Gerontechnology

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Abstract We define and describe the new field of gerontechnology, assess the challenges facing academics and practitioners in designing technology products for older users, and provide some practical advice. We review expected age-related changes in perception, cognition, and psychomotor performance and suggest principles for accommodating such changes with better design. We introduce parameters for using goals, operators, methods, selection rules (GOMS) modeling techniques to improve the design process and provide an example of such modeling for a mobile phone task.

1 Gerontechnology

Our goals for this chapter include describing the new field of gerontechnology, assessing the challenges facing academics and practitioners in designing technology products for older users, and providing some practical advice based on existing research. We also stress the potential benefit of modeling techniques in improving the design process and provide an example of a mobile phone design.

1.1 History and Definition of Gerontechnology

Although technology is as old as the first human who fashioned a tool, the field of *gerontechnology* is of very recent origin. The term apparently originated from the Technical University of Eindhoven in the Netherlands in response to its creation of an interdisciplinary program, the Institute of Gerontechnology (Harrington & Harrington, 2000). One of the earliest definitions was by Herman Bouma: “The study of technology and aging for the improvement of the daily functioning of the elderly” (Bouma, 1992, p. 1). Research in this field also falls under several other labels, such as human factors and aging (e.g., Charness & Bosman, 1992; Fisk,

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Rogers, Charness, Czaja, & Sharit, 2004), and gerotechnology (Burdick & Kwon, 2004), though the term gerontechnology has some advantages (Charness, 2004). The field has continued to mature over the past decade and has its own society, the International Society for Gerontechnology,[1] and a journal, *Gerontechnology*.[2] Nonetheless, given how young the field is, many of the answers to critical questions about design principles await empirical evidence from the research laboratory. As will be seen, general guidelines can be offered from basic knowledge about aging phenomena. However, we need much more research to make sound design decisions for older users of technology.

The above definition for gerontechnology provides an agenda for both academics and practitioners. Gerontechnology must rely on both traditional lab-based experimental studies of the aging process and of technology use, as well as field-based studies that attempt to implement technological solutions to mitigate age-related declines in abilities. Both approaches are necessary to permit appropriate feedback and cross-fertilization between researchers and practitioners. At the same time, this field can and should draw on existing research on disability and that of inclusive design (also known as universal design[3]), given that disability rates increase strikingly after 65 years of age, as seen in Fig. 1.

Similar increases in disability with age can be seen in other developed countries (see United Nations, Statistics Division, 2007), though declines in

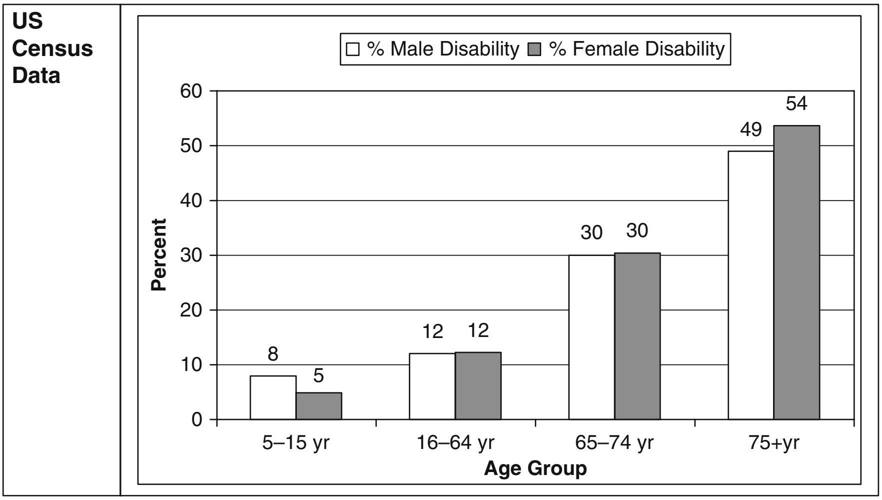

Fig. 1 *Top panel* provides 2005 percent disability rate for the US noninstitutionalized civilian population age 5+. Data source is the US Census Bureau (2005). *Bottom panel* provides disability prevalence for private households in the UK. Data from Health Survey for England, 2000–2001 (Official Document Archive 2, n.d.)

