7

Cognitive Disabilities

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7.1. Introduction

Cognitive processes are those mental processes not involving simply sensing the environment or controlling one's movements, and cognitive disabilities are impairments in cognitive processes. They can arise in many ways, including brain injury or stroke; chromosomal abnormalities that affect the development of the brain (such as Down syndrome), producing *developmental* disabilities; severe mental illness; or effects of aging (see Chapter 8, "Age-Related Difference in the Interface Design Process"). Often the cause of a cognitive disability is unknown.

Because cognitive processes are very diverse, and complex, cognitive disabilities vary greatly in their impact. Because cognitive processes figure in many ways in the use of information technology, there are many barriers to effective use by people with cognitive disabilities.

In part because of social attitudes toward people with disabilities, many information technologists have little contact with people with cognitive disabilities (or, in some cases, have little contact that they are aware of). This chapter begins by describing several real people, as a way of illustrating some ways in which cognitive disabilities play out in people's lives, and the role information technology can play, and then presents some demographic data that place these examples in context. Against this background, the chapter then surveys the barriers to use of information technology that are associated with cognitive disabilities. It then describes the design implications of these barriers, and how design processes should be shaped to address these implications. The chapter ends with a discussion of current trends, including an increased emphasis on meeting the needs of people with cognitive disabilities in the information technology community.

7.2. Some People

7.2.1 AB

AB was "slow" in school, and was unable to obtain the postsecondary educational credentials required for some of his career aims. He reads, but not very fluently, and has difficulty understanding rapid, complex speech, or speech that includes unfamiliar words. He has trouble managing papers, and sometimes becomes flustered when plans must be changed, or a situation becomes complex. There is no "diagnosis" for AB's limitations.

AB is aware of the kinds of difficulties he encounters, and has the self-confidence to be assertive in dealing with them. For example, he will interrupt a meeting if necessary to have an unfamiliar word defined or a complex question restated. His colleagues recognize AB as a capable person with good judgment and valuable insights.

AB uses a computer for e-mail. He is helped by software that allows one of his associates to help with problems on AB's computer over the Internet. AB argues that the computer should provide a tool for looking up unfamiliar words, wherever they appear on the screen, and that, in this and other ways, the computer has great potential for improving access to information for people with cognitive disabilities.

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7.2.2 Jack Horner

Jack Horner (Horner, 2004) is Regents Professor of Paleontology at Montana State University, and holder of a Macarthur Fellowship for extraordinary creativity. He has no undergraduate degree, having failed in seven attempts; he was barely able to complete secondary school. He says:

> My progress in reading, writing, and mathematics was excruciatingly slow... To this day, I struggle with the effects of dyslexia. It takes me a long time to read things, so it's an ongoing endeavor to become as well-read as I would ideally like to be. Self-paced learning is a strategy that helps me cope. Audio books are also a very helpful technology. My first publications were traumatic. I was afraid to even attempt to write something that would go to an editor. I had plenty of data, so I wasn't fearful of critical review, but I had apprehension about people seeing how little I actually knew of the English language. It's a phobia I still live with. After two junior authorships, I wrote three papers on my own, and each was published: one in the Journal of Paleontology, and two in the British journal Nature. I discovered that editors would forgive my writing errors and fix them as long as the science was solid. Writing is still very difficult for me, and I would always rather a more fluent coauthor did the actual writing. I know what I can do and what I can't do, and for the things I can't do, I try to find someone to help.

7.2.3 TT

TT (Hart, 2005) is a secondary school student in a large city in the United States. With an IQ tested at about 70, and diagnosed with autism spectrum disorder, a developmental disability, TT is assigned to "life skills" classes at his school. He is not eligible for computer classes at the school, but he participated in a special tutorial program in which he learned to use the Excel spreadsheet program. During the program he was scored as attaining "independent mastery" of 98% of the Excel topics on the syllabus, which closely matched the syllabus for the mainstream course at the school. He created a database of information about video games, an interest of his. He also experimented with 3D content in a spreadsheet, and with a program that printed out messages that simulated an imminent computer crash.

7.2.4 MJ

MJ (Bergman, 1998) suffered a brain injury in a car accident. After the accident, she had problems in visual perception, memory, reasoning, reading, and writing. These difficulties led to serious financial problems, as she was unable to manage money, even with the assistance of a bookkeeper. Because of difficulty in appreciating numerical amounts, she could not control her credit card spending. She was unable to use a computer reliably, often needing help with the long sequences of steps required to turn it on and access the appropriate software. She made persistent attempts to use the software, sometimes spending several hours before giving up. Her difficulties were extremely frustrating, and, because she believed that the software she was using was the simplest available, she came to believe that she was stupid, and worthless, and that her situation was hopeless.

Customized software, carefully adapted to her needs, transformed MJ's situation. The software guides her through needed financial operations, and maintains records in a form that she can easily access. It prompts her to keep a journal, including logs of conversations, and she is able to use this material to organize her interactions with other people. Using this software, MJ has been able to manage her finances, and other aspects of her life, for more than 10 years.

7.2.5 LR

LR (Dawe, personal communication) is a 25-year-old woman with developmental disabilities. She lives in an apartment with a roommate who provides part-time care. She cannot read, but she has three part-time jobs: rolling silverware in a restaurant, providing childcare in a daycare facility, and passing out water in a retirement home. She uses the bus for some trips. She has many friends, and uses the telephone for social interaction, but sometimes calls people too often, and has trouble recognizing cues to get off the phone. She has trouble learning telephone numbers and using cell phone menus. She remembers to keep her phone charged, but does not understand why it won't work when it is not charged.

7.2.6 Abdulkader Faraax

Abdulkader Faraax (Danielsson and Jonsson, 2001) is a 10-year-old boy diagnosed with autism. His vocabulary is about 400 words, and speaking and understanding speech are difficult for him. On a talkative day he may say 30 or 40 words. Many interactions that ordinarily involve speech, such as using a taxi, are difficult for him. He uses digital photographs, 50 or 60 in a typical week, to help in communication, for example, to show his destination on a taxi ride. He and his teacher have built up a collection of 5000 photographs to represent the people and things that are important to him, such as people in his school. Besides their use in everyday communication, his teacher believes that the photographs help Abdulkader maintain awareness of people and things when they are not physically present. The teacher can also use photographs to tell Abdulkader things, such as where he can sit to work on an art project (conveyed by showing a photo of the designated table, with art supplies laid out on it).

