs from user to user and from context to context. To help ensure that there is at least one tool option that a user is willing to use, several variations of the same approach (as in the just mentioned example of TTS and respelling) are necessary. Even more reading tools are needed to address the diversity seen with RDs. Moreover, Calico’s purpose is to be a reading support for all types of users and literacies, further swelling the number of reading tools that Calico can make available. Sorting through this morass of available tools naturally creates a problem for users. Not only does it involve the user correctly identifying what he needs, he then has to search through the available tools to find the most tools most relevant and appropriate for those needs.

This need to help with technology selection is fortunately not a new problem, and various approaches for addressing this issue have been used previously. For example, King (1999) states that the role of an AT specialist is to use one’s expert knowledge of available ATs and the nature of disabilities to help the intended user search through the available technology options. Mozilla uses a community-approach for add-ons on the Firefox browser. All of the add-ons available for download on Mozilla’s website have user ratings and written reviews, and the most popular add-ons (by rating or number of downloads) are featured prominently.

Unfortunately, both of these approaches have limitations when it comes to users with RDs. Mozilla’s community approach might work for recommending general reading tools, but it has been previously demonstrated that people with RDs are unlikely to act cohesively as a community due to the emphases placed on hiding and normalcy. Assistive reading tools are therefore unlikely to receive many ratings or reviews.
Table 11.3: Examples of Calico meta-tools.

<table>
<thead>
<tr>
<th>TOOL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Johnny Recommender</td>
<td>Evaluate the reading strengths and weaknesses of the user and recommend</td>
</tr>
<tr>
<td></td>
<td>appropriate reading tools. Only recommends tools that fulfill a design contract.</td>
</tr>
<tr>
<td>Chaney Profile Manager</td>
<td>Create, manage, and apply profiles that determine which reading tools are activated based on different contexts.</td>
</tr>
<tr>
<td>Lockdown</td>
<td>Allow an external authority to limit access to certain Calico features during set times and tasks (e.g., academic testing).</td>
</tr>
<tr>
<td>Course Tools</td>
<td>Provide, manage, and update reading tools that an instructor has suggested as useful or necessary for a course or class.</td>
</tr>
<tr>
<td>Company Tools</td>
<td>Provide, manage, and update reading tools that a company has determined as required or useful for its employees.</td>
</tr>
<tr>
<td>Version Manager</td>
<td>Keep up with new versions of a document still in the editing process.</td>
</tr>
</tbody>
</table>

Similarly, the common behavior to hide makes a user with an RD unlikely to seek out advice from an AT or disability specialist. Even if a user with an RD is willing to disclose and seek out help, contacting such a specialist may not be possible. A university may not have an AT specialist, and even if the school does, that specialist may not be aware or trained in ATs for RDs. Furthermore, the user may not be a student, and university disability services are rarely available to people not in school due to resource demands. Thus, access to the expert knowledge provided by disabilities specialists is problematic and leads to many users with RDs having to instead go through the AT selection and configuration process alone.

3.3 Meta-Tools

To address these issues and to help Calico promote diffusion and self-advocacy among users with RDs, a different approach called the Johnny system (discussed below) was developed. The idea behind Johnny was to introduce a new type of tool into Calico—the meta-tool. A meta-tool is an extension to Calico that aids in the management of other tools. As shown in Figure 11.1, reading tools enhance the performance of the basic document viewer, while meta-tools interact only with the reading tools. This interaction includes recommending new reading tools, helping configure installed reading tools, and enabling or disabling Calico features and components. Table 11.3 lists several examples of meta-tools.

3.3.1 The Johnny Recommender

The first meta-tool conceived of was the Johnny system. It was designed to promote self-advocacy in users with RDs by providing an alternative to contacting an AT expert. As suggested in Section 2.8 in the previous chapter, Johnny uses a combination of expert knowledge systems (Bobrow et al., 1986) and recommender systems (Montaner et al., 2003; Adomavicius & Tuzhilin, 2005) to best replicate the knowledge and expertise possessed by such personnel.\(^5\) Beginning with a simple assessment of the user’s reading abilities, this meta-
tool provides suggestions on what tools will be the most effective. Additionally, it informs the user about these tools by providing demonstrations and also helps the user properly configure any tools chosen for adoption.

The implementation of Johnny is motivated from insights from semiotic engineering. Developed by Souza (2005), semiotic engineering interprets interfaces as a communication between the system designer and the user. User difficulties are caused by a breakdown in this communication. As I identified in Deibel (2007a), this approach suggests several means for supporting the adoption and configuration processes. Reasons for failed AT adoption often include a failed understanding of what the technology actually does, why it should be helpful, and uncertainty about how to use and configure the technology (Dawe, 2006). A well-designed system should clearly convey the answers to such questions.