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[1] http://www.gerontechnology.info/

[2] http://www.gerontechnology.info/Journal/index.html

[3] http://www.design.ncsu.edu/cud/about_ud/udprinciples.htm

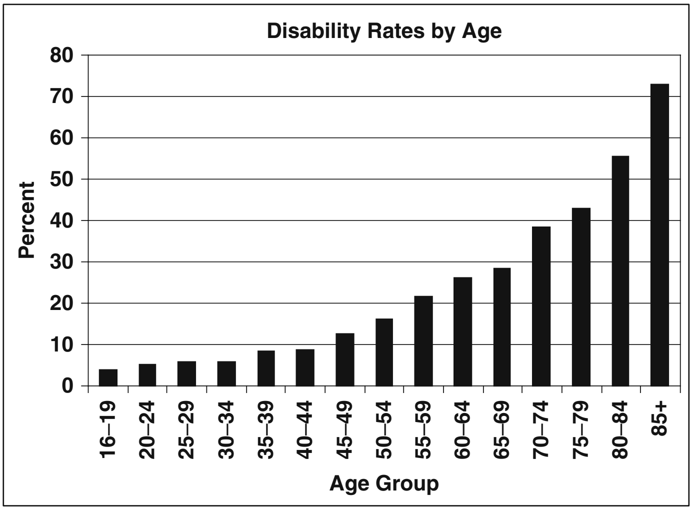
UK Health Survey	

Fig. 1 (continued)

old age are seen occasionally in less developed countries, perhaps because of a "survival of the fittest" phenomenon (few persons reached old age in these countries at the time of the survey). However, as the United Nations site indicates, direct comparisons across countries should not be made because of very different definitions of disability. Given the sharp increase in disability after age 65, we will use that age to define older adult in this chapter. Elsewhere, our research team has discussed issues in design for older workers, those aged 40+ who are in the paid labor force (Charness, Czaja, & Sharit, 2007).

However, we need to be aware that the 65+ population should be segmented into multiple subgroups. Young-old adults, age 65–74, have very different needs and wants than do middle-old adults, age 75–84, as in turn do the old-old adults age 85+. Those in good health have different needs than those with multiple disabilities. One of the challenges for designers is to provide individual solutions that appeal to a particular older adult. Unfortunately, older adults are more variable than younger adults by virtue of their having been shaped by and having shaped their environments much longer. So the challenge is to find robust solutions to perceived needs in the face of increasing variability.

1.2 Older- Adult Demographics and Capabilities

There have been striking increases in longevity in the past century in developed countries that, coupled with declines in fertility, have led to aging populations. However, increased age is associated with normative changes in many human capabilities, many of which lead to declines in adaptability. Technological advances offer the promise of compensating for some of these declines, enabling older adults to lead not just longer, but healthier and more productive, lives.

1.2.1 Longevity

Although most people are aware of the technological revolution that was hastened by Intel's invention of the microprocessor in 1971, not everyone is familiar with the aging revolution that has taken place in the past century. In the US, for instance, average life expectancy at birth has increased nearly 30 years in the past century, from about 47 years in 1900 to about 77 in 2000, though there is a marked life expectancy advantage for women over men (about 6 years). Thus, the very old population (e.g., age 85 +) is predominantly female by a ratio greater than 2:1 (He, Sengupta, Velkoff, & DeBarros, 2005).

1.2.2 Work Longevity

There has been a long-standing trend for men to retire from work at earlier and earlier ages since the establishment of social welfare systems, such as the US social security system. As a result of the implementation of such a safety net, men's labor market participation rates in the age 65 + range fell from about 46% in 1950 to 16% in 1985. However, that trend has reversed in the past decade with rates rising slightly to near 19% in 2003 (He et al., 2005). As a result, the median age of the labor force is rising with values of 35 in 1978, 39 in 1998 and projections of 41 in 2008 (Bureau of Labor Statistics, n.d.). This trend has implications for the design of office equipment.

