Design Challenges of AAC Apps, on Wireless Portable Devices, for Persons With Aphasia

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Abstract

Successful interface design for rehabilitation technologies is much more challenging than generally thought. This paper identifies and discusses several interface methods that have proven beneficial to persons with aphasia on laptop computers that additionally show promise of successful implementation on smaller-format devices such as tablets and laptops. Illustrative, real-life examples will demonstrate how critically important it is to involve users in trying out proposed design solutions and providing user feedback.

Introduction

A cartoon in Donald Norman's classic book on usability, *The Design of Everyday Things*, shows a horse piloting a modern jet airplane. Before him is a control panel bristling with receding rows of closely spaced, diminutive switches. As he raises a hoof to activate one, the horse snorts in disgust, "Who designs these things anyway—raccoons?" (Norman, 1990, p. 187).

It surprises many technology users to learn that it is really quite difficult to design a good human-computer user interface. To emphasize the point, Ben Shneiderman states

> Designing an object to be simple and clear takes at least twice as long as the usual way. It requires concentration at the outset on how a clear and simple system would work, followed by the steps required to make it come out that way—steps which are often much harder and more complex than the ordinary ones. It also requires relentless pursuit of that simplicity even when obstacles appear which would seem to stand in the way of that simplicity. (1986, p. 3)

Even when product developers are equipped with this knowledge, experience has shown that it is all too easy for them to repeat the errors of underestimating the expertise, resources, and time required for successful interface conceptualization, development, testing, debugging, and refinement (Chapanis, 1996; Spolsky, 2001; Thimbleby, 1990). Success requires skill, experience, commitment, and perseverance.

The difficulties are even greater when developers design assistive devices for persons with disabilities. The need to address the unique challenges and special needs of individual users makes design activities all the more arduous. For example, designing learnable, memorable, and usable interfaces for persons with aphasia requires much more complex and challenging tasks than simply replacing text with graphics (the first notion likely to come to mind). The work requires familiarity with the constellation of non-language deficits that are observed commonly to co-occur with aphasia (e.g., right visual neglect, altered hearing, right hemiparesis, apraxia of speech, dysarthria, slower cognitive processing, diminished initiation, and the like). The product developer also must have an appreciation of frequently intact residual capabilities—such as an understanding of situational roles, communicative pragmatics, and object uses—that may be leveraged in the interests of communicative effectiveness. The developer also needs a sense of the peculiar ways in which aphasic deficits may present, so that intended communicative targets can be successfully inferred from approximate communicative performances. Clearly, both thorough theoretical knowledge and extensive practical experience inform successful design solutions for users with aphasia.

To contend with the complexities of developing effective user interfaces, designers have developed methodologies to aid the processes of identifying and characterizing users, assessing needs, defining problems, conceptualizing solutions, and prototyping interfaces, followed by iterations of testing, refinement, deployment, maintenance, and upgrade.

In this paper, we will illustrate what has worked for us in designing rehabilitation applications for persons with aphasia and related disorders. To date, these applications have primarily run on laptop or desktop computers. Our company currently has over 2 decades of experience developing rehabilitation applications for these platforms, preceded by well over a decade of applied research and development plus clinical testing. Throughout this period, our experience has corroborated established wisdom in the discipline, as articulated by, among others, Harold Thimbleby in his 1990 classic, *User Interface Design*. In short, we focus on establishing and deploying good fundamental designs at the outset, then work to improve those, incrementally and continuously, through iterative cycles of feedback solicitation, field observation, and data analysis from deployed designed, followed by design upgrades and sequential releases of improved successor versions.

During trials with our equipment, conducted to identify appropriate candidates for device acquisition, we work directly with end users and their clinicians. We have organized and supported users groups of persons with aphasia that meet weekly in our offices in Princeton, New Jersey, and—with our distance support—in other states as well. We get valuable ongoing feedback through our program of lifetime, unlimited, and no-cost technical support for owners of Lingraphicas as well as their family members, caregivers, and clinicians. Particularly valuable are the comments and suggestions we receive from speech-language pathologists (SLPs) who “inherit” a Lingraphica user, for example, when the client has moved or the client’s clinician has retired. These SLPs are almost always entirely unfamiliar with our devices, their operations, and their uses and constitute a valuable source to us of “naïve expert opinion.” We draw on all sources as we seek to improve the user interfaces in our devices.