7.3 Cognitive Disabilities

All of these people are classified as having cognitive disabilities. The examples give some sense of the diversity of these disabilities, and their impact.

As mentioned earlier, cognitive disabilities arise from impairments in cognitive processes. Because cognitive processes are complex, and have many more or less distinct aspects, cognitive disabilities can affect many aspects of cognitive function. The following list, adapted from Francik (1999), gives broad headings; each heading stands for a range of more specific functions.

- Executive functions
- Memory
- Attention
- Visual and spatial perception
- Language (including reading)
- Mathematical thinking
- Emotional control, expression, understanding
- Speed of reasoning
- Solving new problems
- Solving problems based on experience

To illustrate the finer structure of this functional classification, consider memory. Far from being a monolithic function, memory on this list has to include both *skill* learning and learning of factual (*declarative*) information, though these involve different mechanisms (Anderson, 1993; Anderson et al., 2004). Glisky (1992) reports a training study in which people with memory deficits learned to perform data entry tasks as rapidly as participants with typical memory, even though they could not remember that they had participated in the training sessions. Psychologists also distinguish *short-term* from *long-term* memory. Some people are able to retrieve information learned long ago, but cannot retain information from moment to moment in the here and now, while others can retain information only for short periods. Memory seems to act in quite different ways when material must be *recalled* and when it must only be *recognized* as familiar. In the former situation, but less so in the latter, there are powerful effects of *strategy*, so that one can *learn* to use one's memory more effectively. Any of these aspects of memory function could be impaired.

Similarly, the entry "language" in the list stands for many different functions. For example, a person may be able to process spoken language but not written language.

The entry "visual and spatial perception" refers to a crude distinction between picking up information from the environment, called *sensation* (e.g., patterns of light and dark), and interpreting the information, called *perception*. For example, people can "see" inverted faces as well as they can "see" upright ones, but most people can perform a variety of further processes, including recognition, and judging gender or emotion, much better for upright faces. Interestingly, there is good evidence that perception of faces can be impaired separately from perception of objects of other kinds (Duchaine et al., 2006). Impairment of face perception is called *prosopagnosia*; other forms of perceptual impairment, or *agnosia*, sometimes occur, such as specific impairment in the perception of text, called *alexia* (see Ghaldiali, 2004).

While specific impairment in the perception of faces is rare, there are other, much more common impairments that are also quite narrow in their impact. The conditions, called "learning disabilities" in the United States and Canada (different, more specific terms are used in the United Kingdom and Europe), can impact reading or mathematical skills, and not other mental functions. Some people with these disabilities can perform at a very high level in other areas. Jack Horner, the paleontologist, is an example. West (2000) presents brief biographical sketches of Horner and several other leaders in science, industry, and government who have learning disabilities.

While learning disabilities are narrow in their impact, it is not unusual for a person to have impairments that affect many aspects of cognitive function. MJ is an example of a person with impairments in several areas of function. The fact that a person has trouble in one area of cognitive function (e.g., reading) does not imply that she will have or will not have trouble in other areas.

The description "person with a cognitive disability" can sometimes be useful in focusing attention on difficulties people can have in performing mental operations, separately from difficulties of other kinds, for example in seeing, hearing, or moving. But it is a mistake to make too much of this separation. Many people with cognitive disabilities have other disabilities as well. Further, much of the real impact of anything commonly thought of as a disability, of whatever kind, is really better understood as a product of attitudes expressed in social and political processes (Roth, 1983; Rapley, 2004).

Thinking about people with cognitive disabilities is often shaped by implicit or explicit use of the *medical model* of disability. On this model, a person with a cognitive disability has some particular condition that can be diagnosed and perhaps cured, like a disease. The first question to ask about such a person is, What is the disease? This way of thinking is misleading in a number of ways. First, there is no diagnosis for many people with cognitive disabilities, so the model cannot usefully be applied to them. Second, the variation in cognitive functioning among people with a given diagnosis, for example Down syndrome or autism, is very large. There are people with Down syndrome who are completely nonliterate, and others who are college graduates, so the diagnosis of Down syndrome is not very helpful. Third, the focus on diagnosis, and indeed on disability itself, directs attention to the person, and away from the environment in which the person operates, while it is the environment that is often responsible for the problems people have. As designers, it is important to focus on those aspects of the environment, including the social environment, that can create or eliminate barriers for people, not on diagnoses.

7.3.1 Demographics

Because of the social consequences of disabilities, which commonly include segregation, few designers have much knowledge of people with cognitive disabilities. Designers have asked the author whether people with cognitive disabilities could use the World Wide Web, for example. The answer is that many can and do, but that the question has to be asked is an indication of how poorly people with cognitive disabilities are understood.

A survey commissioned in 2003 by Microsoft (n.d.) found that 16% of working-age computer users in the United States have some form of cognitive impairment. Employment data for the U.S. federal government show that more than 1300 people with developmental disabilities hold white-collar jobs, that is, jobs in administration or other knowledge work (United States Equal Employment Opportunity Commissions, 2005; note that these employment data are actually reported for *mental retardation*, a term, now widely deprecated, for *developmental disability*, an impairment that arises before adulthood, is not traceable to an injury or illness, and affects cognitive aspects of daily life).

These numbers make clear that there are many people with cognitive disabilities who are users of information technology, and who do the kind of work that information technology commonly supports.

While there are many people with cognitive disabilities in the workforce, many are unemployed, as is true for people with disabilities of all kinds. The employment rate for people with disabilities in the United States is less than 56%, according to the U.S. Office of Disability Employment Policy[1]; and for the European Union the rate is less than 43%, according to the European Commission Directorate General for Economic and Social Affairs.[2]

Data on the kinds of barriers related to cognitive processing that people encounter in their work, or in other aspects of their lives, are hard to obtain. Because of the prevalence of the medical model, data collection has focused on the frequency of diagnostic categories, such as developmental disability, rather than on how often people face barriers connected with memory, or attention, or other cognitive functions. The International Classification of Functioning, Disability, and Health (ICF) embodies a new approach to disability-related data (World Health Organization, n.d.). The ICF includes descriptions of activities, participation, and context, as well as descriptions of components of functioning and disabilities. In principle, the new approach can be used to tabulate barriers of different kinds, and could be useful in prioritizing research and development on eliminating or bypassing cognitive barriers.