1.2.3 Perceptual Capabilities

There are predictable age-related changes in vision and hearing, two important senses for interacting with technology artifacts. Vision is degraded for a number of reasons. Foremost, by their mid-40s, most adults develop a condition known as *presbyopia*, the inability to focus effectively on near objects. Presbyopia results primarily from changes in the lens, which becomes larger and less flexible as it adds layers of crystalline cells over time (much as an onion grows larger by adding layers). This change can be alleviated in part with external lenses, bifocal lenses in particular for those already nearsighted. However, such lenses create other challenges in terms of field of view at a given focus strength and in terms of seeing objects at intermediate distances. Problems can arise, for instance, in work settings when older workers must shift their gaze back and forth between the screen and a document on their desk. There are other changes too that degrade vision, such as the yellowing of the lens that makes it more difficult to perceive short wavelength light (the blue-to-green part of the spectrum). Also there is increased scatter of light in the optical media (e.g., from "floaters" in the vitreous humor) that makes glare more of a problem.

Hearing also undergoes negative age-related changes. By the decade of their 50s, many older adults, particularly men, begin to suffer from *presbycusis*, a reduced ability to hear high -frequency sounds. This change is usually due to loss of the hair cells in the cochlea, with differential loss for encoding high-pitched sounds, including critical speech sounds such as the "s" sound, making it increasingly more difficult to perceive speech correctly. Further, older listeners are more disrupted by background noise that can mask critical auditory signals. The result of these and other changes can be seen as reducing the signal/noise ratio for encoding environmental events (e.g., Welford, 1985). That is, older adults confront an increasingly difficult-to-perceive environment.

1.2.4 Psychomotor Capabilities

Another normative change for older adults is loss in precision in motor control. This again can be seen as having a "noisier" motor control system. Thus, for aiming tasks, unless they are willing to accept their own slowed movements, older adults can be expected to have a higher "index of difficulty" for Fitts' law (e.g., Welford, 1977), meaning that they will need larger targets or smaller distances to move (movement amplitudes) to show equivalent performance to younger adults. As an example, such imprecision in movement may make accessing and clicking on small icons on computer screens difficult to accomplish. Choosing a better input device can minimize age differences in performance (Charness, Holley, Feddon, & Jastrzembski, 2004).

1.2.5 Cognitive Capabilities

The cognitive system also changes in predictable ways with age. In general, older adults show a knowledge advantage over younger adults for what has been termed "crystallized intelligence" (Horn, 1982). That is, they are more likely to be able to answer successfully questions dealing with definitions of words, or knowledge of facts. Such an advantage is usually maintained until their 60s or 70s. Conversely, older adults are very likely to have difficulty solving novel problems or performing new procedures, a decline in what has been termed "fluid intelligence" (Horn, 1982). Adults in their 20s typically perform best on these types of test items.

From an information- processing perspective, notable changes take place in functions such as working memory, the processes that support storing and manipulating limited amounts of current information (Baddeley, 1986). Thus, older adults will be disadvantaged by having to store and process large amounts of new information, such as in using an automated telephone menu system that has too many alternatives at each level in the menu structure (Sharit, Czaja, Nair, & Lee, 2003). There is also evidence that older adults are more impaired in tasks that require that they divide attention across multiple input channels (e.g., Hartley, 1992). Similarly, there is evidence that older adults are more prone to being distracted by irrelevant information (Hasher, Stolzfus, Zacks, & Rypma, 1991).

However, the most striking change in performance is general slowing in information-processing speed (Salthouse, 1996). Older adult will typically take 50–100% longer to respond than younger adults in speeded tasks. However, this same slowing parameter holds for learning rates in self-paced learning environments (e.g., Charness, Kelley, Bosman, & Mottram, 2001). Thus, much more time should be allotted for training older adults to use technology, though knowledge, particularly breadth of experience with software, is an important mediating variable (Charness et al., 2001; Czaja et al., 2006). Training should capitalize on existing knowledge when possible.