In the first section below, we discuss the crucial importance of knowing and understanding users. Our users are persons with acquired aphasia as well as those who support them. We discuss important, but sometimes overlooked, characteristics of individuals in this group, and we note the ways that we have found useful to stay focused on their needs and wants. The importance of this approach cannot be overstated. People with aphasia have their own distinctive challenges and abilities; they are different in important ways from adults with other communicative challenges, such as those stemming from congenital disorders such as cerebral palsy or from late-onset degenerative disorders such as amytrophic lateral sclerosis or Parkinsonism. What works well for adults with aphasia are solutions that have been appropriately designed for their specific constellations of disabilities and residual abilities, field tested with their participation, and subsequently refined and improved based on their feedback and observations. We discuss such issues with selected examples from past work of this sort.

In the second section, we describe interface methods that meet two key criteria: first, proven effectiveness in promoting aphasia rehabilitation on computers of laptop or larger size; and, second, experience to date indicating the methods translate well onto smaller-format devices—tablets and handhelds. This section looks at the hopeful side of technology's role in aphasia rehabilitation, in particular, at those methods that apparently can be implemented effectively across the spectrum of device sizes.

In the third section, we introduce some real-life examples, drawn from our practical experience from decades of work in the field. The goal is to illustrate, with concrete particulars, the importance, value, and challenges of getting feedback from users and attending to its implications. What is often most striking here is how seemingly simple things can prove to be complex and demanding. Finding solutions may require great creativity, even though, once identified, they may seem obvious.

In the final section, we discuss what all this means as we move toward developing portable aphasia-rehabilitation apps for wireless, mobile devices. Portability and wireless connectivity are clearly the promising directions for technology development. Whereas there is every reason to view these as promising for persons with aphasia, we know also that unanticipated challenges lie ahead, and we turn here to what these may indeed be.

Understanding AAC Users

Understanding users is the essential first step of successful interface design. You must develop a sense of what the users want to do, what they need to do, the environments where they do it, how they typically proceed, their past experiences, their styles, and their preferences. Various methodologies have evolved to help designers understand end users, including informed observation, structured interviews, field studies, focus groups, and the creation of personas for reference during product development.

Persons with acquired aphasia are a highly heterogeneous group, at all levels of the WHO taxonomies of disease (WHO, 1980, 2001). Among these individuals, severity of impairment runs the gamut from profound to mild, as can restriction of participation and limitation of activities. Arguably, the characteristic common to all is a disproportion between speech/language/communication involvement and other deficit areas. That said, most persons with acquired aphasia also manifest—on testing—some degree of motor, sensory, and cognitive involvement as well. And then, depending on circumstances, they and their families must deal not infrequently with psychological, emotional, financial, and social issues associated with their situations.

To understand how best to serve this disparate population with our tools, materials, and methods, we seek actively to involve users in the various steps of design development. From the earliest work nearly 4 decades ago, participants in the line of research that has led from the ViC through the C-ViC to the Lingraphica have emphasized direct interaction with and observation of persons with aphasia, along with feedback from users and those who are close to them (Aftonomos, Steele, Appelbaum, & Harris, 2001; Gardner, Zurif, Berry, & Baker, 1976; Steele, Weinrich, Wertz, Kleczewska, & Carlson 1989; Weinrich, McCall, Weber, Thomas, & Thornburn, 1995). Observation in a naturalistic setting helped researchers to identify user needs, and the responses of users to the proposed solutions, in turn, helped guide researchers in their decisions on how to proceed. From this experience, we have identified some of the factors that make user interface design for technology applications in aphasia rehabilitation so challenging. We note a few of the key lessons learned below.

In field testing, it is important to cultivate sensitivity to the nonverbal responses of users with aphasia to proposed design solutions. Because of the very nature of aphasia, these users will experience some degree of difficulty describing in words what they like and why and what they dislike and why. Nonetheless, their nonverbal responses can be extremely communicative to those who attend closely. The user's degree of engagement, psychological affect, body language, and facial expressions can help product designers identify what the user may accept or reject. Some design methodologies encourage users to "think aloud" as they are trying out a prototype design, as a way of revealing to designers their internal thought processes. Persons with aphasia typically will not be able to do this, which raises the demands on the designer to arrive at such understandings through alternative means.