7.4. Cognitive Barriers and Information Technology

Use of technology can involve nearly all of the cognitive functions on the previously mentioned list; hence, a wide range of cognitive barriers can arise in technology use. Functions concerning emotions may be an exception, since technology use does not normally engage the emotions. However, as MJ's situation shows, dealing with frustration can be significant. Further, some user interaction techniques are emerging that use simulated human agents in an effort to project friendliness or helpfulness (see, e.g., Brave et al., 2005). It is possible that difficulty in judging emotions could interfere with these interactions.

Here are examples of some of the cognitive barriers to successful use of computer and communication. They are organized in the same categories as the list adapted from Francik (1999), previously shown.

7.4.1 Executive Functions

7.4.1.1 Carrying Out a Sequence of Operations

Cellular phones allow one to take pictures and send them to contacts. Doing this on one common model requires at least eight button presses, plus additional actions to scroll through the contact list. While most of these button presses are cued to some degree, some of the cues are quite cryptic, so that it is essential to keep clearly in mind what one's ultimate goal is during the entire sequence to avoid getting lost.

7.4.1.2 Managing a Stack of Goals and Subgoals

Most tasks of any complexity can be divided into parts, subtasks, which can be completed in a manner substantially independent of the main task. For some people, determining what to do next is difficult when the goal of a subtask (called a subgoal) has been completed. In some cognitive models (see, e.g., Anderson et al., 2004), this transition is managed using an information structure called a *stack*, in which the status of the main task is stored while a subtask is being worked on. For some people, this goal management is unreliable, and prompting to help them sequence the steps in a complex task is helpful (Davies et al., 2002).

A common situation in which goal management is needed in technology use is consulting help information. Here work on the main task has to be suspended, while the subtask of accessing help is carried out, and then resumed when the information sought from help has been obtained.

7.4.2 Memory

7.4.2.1 Memory in Performing a Sequence of Actions

Modern technology rarely *requires* users to carry out a procedure by simple rote memory. As in the cell phone example presented earlier, most actions have some kind of cue associated with them that can guide a user who does not know the sequence of actions required. But memory still plays a part, in many situations. Cues are often cryptic, meaning that their significance isn't completely clear when first seen. For example, in the cell phone sequence described earlier, the required action at one stage is through Option. It leads to a choice of ways to specify the recipient of the picture, but there is nothing about the cue Option that suggests that when it is first encountered. This means that memory is helpful in performing this task, in two ways. One might remember what Option means, in this situation, or one might remember that the action cued by Option is needed at this point, without regard to any interpretation of the cue.

Another consideration regarding the role of memory in using technology is the tradeoff that can be observed between reasoning and memorizing. The actions needed to perform a task usually have a logic based on their connection to underlying

[1] http://www.dol.gov/odep/faqs/working.htm.

[2] http://ec.europa.eu/employment_social/news/2001/dec/2666complete_en.pdf.

processes in the implementation of the task. Someone who understands this logic can often work out what to do to accomplish a task, whereas someone who does not understand it must rely on memory (or an instruction list, an external memory). Because a person with a cognitive disability may have more trouble understanding the logic of a complex system, he may be compelled to rely more on memory.

To illustrate these considerations, suppose you receive a document as an attachment to an e-mail message. You open the document, make some revisions, and save. At some later time you want to find the revised document, but you have difficulty, because it is among the temporary files maintained by your mail system, not among your own documents. A colleague advises you that you can avoid this problem in the future by remembering to use Save As rather than Save after revising an attachment, and to specify one of your document folders when you perform the Save As operation. If you understand the logic of Save As, and its relationship to Save, you will understand your colleague's suggestion, and will find it easy to follow in the future. If you should forget that Save As is the particular action needed, you can easily work it out. But if you do not understand the underlying logic, you will be forced to rely much more on your memory (internal or external), both for the needed action, and for what you must specify as a destination when you perform the Save As operation.

This example highlights another challenge associated with memory for actions. Both in form and in meaning, Save and Save As are quite similar, yet correct operation requires a user to discriminate between them. Technology use often requires this kind of fine discrimination: in URLs, case distinctions and the difference between .htm and .html; in programming, the distinction between X=Y and X==Y in many programming languages, and so on. As noted as long ago as 1982 in Lewis and Mack, these discriminations are a rich source of usability problems for people with typical cognitive functioning. While specific data are scant (though see the discussion in Small et al., 2005), it is likely that these problems are even more common for people with cognitive disabilities. As for other usability problems, their impact is also likely to be greater, because people with cognitive disabilities may have more trouble detecting that an error has occurred, and in recovering from it.

7.4.2.2 Procedural and Declarative Information in Technology Use

As mentioned earlier, memory for skills (procedural knowledge) involves different mechanisms from memory for facts (declarative knowledge). The example just discussed shows how these two kinds of information are intertwined in common uses of technology. One can "know what to do" as a procedure, a well-learned skill, or one can "know what to do" by deploying declarative knowledge of what particular cues mean, or how a system works. Further, as Anderson et al. (2005) argue, declarative knowledge can be proceduralized, that is, converted to skill form. A person whose declarative memory is impaired, like some of Glisky's trainees in the study cited earlier, can perform some tasks by reliance on procedural memory.

Other aspects of common technology uses make demands in which these two kinds of information are more separate. For example, keyboarding is a procedural skill called for in many technology uses. Some people with cognitive disabilities also have motor disabilities that can make keyboarding difficult. But some people have impairments in procedural memory, associated for example with severe depression, that make skill learning difficult (Budson and Proce, 2005). On the other hand, unlike declarative memory, procedural memory is often spared in patients with head injury (Milders, 1997).

Keeping track of one's files is an example of a task with heavy demands on declarative memory. Finding a file without extensive search requires recalling its name, or the names of the folders or directories within which it was placed. If recall of this information fails, one can browse, hoping to be able to recognize the name one could not recall. Such browsing may be impractically inefficient if one has many folders and cannot recall information that can be used to limit the search. Some systems allow files to be searched by contents, but even this kind of facility requires some recall of what is in a file.

Finding things can also involve spatial memory and spatial reasoning. Some people use spatial layouts rather than lists when viewing the contents of folders. Spatial memory is thought to involve different brain mechanisms from other forms of memory, and some people with cognitive disabilities have impairments in these mechanisms (Pennington et al., 2003).

Jarrold et al. (1999, 2007) have studied the relationship between verbal (linguistic) and spatial abilities, including learning, in people with different developmental disabilities. Williams syndrome is associated with relatively strong verbal abilities and weak spatial abilities, while Down syndrome shows the opposite pattern. These studies are valuable in contributing to increased understanding of the organization of cognitive functions, showing that there is a separation of mechanism between these two forms of learning. They also make a point that will be revisited in the following, that different users have different patterns of strengths and weaknesses that design needs to accommodate.