1.2.6 Anthropometrics and Physical Fitness

A variety of changes in body dimensions and capabilities also are associated with aging (e.g., Kroemer, 2005; Steenbekkers & van Beijsterveldt, 1998). Muscular strength generally diminishes with increased age, though functional strength is often hindered more by normative onset of disease processes such as arthritis, which can make movement and force generation a painful process. Height diminishes in response to changes in bone structure and disc degeneration in the spine, more so for women than men, in part because women are more prone to bone loss (osteoporosis) than men. Many of these changes begin to occur in middle age or later, and some are associated with reduced work ability in job settings (e.g., Ilmarinen & Louhevaara, 1994; National Research Council, 2004), though strength loss can be mitigated partly by maintaining appropriate exercise routines. Thus, devices designed for an aging population should make minimal demands on strength, dexterity, and reach capability.

2 Technological Innovation

Although longevity clearly accelerated in the 20th century, the pace of technological innovation has also shown spectacular growth. A good example is found in the field of computing. Within a period of about 50 years, we have witnessed the migration of computing from mainframe systems in institutional settings to microcomputer systems in many households in the developed countries. With the invention of the microprocessor in 1971 by Intel, it became possible to build personal computer systems that could sit on a desktop. With the invention of Ethernet protocol, it became possible to link these systems through networks. With the invention of the http protocol and the Web browser, it became possible to disseminate and display information no matter what operating system the computer ran. An even more impressive example of the rapid spread of technology is afforded by the mobile phone, with many developing nations building telephone networks solely around mobile devices rather than wired landline systems. Modern mobile phones were introduced in the mid-1970s, and it has been estimated that there were 2 billion users by 2005 (GSM Association, 2005).

2.1 Principles of Design for Older Adults

In this section we provide an overview of design principles from the perspective of technology use, and focus particularly on human–computer interaction. More detail can be found in Fisk et al. (2004). Technology products can play an important role in maintaining independence in old age when disabilities strike (e.g., Mann, Ottenbacher, Fraas, Tomita, & Granger, 1999). Computers and the Internet can even help with many of the tasks defined as instrumental activities of daily living, such as shopping, using transportation, financial management, telephone use, and so on, as noted in Charness (2005). However, many current technological systems make undue demands on older users, particularly given the trend toward increased miniaturization seen in devices such as mobile phones.

A useful framework for understanding the relationship between users and technology systems is offered in Fig. 2, from the Center for Research and Education on Aging and Technology Enhancement (CREATE; Czaja, Sharit, Charness, Fisk, Rogers, 2001).