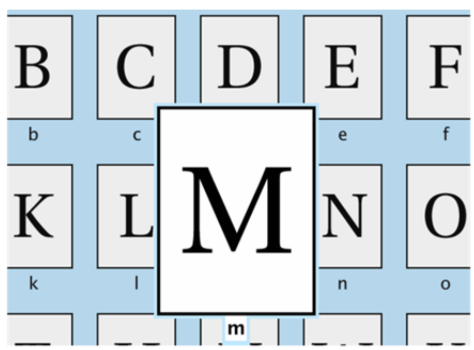
It is no less important to identify and exploit to maximum benefit the residual strengths common among persons with aphasia. These typically include the ability to identify objects visually and understand their basic uses, recognize pictures of familiar people and places, exhibit reasonable dexterity in the unaffected hand (usually the left hand), and show reasonable understanding of the pragmatics within situations. By focusing on consistently involving users with aphasia, conducting effective field testing, and appropriately building applications to exploit the residual strengths common among persons with aphasia, we should move effectively toward the successful development of applications that support the needs and wants of these users for their own proper purposes and in ways that users experience as empowering and rewarding.

Lessons to Date

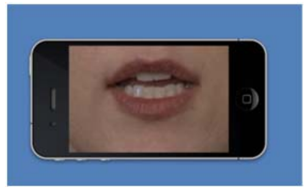
Below are several important and illustrative design solutions that have proven to be especially usable by, and beneficial to, persons with aphasia who employ a speech-generating device (SGD). We discuss briefly how SGDs operate in the desktop/laptop environment, and why they are well matched to their users.

One-click/one-touch operation refers to interface design solutions that permit users to access and use all materials on their SGD merely by positioning the cursor on a target and clicking once; or, if their device has a touch screen, by touching once on targets on the screen. This approach contrasts with a convention common within interface design that associates a "single click" with "selecting" an item and a "double click" with "opening" the item. The reason that "one-click" or "one-touch" operation is helpful to our population is that persons who have acquired aphasia following stroke may have motor involvement in addition to speech-language-communication deficits. For some, the coordinated rapid repetition and fluid execution associated with double-clicking may fall outside their performance abilities, particularly inasmuch as many persons with aphasia also have a right hemiparesis that requires them to employ their non-dominant left hand to operate an interface. "One-click operation" is considerably less demanding, and—if targets are made sufficiently large to make acquiring them easier—may be mastered by the majority of potential users.

From the earliest days of research into computer-based visual communication, entities in the lexical database have been associated with interactive, multimodal icons (Steele et al., 1989; Steele, Kleczewska, Carlson, & Weinrich, 1992; Steele, 1995). At first, multimodality and interactivity were limited, but gradually, over time they have been enhanced in response to clinical experience and as technological developments have permitted. Currently, Lingraphica icons have distinctive, consistent behaviors and provide feedback via various modalities, including representational graphics, text, and speech output. In addition, they may also incorporate animation, video, and non-speech sounds. The interface supports direct manipulation of icons, allowing them to be dragged and dropped at will for purposes of rearrangement. And it is designed to be highly flexible, easily learnable, memorable, and—an aesthetic value—engaging.



Projection is a conceptually simple method that has enormous practical benefit for our users. When clicked, Lingraphica icons respond first by being re-displayed within a heavy black border, after which they nearly instantaneously enlarge, doubling dimensions horizontally and vertically to yield quadrupled surface area. In effect, the icon appears suddenly to throw itself forward (in consonance with the etymological meaning of project: pro "forward" + ject "throw") toward the viewer. The icon remains enlarged for three seconds or so (precise time may be shortened or increased), during which it presents its linguistic identity—saying the word associated with the image, showing the text for the name, and, if the icon represents a verb or preposition, playing an illustrative animation. Thereafter, the icon reverts to the original, pre-enlargement size, yet retains a heavy black border to identify it as the most recently selected icon. The benefits of these projection behaviors lie in the responses they evoke in a human observer. These icon behaviors attract the observer's attention from anywhere else on the screen; redirecting it and focusing it on the icon; the icon's sudden enlargement in size also evokes in the observer a heightened level of arousal, as shown by studies of galvanic skin response (Reeves & Ness, 1996). The explanation is straightforward: in our evolutionary history, those ancestors selected for survival were the ones who—when faced with things in the environment that behaved like this—responded with redirected and focused attention and heightened arousal levels. Such behaviors were associated with threats and triggered preparation for fight or flight. Note that this method used in the Lingraphica methodically prepares the user for receptivity to the language information associated with our icons, with documented benefits for persons with the deficits of aphasia and related disorders (Aftonomos, Appelbaum, & Steele, 1999; Aftonomos, Steele, & Wertz, 1997; Steele, Aftonomos, & Munk, 2003).