7.4.3 Attention and Perception

7.4.3.1 Interpreting a Complex Display

The home page of a typical web site has many parts, each of which contains many possible controls. The home page for the Mayo Clinic, a popular health information site in the United States, when viewed on February 25, 2007 contained 15 major, visually marked subdivisions, and a total of 107 controls, including two text-entry fields, two scrolling lists, and 101 links. The two scrolling lists exposed a total of 30 additional links. A survey of web pages reported in Ivory et al. (2000) found an average of 11 distinguished text areas per page, and 40 links. Interestingly, pages in their sample ranked favorably by experts were even more complex, having an average of 18 text clusters and 60 links. Scanning a display of this complexity, looking for desired information, or for a link to follow, requires nontrivial control of visual attention (Kitajima and Polson, 2007), shifting attention from area to another, and scanning the cues associated with many controls.

Such searches may be especially difficult for some people with cognitive disabilities. Chan (2001) reviews literature on attentional deficits following brain injury, including some evidence that shifting attention is difficult for some patients. Carlin et al. (1995) present data on simple visual search by people with developmental disabilities, showing a complex pattern of impairment, with results differing according to the stimulus aspects needed to identify targets (e.g., color vs. form). Studies show superior performance by people with some cognitive disabilities in tests of visual perception using complex patterns (O'Riordan et al., 2001; Greenaway and Plaisted, 2005). As Carlin discusses, it is difficult even in a simple search task to separate the effects of attentional control and perception from other cognitive factors, such as problem solving. Problem solving, including the use of background knowledge, is certainly involved in processing web pages, as Kitajima and Polson bring out. Because cues for links are nearly always textual, language processing is also involved.

7.4.3.2 Interpreting Symbols

While many cues found in interfaces, such as on web pages, are textual, many are not. Icons, small symbols, are widely used in interfaces to mark controls (usually buttons to be operated by a pointing device). The Microsoft Word screen contains 40 icons, mostly indicating operations, such as indentation, or text highlighting, but a few indicating status, such as the state of grammar checking. A further 25 icons are supplied on the same screen by the operating system. Again, most of these indicate actions, but a few indicate status, such as the charge level in the laptop's battery. One of the icons does double duty: an icon of a loudspeaker shows me the current volume level of the speaker, acting as a status indicator, but also serves as a button that exposes a volume control.

Nearly all icons embody some form that is meant to be familiar, such as the outline of a file folder or a floppy disc. This referent is not always familiar, in reality: file folders of the U.S. kind are not familiar elsewhere in the world, and hardly anyone uses floppy disks anymore. Further, the depiction is often so reduced, especially in small icons, that the form may not be easily recognized when first encountered. See Byrne (1993) for a discussion of visual search using icons.

Few icons can be interpreted without some explanation. For example, a user might encounter a small, geometric icon near the top right corner of the screen. Presumably, the user in question has seen it hundreds of times, but still may have no idea what it represents, until she selects it and finds that it reveals a menu relating to the Bluetooth wireless system. The user can now conjecture that the icon is a kind of stylized letter B, and may remember that, and interpret it in that way, when seeing the icon in the future. Like other icons, this one operates (when it works) more as a cue for remembered content than as an independent representation. The remembered content has to be obtained by exploration, as in this example, or from a short textual description that is supplied when the pointing device hovers over the icon without selecting it, or (if a more complex explanation is needed) by a help system or manual.

Research has shown that recognizing and using symbols, and even accurate pictures like photographs, is a complex skill (Stephenson and Linfoot, 1996). People with severe cognitive disabilities may require extensive training, or, in some cases, may be unable to attain mastery. Thus while some people may be helped by use of symbols rather than text in an interface, others may not be.

7.4.4 Language

7.4.4.1 Understanding Text

As discussed previously, even apparently nonlinguistic features of interfaces, like icons, usually require some interpretation of linguistic material for their use. Language in information systems is usually presented as text, requiring users to be able to carry out a chain of operations starting with visual perception of the elements of the text, proceeding through the recognition of words, taking in the assembly of words into meaningful structures, as provided for in the language, and continuing to the interpretation of these meanings in the context of the situation at hand (Friederici and Lachman, 2002).

Any of the stages in this chain can present problems. Some people with cognitive disabilities cannot carry out the early stages, and are not literate at all. Others can recognize words, but have a limited vocabulary. Some people may recognize the words in a sentence, but have trouble processing the sentence if its syntax is complex, apparently because of the demands on memory (Friederici and Lachman, 2002).

Because literacy develops over time, young children have limited vocabulary, and have trouble with complicated sentences. It has been therefore become common to use stages in literacy development, usually related to grades or levels in school, to characterize the literacy of people with cognitive disabilities. But this does not work very well. The development of vocabulary is driven by experience, not just schooling, and adults with cognitive disabilities have experiences, and hence vocabulary, that do not correspond to those of schoolchildren. At the same time, range of vocabulary, and ability to process complex sentences, are not linked in a simple way (Gajar, 1989).

The practical effect of this complex situation is that people with cognitive disabilities may have trouble with the linguistic content of an interface, but there is no simple way to predict this. As Redish (2000) points out, the aspects of language assessed by readability formulas do not suffice to characterize the situation. Shorter sentences can be harder to understand than longer ones, especially if the shorter sentences are produced by cutting up longer ones, as is sometimes done to produce a better readability score for a text. Using common words may be less effective than using less common ones, depending on the context. Redish (personal communication) describes an effort to rewrite a standard lease to make it more accessible for poor readers. Replacing the term *security deposit* by a locution using more common words led to a general *decrease* in comprehension, because the adult poor readers in the study already knew what a security deposit is, from their life experience. In the face of these difficulties, rather than trying to simplify the vocabulary used in interfaces, it may be more promising to provide a means by which users can get an explanation of whatever terms are used, if they need it.

Other aspects of interfaces can have a big impact on the accessibility of linguistic material. It is obvious that a person who is blind will profit from audio presentation of text, but it is also true that this can benefit a person who has a cognitive disability that interferes with the recognition of words. While no specific data were found regarding people with cognitive disabilities, it is plausible that a *combination* of visual presentation of text with audio presentation is superior for sighted users with cognitive limitations over pure audio presentation (see Fang et al., 2006, for a review of studies of dual mode presentation). The combination may allow them to gain some of the advantages of visual presentation, such as the ability to review material by referring to the visual form, rather than having to rely on auditory memory, and the ability to link different parts of an interface via their spatial arrangement, while not having to do the work of decoding the content strictly from the text.