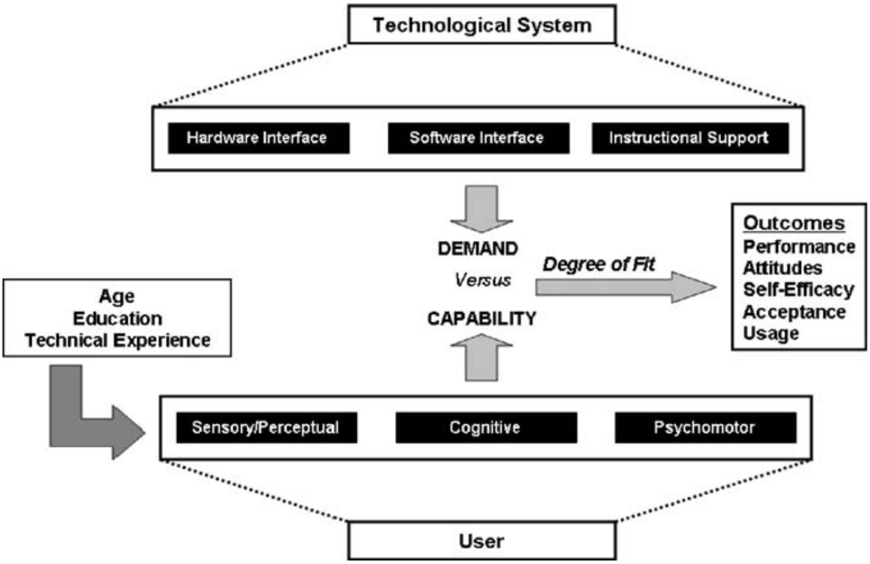


Fig. 2 Framework for understanding the demand/capability balance between systems and users. Technological systems with hardware, software, and instructional components make demands on a user's sensory/perceptual, cognitive, and psychomotor capabilities. The degree of fit determines outcomes such as performance with the system, attitudes toward the system, self-efficacy, as well as acceptance and use of the system. Different users have different educational and technical backgrounds and are of different ages, all of which affect their capabilities

Users bring differing capabilities to the operation of technical systems, such as their perceptual, cognitive, and psychomotor abilities. Technological systems make demands on those capabilities when people interact with hardware components, software interfaces, and training materials. Age is a potentially powerful individual difference variable that directly and indirectly (through education or technical experience) affects user capabilities (e.g., Czaja et al., 2006). The degree of fit between user capabilities and system demands affects the many aspects of the interaction with a system, including short- and long-term usage patterns and attitudes toward the system.

2.2 Ethics of Design

One useful principle for ethical design is encapsulated in the physician's Hippocratic oath: "First do no harm." Good design is intended to improve the comfort, safety, and efficiency of a product or process. Particularly in the design of products for work environments, efficiency and safety seem to be given strong emphasis. In the aging world, the top-level goal that might be envisioned for products and processes is to improve quality of life.

Quality of life is usually evaluated through measures of global life satisfaction as well as subjective well-being measures focusing on positive and negative affect components. Although these components can show differential change (e.g., Kunzmann, Little, & Smith, 2000; Steverink & Lindenberg, 2006), they are mostly stable across the life span. They appear to be most strongly influenced by health status and interpersonal relationship situations. Such well-being measures often seem to reflect trait-like characteristics, such as whether someone is a generally happy or unhappy person, rather than state-like measures, such as current mood, that might be immediately influenced by interactions with a product or process. Thus, it is not surprising that, for instance, computer and Internet use have not shown any substantive effects on general well-being (Dickinson & Gregor, 2006). Any one product or process can be expected to have only a minor influence on global well-being. So, the more modest goal of improving one facet of well-being seems feasible, particularly if it relates to improvement in capabilities such as the activities of daily living or the instrumental activities of daily living. One potentially important, though often overlooked, dimension of design is comfort. As shown in the capability-demand framework of Fig. 2, comfort can address outcomes of interaction with technology such as attitudes, self-efficacy, acceptance, and usage of products. Comfort also subsumes some aspects of aesthetics, an important feature for technology that some companies (e.g., Apple Inc.) have shown to be critical in product success.

There is a dearth of empirical work on ethical concerns in design. Some scenario studies have been conducted by Caine, Fisk, and Rogers (2006) on privacy concerns in high-tech aware-home environments. A group of 25 older adults were shown a variety of cutting-edge technologies that tracked people using video technology. The camera systems presented information to the viewer about the occupant either as full video images, as point-light images, or as images that distorted people into blobs so only presence and general movement in a room was depicted. Twelve scenarios were devised to describe the monitoring situation as one where the older occupant possessed varying levels of physical and mental impairment. Acceptability of these different levels of monitoring was measured under these different occupant capability scenarios. Older adults were willing to trade off privacy for the benefits of monitoring, suggesting that they engage in cost-benefit considerations with well-differentiated views on privacy. Privacy protection is often seen as one of the primary concerns for the design of active (or passive) monitoring systems for older adults. Ethical design would be expected to respect privacy rights. However, there is apparently variability in older -adult desires for privacy.