Johnny ensures that any reading tool it recommends is capable of clearly articulating these questions. This is accomplished through a contract that must be fulfilled if Johnny is to include the tool in its recommendations. First, this contract requires the tool to provide both a demonstration of what it does and a configuration wizard. The demo addresses the issue of needing to understand what the tool does, while the wizard is a surrogate for the disability expert who would normally help in configuring the tool. The second part of the contract requires the tool to report to Johnny measures of its effectiveness on different reading tasks. For example, the Smart Dictionary tool would highly support word sense disambiguation but would provide little benefit to phonological processing.

With a collection of reading tools that meet this contract, an example usage of Johnny would be as follows. It would begin by conducting an automated reading assessment of the user. Using an adaptive format, this assessment would aim to provide both a broad understanding of the user’s needs (Perkins & Cohene, 2006) as well as in-depth understandings of particular problem areas (Protopapas & Skaloulmbakas, 2007; Singleton & Henderson, 2007; Singleton et al., 2009). The user has the option to skip questions or stop at any time, but the system would encourage later continuation in order to provide better recommendations.

Johnny would then use the results from assessment and each tool’s contractual measures of its effectiveness to provide recommendations. As an example, assume the questionnaire identifies a user as having significant difficulty with phonological processing. Explaining this finding, Johnny suggests three tools: Text-to-Speech, Word Aloud, and the Phonetic Respeller. Using the provided demos, the user decides against the two audio tools, but decides to give the respeller a try. Johnny then activates the respeller’s configuration wizard to help the user adjust tool to his needs. As the user wants to avoid having the text look childish, the system guides him to have the respeller appear only on demand and to use the international phonetic alphabet for the respellings.

### 3.3.2 Chaney Profile Manager

Another example of a meta-tool is Chaney which helps the user manage which tools are active at different times. This is a means of addressing one of the other weaknesses of Calico’s usage of reading tools. Consider
a Calico user who uses the system to read science articles at work but read fiction for pleasure in her off times. For each of these reading activities, she will have different tools installed. Some, but not all, are applicable for both tasks. To avoid having unnecessary tools clutter the interface, a profile manager would allow Calico to have multiple usage modes. In the case of this example, Chaney would include a mode for fiction reading and a mode for scientific reading, effectively creating two distinct versions of Calico installed on one device.\(^6\)

Chaney’s ability to offer easy control of what reading tools are active in certain contexts has particular benefits for users with RDs. For each reading difficulty experienced by the user, there is a reading tool that provides the greatest benefit. However, usage context can hinder if adoption of such a tool if the visibility of its use is overly stigmatizing. This leads the user to choose a suboptimal tool that offers less benefits to reading but better promotes normalcy and privacy. A context manager like Chaney allows the user to still use the more stigmatizing reading tool in contexts where the user feels more comfortable. The Phonetic Respeller, for example, would be active in the default case, but TTS could be used when the user is alone. The context manager would allow the user to make sure that TTS is never active in certain contexts but is still available to provide its greater performance benefits when the user was willing to use it.

How Chaney determines what profile to use can be implemented in several ways. The most direct and safest approach is to always start in a default state and only change profiles when the user indicates to do so. Context usage shifts could also be automatically determined based on available information. Automated detection of the type of document being currently read could also activate specific profiles. If the device has the ability to detect its location as with the GPS units in iPads and smartphones, certain an AI system could learn what usage profiles are associated with what location and time contexts. When used at the office, Calico would switch to its business mode but would return to a fiction reading mode when taken home.

### 3.3.3 Examples of Other Meta-Tools

Other uses of meta-tools as mentioned in Table 11.3 include supporting multiple users of Calico working together in some way. In a college course, a meta-tool can be used to ensure that all students have the same reading tools available as recommended by the instructor. When the course is over, such a meta-tool would also help students remove said tools if they are no longer desired. Management of shared documents could also be supported through a meta-tool.

Most importantly, meta-tools provide a means for addressing the academic fairness concerns that dominated most of the value-based technology reviews in Chapter 9. As a reminder to the reader, both assistive and general-purpose digital reading technologies are relatively new to classrooms. Usage policies have yet to be codified or standardized for these technologies, particularly in high-stake situations such as performance exams. Even if students are permitted to consult their textbooks during a test, a student using one of these devices would raise concerns of fairness. Search functions would make it easier for the student to look up
information in the textbook. The device could also have other useful documents already stored within it. Network connectivity could also give students unfair access to more knowledge resources.