The informational web site thedesk.info illustrates these approaches at work. The site presents descriptions of government services of interest to people with cognitive disabilities in the United States. The creators work from descriptions that are provided by different government agencies, reorganize them under topical headings, and group together related information from different sources. They write descriptions that avoid unfamiliar and complex words, and use simple syntactic forms. They also provide audio presentation of the key texts. The site uses icons to mark major topical groupings, so as to reduce the reliance on text. The site does not have a facility for looking up unfamiliar words, though (as Redish would suggest will commonly occur) there are unfamiliar words used, even in the simplified descriptions. For example, the word *waiver* is used to describe a funded service, for historical reasons. People without experience in the support system would not recognize this unusual use, but many of the intended users of the site will understand it.

In addition to reading or otherwise comprehending text, some interfaces require users to produce it. Conducting a web search, for example, usually requires the user to type in search terms. For some users with learning disabilities, spelling is a major difficulty, and the facilities some search engines have for suggesting corrected spelling is a big help. For other users, a speech interface could be valuable.

7.4.4.2 Nonlinguistic Communication

Because some people, like Abdulkader, introduced previously, have difficulty processing language, there is interest in interaction and communication techniques that do not require it. Vanderheiden and colleagues at the Trace Center (Law and Vanderheiden, 2000) have developed EZAccess, a set of controls for common functions in information systems that can be identified using shape and color cues. Once learned, these controls make it possible to perform basic operations in a range of application systems without the need to interpret textual labels or explanations. For example, a postal kiosk patron uses these controls to navigate among choices and confirm selections (though some aspects of most transactions, such as buying postage that depends on the destination, require processing text).

Kitzing et al. (2005) review a number of projects for supporting people with language difficulties, including the one in which Abdulkader participates; see also McGrenere et al. (2003). As Danielsson and Svensk (2001) suggest, the ever-increasing ease of capturing, editing, storing, and retrieving digital images are increasing the opportunities for image-based communication and interaction.

7.4.5 Speed of Reasoning

7.4.5.1 Time-Dependent Interactions

Some interactions with IT require responses within a certain time, and these are difficult when speed of mental operations, such as understanding language or making a choice, is reduced. For example, voice dialogues accessed by telephone commonly time out if a response is not made within an allowed interval. Some computer operations, such as logging off, may allow a certain amount of time for the user to confirm the operation before it is canceled.

Besides these cases of system-imposed speed requirements, there are situations in which operations can be too slow to be practical. According to a survey of web users seeking information for personal interest or needs (GVU, 1998), typical users give up on a search after a half hour or less. If a person's speed of reasoning is such that typical searches take an hour or more to complete, only the most pressing needs will justify persistence.

7.4.6 Solving New Problems

7.4.6.1 Using a New Tool

In addition to the problem solving that may be involved in one's own personal or professional tasks, the IT user confronts the need to solve problems that are presented by the technology itself. For example, a user recently acquired a new image-editing program, and wanted to use it to create a greeting card by combining parts of different digital photographs. The user had to give up on the new program, and do the job with an older, familiar program, because she could not figure out how to paste an image cut from one photo into another. The new program provided familiar cut-and-paste operations, but the paste operation required some follow-up action that the user could not discover in the time she was willing to invest. This kind of situation, which is not rare for a person with typical cognitive capabilities and a good deal of knowledge of computer interactions, is more common for someone whose background knowledge and problem-solving ability are limited.

7.4.6.2 Dealing with Errors

Even if one has mastered the use of a system, problems occur that require *troubleshooting*, a form of problem solving that is often even more difficult. Troubleshooting almost always requires some understanding not only of the task that one is trying to perform, but also of how the underlying system works (Kieras and Bovair, 1984). For example, a colleague recently found that he could not open a file that had been attached to an e-mail message he had received the previous week. The message referred to the file having been "shortcutted," and not available "offline." My colleague could interpret neither of these assertions, and neither was explained in the help system. He had to get technical assistance, and it emerged that "shortcutting" and "offline" referred to aspects of the implementation of her mail system of which she was completely unaware. Again, problems of this kind are common, and extremely debilitating, for users with typical cognitive capabilities and knowledge; they are more common, and more debilitating, for people with cognitive limitations.

7.4.6.3 Complex Search

Returning to a situation discussed earlier, searching for information on the web requires problem solving as well as perception of large displays (and linguistic interpretation of cues like link labels). The user has to decide which of several links looks most promising, keep track (if possible) of which links have already been explored, and the like, operations at the heart of Newell and Simon's (1972) classic account of problem solving. Unfortunately, as Pirolli (2005) shows, a relatively small decrease in the accuracy with which the user can evaluate links leads to a very large increase in the amount of searching that must be done, and hence in the time required to find something. Thus people with cognitive disabilities may find it impossible to use a site that is only frustrating for users with typical cognitive capabilities.

7.5 Implications for Design and Design Process

Given this inventory of barriers, what can be done to avoid them in designing accessible information technology? There is a parallel with design for usability, where it was recognized early on (Gould and Lewis, 1985) that design for usability has to include not only attention to particular design features, but also design processes that use actual data about effectiveness. Similarly, design for universal access has to incorporate design features that promote cognitive accessibility, but it also has to recognize that user testing is needed to ensure an adequate level of effectiveness. Because of the diversity of the audience to be addressed, there is the further need, perhaps not so prominent in design for usability, to allow for *configurability* of interfaces so as to address different, and sometimes incompatible, needs of different users.

7.5.1 Interface Features

Many aspects of good user interface design have become generally accepted, such as using a two-stage protocol with confirmation for operations that cannot easily be reversed or providing automated, "wizard" support for complicated operations like installation. Good design for usability is important for people with cognitive disabilities as it is for other users. But there are specific interface features that have special importance for people with cognitive disabilities. These include:

- *Providing users enough time to read and use content* (see W3C, 2007, Guideline 2.2). As recognized in accessibility regulations and guidelines (for example, United States Access Board, n.d. or W3C, 2007), interfaces that require users to act or respond within a short time window are unacceptable because of the barriers they create for many people with disabilities.
- Any interface should include *a facility for looking up the meanings of unfamiliar words or phrases*, or it should be designed so as to work effectively with an assistive technology tool that provides that function (see W3C, 2007, Guideline 3.1).
- *Redundant, user-controlled modality of information* (Francik, 1999). Interfaces should support audio presentation of text, either in the interface itself or by the use of an appropriate tool. This is needed not only for users who cannot see, but also for users who can see the text, and can understand the words in the text, but cannot easily read them.
- *Spelling correction* should be provided for any spelling-sensitive interaction, for example issuing commands or entering search terms. Similarly, if an interface requires users to perform calculations, the interface should provide support (see Francik, 1999).
- *Compatibility with assistive technology.* As mentioned in connection with some of these features, users may need to use assistive technology tools, such as a screen reader. Therefore, it is very important that interfaces not include features that block the use of these tools.