Articulation video playback facilitates modeling behaviors for patients, who observe and imitate—a long-standing strategy used by speech-language pathologists. For instance, demonstrating clearly how a particular sound or word is produced may help a patient imitate and improve volitional performance. It can be helpful for a patient to observe himself or herself in a mirror, to self-monitor performance. And studies have shown that the models need not be provided in person; videos of individuals' articulating words are also effective (Fridriksson, Baker, Whiteside, Moser, Vesselinov, & Rorden, 2009). Recently, researchers have identified autonomic—as well as volitional—neurological mechanisms at work that can contribute to success here. In the early 1990s, researchers in Italy discovered the existence of so-called "mirror neurons" (Buccino, Solodkin, & Small, 2006). These neurons are recruited as part of the neural network that is activated in the brain of a human or other primate either when carrying out the motor activities of speech articulators or of the upper or lower limbs or simply by observing another individual carrying out that task. The name derives from the notion that they "mirror"—in the brain of the observer—the activity of the active agent's neural networks. Rehabilitation specialists can exploit the power of these mirror neurons by capturing and re-playing high-quality, close-up shots of the lower head and mouth as a speaker enunciates a word or phrase deliberately and clearly—with even slightly exaggerated articulatory motions—in order to provide a clear production model of the utterance. Viewing the video causes the mirror neurons associated with that utterance to become activated in the brain of the observer; and repeated viewings may improve the signal-to-noise ratio in the observer's brain. Many users can then employ the already-activated network of mirror neurons to recruit the remainder of the neural network associated with that utterance's production, thereby cuing their own functional speech. When such articulation videos are presented immediately following the projection approach described earlier, the user is methodically moved first into a state of focused attention and heightened arousal Then—and only then—he/she is presented with stimuli that are likely to support cued functional speech. This is an example of the effective scaffolding of complementary interface methods that together may yield a total that is greater than a simple sum of their parts.

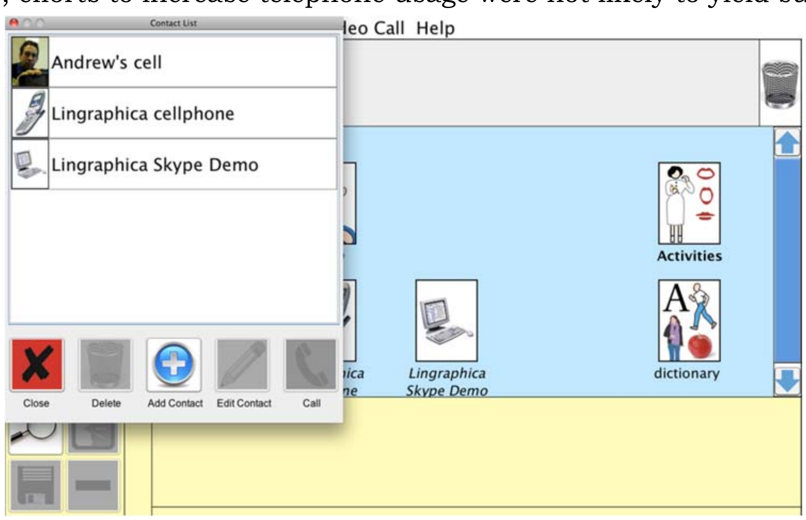
Real-Life Examples

We present here case studies that provide concrete, comprehensible examples of challenges, demands, and unexpected difficulties encountered by developers of user interfaces. As these cases illustrate, sometimes the developer's focus, thought, and effort can overcome these difficulties. Sometimes technological adjustments provide solutions; when they cannot, the developer may need to recruit outside assistance. We illustrate both types of situations below, starting with the second case.