A meta-tool like Lockdown can prevent such actions. Prior to the start of the exam, the instructor would require that this meta-tool be installed and activated. Temporary restrictions would then be placed on Calico limiting access to certain documents, which reading and meta-tools are activated, and other features such as network connectivity. The user could even be restricted from switching to other applications on the device. Lockdown would only deactivate after a set time period or if a security code is entered by the instructor. This meta-tool thus provides instructors with a modicum of control in regards to the usage of electronic reading technologies in their classrooms, thereby addressing value issues related to trust and fairness.

4 Discussion

The Calico system just described is a system for delivering reading assistance to everyone, not just adults with RDs. It is only a proposal, however, and has not yet been fully implemented. Because of this, how successful Calico is at achieving the goals of successfully promoting the adoption of assistive reading technologies by adults with RDs cannot be determined at this time. Still, there are several reasons to be optimistic about Calico’s potential. At the same time, there are some open questions to consider as well.

4.1 Promoting Diffusion

A key aspect of Calico’s design is that it is targeted at the general population and not just adults with RDs. As this is a significantly larger population, the amount of communication about the technology can be greater than it would be otherwise. Moreover, the general population is more likely to engage in public usage of a reading technology than the far more invisible RD community. According to Roger’s theory on the diffusion of innovations, these social and communication elements are exactly what is needed for technology adoption to occur (Rogers, 2003).

Calico is also not reinventing the wheel. Ten years ago, introducing software for supporting reading on a digital device would not have been successful as reading from digital devices was still in its infancy. The recent surges in the popularity of e-book readers and tablet computers demonstrates that a shift in how people read is beginning. Calico makes only a few assumptions about the hardware it would run on. The only expectations are that a computational device is available for performing the various functions of the reading tools and that the device can somehow connect to resources online. Thus, Calico should be implementable on whatever portable technologies are currently popular for displaying documents to be read and can thereby latch on to the diffusion rates of those technologies.

Diffusion of assistive reading tools is also supported by Calico. The successful adoption of Calico by the general reading populace helps place the technology in the hands of users with RDs. The range of reading
tools can address the diverse difficulties associated with RDs, and if such a need is unmet, the ability of users with the necessary skills to design and implement new tools can address such a gap. The Johnny system meta-tool also demonstrates an alternative to having to consult with a disability expert to learn about the AT options, thus addressing the challenges associated with hiding and lack of disclosure.

4.2 Navigating Normalcy

Due to its basis in universal design, Calico helps a person with reading disabilities navigate the issues surrounding disability, normalcy, and stigma. This is because Calico is framed as a technology for the general population of readers. If reading from an electronic device attracts any attention from others, it is not because such an act is unusual and distinctive. Kindles, iPads, and tablets are now common tools for reading in public. Attracting attention from others will likely indicate interest in the device itself—a critical aspect of the diffusion process.

However, it is possible that simply using a reading tool might indicate that the user has a reading disability. Calico addresses this possibility in several ways. First, the range of reading tools available allows the user to pick assistive approaches that are lower in their conspicuousness and less likely to lead to embarrassment if noticed. Profile management as offered by Chaney provides further power to control the potential threat of disclosure from AT usage, thus making Calico flexible to the user’s various social interactions.

The Johnny meta-tool is a potential concern, however, as it does have strong links to the concept of reading disabilities. Fortunately, Johnny is not used continuously. Unlike an assistive device that is always present like a wheelchair, white cane, or Kurzweil 3000, Johnny is only used when a recommendation is desired by the user. Thus, any risks associated with its usage are constrained to narrow moments of time. Moreover, rather than having the meta-tool permanently installed and visible in Calico, only the user’s assessment data needs to be stored. Thus, another person is even less likely to accidentally discover that the user is hiding an RD.

4.3 Open Design Questions

Unfortunately, many implementation issues must be addressed before Calico and its various components can be realized as an actual application. Some are easily resolved, such as achieving the design recommendation that quality typographic rendering needs to be implemented (Chapter 10, Section 2.4). The legibility of print research by Tinker (1963, 1965) and the digital typography algorithms developed by Knuth (1999) provide guidelines and solutions for implementing text rendering in Calico. Support for getting access to documents is also needed, including the ability to import and convert various file formats. Implementing these features can draw upon previous efforts in text digitization, OCR, and file conversions, but additional work will be required to ensure that the digital texts used by Calico to ensure a “rich” text experience as described in one of the design recommendations from the previous chapter (Chapter 10, Section 2.2).