Any interface should have all of the features just listed; but there are other features that are only conditionally useful, in that they are useful in some situations but are actually debilitating in other situations.

As discussed earlier, some users can process textual information relatively better than spatial information, while for others the opposite is true. Thus, for example, replacing a diagram by text in presenting a concept may help some users but harm others. No single design choice dominates for all users.

Early design guidelines for usability called for menus or screens that presented a limited number of choices, under the influence of an erroneous reading of George Miller's famous seven plus or minus two concept (LeCompte, 2000). Current design practice recognizes that wide interfaces, ones that present very many choices on each screen, have substantial advantages, including requiring fewer interactions to complete a task, and lack of reliance on general descriptors for categories of choices, which are difficult to create (for early discussion, see Landauer and Nachbar, 1985). In keeping with this recognition, web pages now commonly offer tens or even hundreds of links.

While typical users are well served by this design, what about users for whom processing a complex display, or choosing among many confusing alternatives, is difficult? For them, a narrower interface that presents only a few choices at a time could be better.

As discussed in Lewis (2007), there is a tradeoff at work here. If a given number of alternatives are to be offered to users, an interface can present fewer on a given screen only by requiring users to process more screens, and hence take more steps. For some users, the difficulty of managing an interaction that requires more steps may outweigh the benefit, if any, associated with each screen being easier to process. Therefore no single design can be assumed to be superior for all users. Typical users are generally better served by wide interfaces, but some, though not all, users with cognitive limitations may benefit from narrower interfaces.

What about simply eliminating choices, so that a user confronts fewer choices *and* fewer screens? For some users, this is not helpful because they really need and use a very wide range of functions. But for other users, including users who simply do not need rarely used options, as well as users for whom processing options is difficult, this can be an excellent design direction.

Dealing with design features that are good for some users and bad for others requires configurability. Fortunately, software is sufficiently flexible that different users can have different user interfaces, chosen to meet their particular needs. Commercial software, like Microsoft Word, offers a wide range of configuration controls, including the ability to eliminate whole categories of functions from the user interface. For example, a user who never needs to include tables in documents can remove all table-related controls from the interface. The flexibility to eliminate inessential functions is a key requirement for cognitive accessibility (Francik, 1999).

While this kind of configurability offers benefits in principle, in practice problems remain. Configuring software like Word is not so easy, and few users know how to do it. Equally important, it is hard to determine what configuration would be suitable for a particular user. Making changes in the interface can make it harder to use documentation or help that refers to a standard configuration. If users have configured their personal copies of some software, this does not help them if they need to use a computer other than their own, for example in a public library. And there is the further difficulty that some important forms of configurability, for example shifting between textual and nontextual presentations, are currently beyond the reach of technology. More work is needed on this whole complex of issues, as discussed in the following.

7.5.2 Design Process

Some important attributes of good design for people with cognitive disabilities cannot be reduced to interface features. For many interfaces, comprehensibility of text (e.g., labels on links on a web page) is crucial. But, as discussed earlier, there is no reliable way to predict that a given piece of text will or will not be comprehensible by a particular audience.

This means that the design process for comprehensible text has to include user testing for the intended audience, and it is helpful if people with cognitive disabilities are involved in creating the material, as recommended by Freyhoff et al. (1998). More generally, as it has long been recognized for usability for typical users, many other aspects of an interface cannot reliably be evaluated without user testing, including whether users will notice needed controls, will interpret symbols as intended, or will realize that needed functions are possible in the interface. Design for cognitive accessibility has to include user testing.

Useful advice on user testing with people with disabilities, including people with cognitive disabilities, is becoming available (Henry, 2007). As discussed in the following, greater inclusion of people with disabilities in user studies must be a priority for the future.

While design for usability now commonly incorporates user testing, it also uses inspection methods, such as the cognitive walk-through or heuristic evaluation (Nielsen and Mack, 1994) that does not involve user testing. Inspection methods provide a structured way for designers to identify potential weak points in a design, often before the design is sufficiently realized to permit testing. Inspection methods that address accessibility are starting to become available (e.g., Paddison and Englefield, 2003), but these do not yet address cognitive accessibility. Material from Bohman (n.d. i, ii) and LD-Web (http://www.ld-web.org) could be used as the basis for an enhanced accessibility inspection that would give attention to cognitive issues.

At a higher level of process, the report by Freyhoff et al. (1998), already mentioned, describes a development process for cognitively accessible text that can be adapted as the skeleton for a design process for cognitive accessibility much more broadly. Here are the key steps, restated in terms of system design rather than document design:

- Decide on the aim of the system.
- Prepare a list of the key functions.
- Create a prototype based on the key functions.
- Check whether people with cognitive disabilities can use the prototype.
- Modify the prototype as needed and test again.

This development road map agrees well with recommended practice for design for usability, as described for example in Lewis and Rieman (1996). This convergence is not surprising, given the need for user testing in both usability and accessibility design.

7.6 Trends

Greater attention is being focused on the needs of people with cognitive disabilities. In part due to the advance of the self-advocacy movement (Dybwad and Bersani, 1996), in which people with cognitive disabilities speak out to assert their rights, people with cognitive disabilities are claiming a greater share of attention in the accessibility world. In 2007 the Web Accessibility Initiative of the World Wide Web Consortium, recognizing issues in the coverage of cognitive issues in its Web Content Accessibility Guidelines, carried out special consultation, leading to recognition of the need for future work directed at this area. Similarly, the Telecommunications, Electronic, and Information Technology Advisory Committee of the U.S. Access Board, the body responsible for accessibility regulations in the United States, has given special attention to cognitive issues. On the commercial side, Nokia included cognitive accessibility in a major review of accessibility developments.