Once a device has been researched, designed, and, eventually, purchased, an ongoing challenge remains: supporting the end users. The first and foremost reason this is difficult is that persons with aphasia may have very little expressive ability and may require the assistance of another person. Our experience has been that many caregivers and family members are simply too busy to provide this type of assistance. In addition, because the majority of our users are elderly, their caregivers are often elderly too and have little to no computer experience. They may even be fearful of the technology. Our technicians are skilled at instructing older people; they are patient and break steps into minute parts. However, sometimes caregivers perseverate on why they cannot perform the requested task, rather than listen to instructions. Nevertheless, the use of the Internet has greatly improved our ability to support our users. Once the Lingraphica is connected to the Internet, either by a wireless connection or an Ethernet cable, our technicians can connect to the Lingraphica with no effort on the user's part.

A recent technical support call illustrates the importance of the Internet for supporting our users and, more specifically, the importance of securing Internet access. The spouse of a user in South Dakota called for technical support. She was having difficulty installing our most recent upgrade from a DVD. Because she did not have Internet access (which would have allowed us to do the upgrade remotely), a technician needed to talk her through the steps to solve the problem. Because she wasn't comfortable with technology, she would not cooperate with the technician. She did, however, offer to contact her local elementary school to find out if they had wireless Internet and to see if someone there would be willing to help. Within the hour, she had called us back and given us the name of the technical manager at the school. The manager connected the Lingraphica to his network and set up a time to do the remote session. At the appointed time, our technicians and the manager collaborated and resolved the problem within a few minutes. Had the spouse not been as resourceful as she was, the Lingraphica would have needed to be shipped to our offices in New Jersey, and her husband would have been without means to communicate for several days.

We turn now to a second case, which addresses technical issues associated with developing an interface that will support much-improved distance communication for persons with aphasia. In the last century, people with aphasia found distance communication to be particularly challenging. Often, they concluded the results were not worth the effort. During that period, the primary widespread technology for distance communication was the telephone, which transmitted purposefully clipped auditory signals, but no video, between conversation participants. In the absence of visual cues that would enable a person with aphasia to monitor the speaker's articulatory motions, observe gestures, monitor body language, and view pictures, drawings, and spelling, communicative success was typically much lower than with in-person communication. As a result, individuals with aphasia often simply avoided the telephone. Only in those instances where auditory verbal comprehension (AVC), specifically, could be boosted significantly through therapy, practice, and rehearsal did the frequency of telephone use tend to rise, accompanied by expressions of increased satisfaction. But, absent improvement in AVC, efforts to increase telephone usage were not likely to yield success.



The introduction of Skype software several years ago has fundamentally changed this situation. The Skype application can be downloaded free from the Skype website (www.skype.com) onto home computers. Once installed, it supports free computer-to-computer communication (though a charge is levied when a Skype user calls a telephone rather than another computer). If computers at both ends of the connection have a microphone and a camera, then both audio and video signals are transmitted between the computers: participants can both hear and see each other. Although Skype's audio and video signals are not up to television signal standards, audio-video synchronization is sometimes poor, and occasionally the program freezes for a time; on the whole, Skype is quite usable, and it is free. For persons with aphasia, the addition of a video signal, even if it is of somewhat degraded quality, is hugely beneficial. In consequence, we have been working with our users group to determine what is necessary to make the Skype interface operable by persons with aphasia, so that they can exploit its audio-plus-video display capabilities to support distance communication.

The work has been instructive. We started by having our users group, several people with aphasia who gather weekly in our offices to use our devices and interact with our staff, try using the existing Skype interface for distance communication. While they were successful communicating once the call had been placed, they encountered numerous difficulties initiating and concluding the call. These issues fall broadly under the descriptors size, ink, text only, graphic, overload, and unneeded functionality.

Regarding size, people with aphasia often benefit from having images displayed larger than they would appear in the standard Skype interface. The relatively small size of Skype's text, buttons, and icon drawings is problematic for some persons with aphasia. The solution here is obvious: make things larger.