Several components of the Johnny Recommender meta-tool are also in need of further development. The
design contract that recommended tools must meet needs to be codified, including a specification of how reading tools report their effectiveness on different reading tasks to Johnny. These effectiveness measures will also have to be mapped to the diagnostic component of Johnny that that utilizes expert knowledge to characterize the user’s reading strengths and weaknesses needs to be constructed. Implementing some of this automated questionnaire will be derived from previous efforts at computer-based disability screening (Perkins & Cohene, 2006; Protopapas & Skaloumbakas, 2007; Singleton & Henderson, 2007; Singleton et al., 2009).

Once constructed, the assessment will still need several iterations of refinement to test its validity and reliability as well as to ensure that completing it does not require the user to spend an excessive amount of time.

Several aspects are also open areas for computer science research. Foremost among these are the human-computer interactions issues regarding the usability of Calico’s extensible, multi-layer interface with particular emphasis and concern for users with RDs. For example, how users will respond to the framework is uncertain, but studies of similar systems offer some promise. In studying the potential of multi-layer interfaces, Shneiderman (2003) found that participants with little to no computer experience quickly grasped the concept and rated it positively. Hanson and Richards (2004) developed a package of interoperable tools that allows Internet Explorer to transform web pages to be more accessible. One year after the public release of the software, they reported that several thousand people with disabilities, including RDs/LDs, had become users of their system. Both studies suggest that the general design concepts of Calico can be implemented successfully, but care must be taken to ensure that the overall system and its components provide a smooth and easy user experience.

Similarly, software engineering issues abound in regards to providing Calico’s extensible framework and user development opportunities. The internal document model will need to provide enough structure and information to allow reading tools to perform reading enhancements efficiently. Computer security is also a concern. Meta-tools like Lockdown will need the ability to control system access and prevent workarounds while also not providing opportunities for malicious tools to be implemented. A more general concern about reading tools and meta-tools concerns how to guarantee that multiple tools compose rather than interfere with each other. Lerner and Grossman (2010) have analyzed and proposed approaches for addressing similar concerns with the composition and programming languages behind web browser extensions. Applications of their insights is planned.

5 Chapter Summary

Using the insights gained from previous chapters, this chapter recognized that multiple obstacles currently exist that prevent successful diffusion of any technologies designed specifically as ATs for adults with RDs. An alternative approach to providing assistive reading tools was proposed. This system—Calico—focuses on
providing reading support to all readers of all abilities. Specific reading needs, including those associated with RDs, are addressed through an extensible framework of reading tools, and further control for these reading tools is provided through the use of meta-tools. Arguments were then discussed as to how this infrastructure addresses the design goals of supporting literacy, promoting the user’s sense of normalcy, and encouraging successful technology adoption.
Notes to Chapter 11

1. I originally chose the name ‘Calico’ essentially at random when it became too cumbersome to constantly refer to “my proposed system” or “the reading system.” The name itself was inspired by my beloved cat Susie. Although it was initially selected as a placeholder until I came up with a more appropriate name, the eventual development of a backronym made it official. Calico, after all, stands for “Computer-Assisted Literacy Interface via Composable Orthotics.”

2. Although Calico does not inherently provide support for selecting what tools may benefit the user, Calico can be extended to provide this functionality through the use of a meta-tool. These are discussed in Section 3.3 of this chapter.

3. Naturally, some literacies are more difficult to support than others. One particular challenge would be the literacies associated with comics and graphic novels. Because of their tight integration of text and images, the reading experience is very different than the traditional printed text. Many of the reading tools mentioned in this chapter cannot be readily applied to comics. Manipulating the size or formatting of text would have to integrate with the visual flow of the comics, for example.

Because comics and graphic novels are so different, they are not supported in any of the upcoming planned implementations for Calico. I do hope to explore this issue of supporting comics for users with RDs in the future, however. This is particularly motivated by the interest in comics seen by some people with RDs/LDs as evidenced by some of the interviewed and recruited participants for the life stories study in Chapter 8.

4. The frequent usage of chapter endnotes in this dissertation is admittedly intentional in order to provide an example of this back and forth reading task.

5. The Johnny system is hence named after Why Johnny Can’t Read by Flesch (1955) as part of its purpose is to identify the user’s reading needs.

6. Due to its ability to transform Calico into different systems, the Chaney profile manager is named after silent film actor Lon Chaney, Sr. Known as the “Man of a Thousand Faces,” he pioneered the usage of makeup and costumes to transform himself into memorable film characters such as the Phantom of the Opera and the Hunchback of Notre Dame.