This increased focus on cognitive accessibility will bring with it developments on a number of fronts. Because cognitive accessibility cannot be addressed only by attention to specific interface features, regulatory approaches may need to shift from a primary emphasis on checking interface features when assessing compliance to an approach that includes user testing. See Sampson-Wild (2007) for a discussion of this need in the context of web accessibility.

Technical developments to support interface configurability will accelerate. The Fluid project (http://fluidproject.org) is a major international effort to support interface configurability in community source projects in higher education. The intention is to promote the development of infrastructure for configurability, including both software structures that allow different user interface components to be selected for different users, and in allowing users to create and deploy profiles that capture their interface preferences in a portable way, available on the web, so that they can get an appropriate interface on any computer, not just their own.

Integration of accessibility, including cognitive accessibility, into design and development processes, is starting to take place. The Fluid project illustrates this trend as well. This will lead to the development of inspection methods that address cognitive accessibility. It will also lead to a very desirable increase in inclusion of people with disabilities, including cognitive disabilities, in design and development activities like focus groups for requirements development, and user tests. A positive feedback loop can accelerate these changes: as more designers and developers become more familiar with people with cognitive disabilities and their needs, barriers to inclusion are likely to diminish more rapidly.

A related trend, now in its early stages, is greater participation by self-advocates in regulatory and development processes affecting accessibility. In all spheres, technical, social, and political, participation by people with disabilities has led to great advances in accessibility, and the same can be expected from people with cognitive disabilities.

References

Anderson, J. R. (1983). *The Architecture of Cognition*. Cambridge, MA: Harvard University Press.

Anderson, J. R., Bothell, D., Byrne, M. D., Douglass, S., Lebiere, C., and Qin, Y. (2004). An integrated theory of the mind. *Psychological Review* 111: 1036–1060.

Bergman, M. M. (1998). Cognitive orthotics enhance the lives of users with cognitive deficits, in the *Proceedings of the Technology and Persons with Disabilities Conference (CSUN) 1998*, March 1998, Los Angeles. http://www.csun.edu/cod/conf/1998/proceedings/csun98_160.htm.

Bohman, P. (n.d. i). Cognitive disabilities part 1: We still know too little, and we do even less. WebAIM. http://www.webaim.org/articles/cognitive/cognitive_too_little.

Bohman, P. (n.d. ii). Cognitive disabilities part 2: Conceptualizing design considerations. WebAIM. http://www.webaim.org/articles/cognitive/conceptualize.

Brave, S., Nass, C., and Hutchinson, K. (2005). Computers that care: Investigating the effects of orientation of emotion exhibited by an embodied computer agent. *International Journal of Human-Computer Studies* 62: 161–178.

Budson, A. E. and Proce, B. H. (2005). Current concepts: Memory dysfunction. *New England Journal of Medicine* 352: 692–699.

Byrne, M. D. (1993). Using icons to find documents: Simplicity is critical, in the *Proceedings of the INTERACT '93 and CHI '93 Conference on Human Factors in Computing Systems (InterCHI-93)*, 24–29 April 1993, Amsterdam, The Netherlands, pp. 446–453. New York: ACM Press.

Carlin, M. T., Soraci, S., Goldman, A. L., and McIlvane, W. (1995). Visual search in unidimensional arrays: A comparison between subjects with and without mental retardation. *Intelligence* 21: 175–196.

Chan, R. C. K. (2001). Attentional deficits in patients with post-concussion symptoms: A componential perspective. *Brain Injury* 15: 71–94.

Danielsson, H. and Jonsson, B. (2001). Pictures as language, in the *Proceedings of the International Conference on Language and Visualization,* 8–9 November 2001, Stockholm, pp. 1–35. AQ1

Danielsson, H. and Svensk, A. (2001). Digital pictures as cognitive assistance, in *Assistive Technology Research Series: Vol. 10, Assistive Technology: Added Value to the Equality of Life* (C. Marincek, C. Buhler, H. Knops, and R. Andrich, eds.), pp. 148–153. Amsterdam: IOS Press.

Davies, D. K., Stock, S. E., and Wehmeyer, M. L. (2002). Enhancing independent task performance for individuals with mental retardation through use of a handheld self-directed visual and audio prompting system. *Education and Training in Mental Retardation and Developmental Disabilities* 37: 209–218.

Duchaine, B. C., Yovel, G., Butterworth, E. J., and Nakayama, K. (2006). Prosopagnosia as an impairment to face-specific mechanisms: Elimination of the alternative hypotheses in a developmental case. *Cognitive Neuropsychology* 23: 714–747.

Dybwad, G. and Bersani, H. (eds.) (1996). *New Voices: Self-Advocacy by People with Disabilities*. Cambridge, MA: Brookline Books.

Fang, X., Shuang, X., Brzezinski, J., and Chan, S. (2006). A study of the feasibility and effectiveness of dual-modal information presentations. *International Journal of Human-Computer Interaction* 20: 3–17.

Francik, E. (1999). *Telecommunications Problems and Design Strategies for People with Cognitive Disabilities*. http://www.wid.org/archives/telecom.

Freyhoff, G., Hess, G., Kerr, L., Menzel, E., Tronback, B., and Van Der Veken, K. (1998). Make it simple: European guidelines for the production of easy-to-read information for people with learning disability. *Inclusion International.* http://digitalcommons.ilr.cornell.edu/gladnetcollect/270.

Friederici, A. D. and Lachman, T. (2002). From language to reading and disability: Cognitive functions and their neural basis, in *Basic Functions of Language, Reading, and Reading Disability* (E. Witruk, A. D. Friederici, and T. Lachmann, eds.), pp. 9–12. Norwell, MA: Kluwer.

Gajar, A. H. (1989). A computer analysis of written language variables and a comparison of compositions written by university students with and without learning disabilities. *Journal of Learning Disabilities* 22: 125–130.

Ghaldiali, E. (2004). Cognitive primer: Agnosia. *Advances in Clinical Neuroscience and Rehabilitation* 4: 18–20.

Glisky, E. (1992). Acquisition and transfer of declarative and procedural knowledge by memory-impaired patients: A computer data-entry task. *Neuropsychologia* 30: 899–910.

Gould, J. D. and Lewis, C. (1985). Designing for usability: Key principles and what designers think. *Communications of the ACM* 28: 300–311.

Greenaway, R. and Plaisted, K. (2005). Top-down attentional modulation in autism spectrum disorders is stimulus-specific. *Psychological Science* 16: 987–994.

GVU (1998). *9th WWW User Survey: Internet Shopping Part 2*. http://www.gvu.gatech.edu/user_surveys/survey-1998-04/reports/1998-04-Netshop2.html.