"Ink" refers to the darkness of letters in text of the interface. Much of the text is in black ink, which gives maximum contrast against a white background. Some letters are displayed in gray, making them difficult for some of our users to read. The solution is to use only black ink.

"Text only" refers to the absence of graphic representations when they would be useful and easy enough to include. A key example here is the list of call recipients: in the standard Skype interface; only a list of names is displayed. We have found it helpful to juxtapose a small head shot photograph by each person's name, in line with the multimodal principle—text and graphics collaborating—mentioned earlier.

Three problems exist with the graphics that are included in the standard Skype interface. First, they are not accompanied by text, as required by the multimodality principle. Second, they are too small—the "size" issue. And third, they may be "non-transparent" – that is, their meaning may be ambiguous or unclear.

The standard Skype interface also suffers from overload; that is, information is displayed that is not likely useful or even desired by persons with aphasia. For example, in the expanded view of a user's information in the call list, the local time in that person's time zone appears beneath the person's picture slot, followed in parentheses by an indication of that person's time zone with regard to Greenwich Mean Time. For example, a person on the East Coast of the United States would see (GMT -5)—that is, 5 hours earlier than Greenwich Mean Time. Our users with aphasia indicated a preference for removal of that information, because they found it unnecessary and distracting.

An example of unneeded functionality is the inclusion of short messages that Skype communication partners may choose to display beside their names in the call list. Among my recipients, one has posted the quote from Maya Angelou, "If you don't like something, change it. If you can't change it, change your attitude." Another informs me, "can't fix my parents' webcam@@." Such messages may be inspirational, humorous, surprising, or merely random. All are likely to be indecipherable by persons with aphasia–our users–and, hence, may safely be excluded from the simplified interface.

We are in the process of incorporating Skype within the Lingraphica interface, so that users can have access to the multimodal icons within Lingraphica while on a Skype call. We have also greatly simplified the interface for use by people with aphasia, based on the feedback and observations of our users group. Without going into great detail, suffice it to say that text is large and written in black, names are displayed to the right of portrait photographs of users, a call is initiated via a single large button with a telephone receiver against a green background, and a call is ended via a single large button with a telephone receiver against a red background. With the greatly simplified interface on the laptop computer, our users with aphasia experience higher success rates during use, and express greater degrees of satisfaction overall.

Smaller Platforms

The next challenge—and it will indeed engage the minds, skills, and resolve of all concerned—will be to develop and refine aphasia rehabilitation applications onto the smaller platforms (e.g., a tablet-sized device and then a handheld device). Such new applications have the opportunity to both support and extend proven rehabilitation applications and also to introduce new functionality.

To a degree, we can draw on accomplishments to date. In an earlier section, we identified methods that appear to be more or less directly transferable from the larger to the smaller platforms. This is encouraging, and we should constantly look for ways to exploit these methods in new settings for maximum benefit.

As the case study shows, however, unanticipated difficulties are bound to arise, often under ordinary circumstances. Some mundane issues have fairly simple solutions, even on small-format platforms. If gray ink is not helpful, then we can use black ink or whatever other color is helpful, and this can be done on platforms of any size. Other issues are not necessarily as easily resolved. On a small screen, size can become a genuine and challenging problem and may, in some instances, be insurmountable. However, sometimes technology can provide a work-around. For example, the method of projection, discussed above, does several useful things as we noted—it attracts, redirects, and focuses attention, and it heightens arousal level. However, it also does another thing: it enlarges, which in certain applications may help address the issue of small size. Perceived size is a psychological construct, and sometimes—if one first makes a hypothesis about the meaning of an icon while looking at a small version—the enhancement of displaying additional confirmatory information on an enlarged version during projection will permit functional use. It remains to be seen when and where this solution may be effectively exploited and where not. But it is an example of a plausible design solution to an identified problem.

It is said among human factors specialists that bad interface design takes its toll in four areas. First, it takes longer to learn; second, people are more prone to make errors while using it; third, it wears the user out more quickly; and fourth, it is forgotten more quickly. Conversely, good interface design supports ease of learning, provokes fewer operator errors during use, is easier and more enjoyable for the user, and is retained as a functional skill for a longer period. The material above gives some sense of the very practical issues that get addressed when interfaces are designed for individuals with special needs on laptop computers and how they may require change when implemented on mobile platforms of the future.

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