Hart, M. (2005). Autism/Excel study, in the *Proceedings of ASSETS 2005 (Seventh International ACM SIGACCESS Conference on Computers and Accessibility)*, 9–12 October 2005, Baltimore, Maryland, pp. 136–141. New York: ACM.

Henry, S. (2007). *Just Ask: Integrating Accessibility throughout Design*. http://www.uiaccess.com/accessucd/index.html.

Horner, J. (2004). *Jack Horner: An Intellectual Autobiography*. http://mtprof.msun.edu/Spr2004/horner.html.

Ivory, M. Y., Sinha, R. R., and Hearst, M. A. (2000). Preliminary findings on quantitative measures for distinguishing highly rated information-centric Web pages, in *Proceedings of the 6th Conference on Human Factors and the Web*, 19 June 2000, Austin, Texas.

AQ2

Jarrold, C., Baddeley, A. D., and Hewes, A. K. (1999). Genetically dissociated components of working memory: Evidence from Down's and Williams syndrome. *Neuropsychologia* 37: 637–651.

Jarrold, C., Baddeley, A. D., and Phillips, C. (2007). Long-term memory for verbal and visual information in Down syndrome and Williams syndrome: Performance on the doors and people test. *Cortex* 43: 233–247.

Kieras, D. E. and Bovair, S. (1984). The role of a mental model in learning to operate a device. *Cognitive Science* 8: 255–273.

Kitajima, M., Polson, P. G., and Blackmon, M. H. (2007). CoLiDeS and SNIF-ACT: Complementary models for searching and sensemaking on the Web. Paper presented at the *Annual Meeting of the Human Computer Interaction Consortium*, February 2007, Granby, Colorado. http://staff.aist.go.jp/kitajima.muneo/English/PAPERS(E)/HCIC2007.html.

Kitzing, P., Ahlsen, E., and Jonsson, B. (2005). Communication aids for people with aphasia. *Logopedics Phoniatrics Vocology* 30: 41–46.

Landauer, T. K. and Nachbar, D. W. (1985). Selection from alphabetic and numeric menu trees using a touch screen: breadth, depth, and width, in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 14–18 April 1985, San Francisco, California, pp. 73–78. New York: ACM Press.

Law, C. and Vanderheiden, G. (2000). The development of a simple, low cost set of universal access features for electronic devices, in *Proceedings of CUU'00*, 16–17 November 2000, Arlington, Virginia, pp. 118–123. New York: ACM.

LeCompte, D. C. (2000). 3.14159, 42, and 7+/–2: Three numbers that (should) have nothing to do with user interface design. *Internetworking*.http://www.internettg.org/newsletter/aug00/article_miller.html.

Lewis, C. and Mack, R. (1982). Learning to use a text processing system: Evidence from "thinking aloud" protocols, in *Proceedings of the 1982 Conference on Human Factors in Computing Systems*, 15–17 March 1982, Gaithersburg, Maryland, pp. 387–392. New York: ACM.

Lewis, C. and Rieman, J. (1996). *Task Centered User Interface Design: A Practical Guide*. http://www.hcibib.org/tcuid.

McGrenere, J., Davies, R., Findlater, L., Graf, P., Klawe, M., Moffatt, K., et al. (2003). Insights from the Aphasia Project: Designing technology for and with people who have aphasia, in the *Proceedings of the 2003 Conference on Universal Usability*, 10–11 November 2003, Vancouver, British Columbia, pp. 112–118. New York: ACM Press.

Microsoft (n.d.). *The Market for Accessible Technology: The Wide Range of Abilities and Its Impact on Computer Use*. http://www.microsoft.com/enable/research/phase1.aspx.

Milders, M. V. (1997). *Memory for People's Names in Closed Head Injured Patients.* Dissertation, University of Groningen. http://dissertations.ub.rug.nl/faculties/ppsw/1997/m.v.milders.

Newell, A. and Simon, H. A. (1972). *Human Problem Solving*. Englewood Cliffs, NJ: Prentice Hall.

Nielsen, J. and Mack, R. L. (eds.) (1994). *Usability Inspection Methods*. New York: John Wiley & Sons.

O'Riordan, M. A., Plaisted, K. C., Driver, J., and Baron-Cohen, S. (2001). Superior visual search in autism. *Journal of Experimental Psychology: Human Perception and Performance* 27: 719–730.

Pennington, B. F., Moon, J., Edgin, J., Stedron, J., and Nadel, L. (2003). The neuropsychology of Down syndrome: Evidence for hippocampal dysfunction. *Child Development* 74: 75–93.

Pirolli, P. (2005). Rational analyses of information foraging on the Web. *Cognitive Science* 29: 343–373.

Rapley, M. (2004). *The Social Construction of Intellectual Disability*. Cambridge: Cambridge University Press.

Redish, J. (2000). Readability formulas have even more limitations than Klare discusses. *ACM Journal of Computer Documentation* 24: 132–137.

Roth, W. (1983). Handicap as a social construct. *Society* 20: 56–61.

Small, J., Schallau, P., Brown, K., and Appleyard, R. (2005). Web accessibility for people with cognitive disabilities, in *CHI '05 Extended Abstracts on Human Factors in Computing Systems*, 2–7 April 2005, Portland, Oregon, pp. 1793–1796. New York: ACM Press.

Stephenson, J. and Linfoot, K. (1996). Pictures as communication symbols for students with sever intellectual disability. *AAC Augmentative and Alternative Communication* 12: 244–255.

United States Access Board (n.d.). *Telecommunications Act Accessibility Guidelines*. http://www.access-board.gov/telecomm/rule.htm.

United States Equal Employment Opportunity Commission (2005). *Annual Report on the Federal Work Force: Fiscal Year 2004*. Table 6. http://www.eeoc.gov/federal/fsp2004/aed/table6.html.

West, T. G. (2000). The abilities of those with reading disabilities: Focusing on the talents of people with dyslexia. *LD Online.* http://www.ldonline.org/article/5867.

World Health Organization (n.d.). *International Classification of Functioning, Disability, and Health*. http://www.who.int/classifications/icf/en.

W3C (2007). *Web Content Accessibility Guidelines 2.0.* http://www.w3.org/TR/WCAG20.

Author Queries

AQ1: Can you supply publisher name and location for Danielsson and Johnson (2001)?
AQ2: Can you supply publisher name and location for Ivory et al. (2000) reference?