2.3 Design for Input/Output Devices

We now attempt to provide some general guidelines, followed by illustrative examples. Broad principles to consider include minimizing steps for users, adopting consistent layout of elements for controlling a device, and ensuring adequate visibility of control elements. Given that older adults have noisier perceptual and psychomotor systems for interacting with devices, they are more likely to make errors, particularly when forced to respond quickly. Minimizing steps is an important principle to observe to maximize the probability of the older adults being able to complete a complex procedure in error-free fashion.

As an example, consider the simple task of entering text associated with a phone number on a mobile phone. The user must be successful at quite a few subtasks. He or she must locate the desired character on the keyboard if unfamiliar with the keyboard, monitor the phone display to detect any button press errors (slips of the finger from the intended key), and complete keystrokes to generate an alpha character before a time-out period that moves the cursor position to a new position in the word string (e.g., a time-out of between 1–1.5 s).

The chance of completing an entry in error-free fashion diminishes with each step in the procedure if there is a constant probability of error on each step. More precisely, if there are N steps with each having the probability p of failure, the probability of success equals $(1\text{-}p(\text{failure}))^{N}$. If $p = .05$ (95% success rate at each step), then by the 13th step the probability of completing all these steps without error is only $p = .5$. Minimizing steps is a very good principle to observe when designing a product.

Consistency in layout is also a very important principle, particularly for older adults who learn new information more slowly. To the extent that design can draw on *population stereotypes*, such as pushing a switch upward to turn on a light or pushing it downward to turn it off (e.g., in North America), this also will aid older users. By consistency in layout, we mean that control elements should always appear in the same spatial location, minimizing the need to search a display to find a control. For instance, in software interface design, one should have icons or menus appear in customary locations (such as at the top and in consistent left-to-right order, depending on cultural norms). Many modern operating systems for computers provide automated tools to programmers for conforming to such guidelines (e.g., window element controls).

Another important consideration in design is to ensure adequate visibility of controls that are to be used in indoor environments. Lighting is often below optimal levels in homes, and can be particularly problematic for older adults (Aarts & Westerlaken, 2005; Charness & Dijkstra, 1999). Most work environments do have reasonable luminance levels (typically 100 cd/m^2 reflectance from paper-based reading materials) but designers working in such environments should not assume the existence of similar luminance levels in people's homes or in public buildings because those levels may be more in the range of 30 cd/m^2 (Charness & Dijkstra, 1999). Having adequate contrast (foreground/background ratios) for words and symbols, or physical controls such as buttons and switches, is particularly important in low- light environments.

2.3.1 Input Devices: Positioning

Positioning devices can be classified into those with direct positioning and indirect positioning characteristics. For pointing tasks, direct positioning devices, such as placing a stylus or finger on a touch -screen device (e.g., a personal digital assistant [PDA]) or light pen on a CRT device, should be preferred to indirect positioning devices, such as a mouse or trackball. A trackball should be preferred to a mouse when using indirect positioning because the trackball can help with double-clicking tasks given the separation between positioning (using the ball) and clicking (using the keys) functions, thereby counteracting the effects of tremor. With indirect positioning devices, people must learn to map control in one plane with movement in a different plane, and older adults in particular have difficulty with this mapping (Charness et al., 2004; Murata & Iwase, 2006). However, it is difficult to set rules because the nature of the positioning task is crucial to determining which device might be optimal (e.g., Rogers, Fisk, McLaughlin, & Pak, 2005). Additional research is required to offer specific advice on a variety of the design challenges that arise.

2.3.2 Input Devices: Data Entry

Many devices require alphanumeric input from the user, and common devices such as keypads and keyboards are typically offered. Many older adults do not have typing skills (this will change with future cohorts of older adults), although they may well be familiar with number placement conventions used in keypads for telephony devices. Also, many older adults can suffer from arthritis, which makes typing or key pressing painful. Ensuring adequate key sizes and spacing between keys, and providing appropriate tactile and auditory feedback about the key press, can help older adults interact with keyboards successfully. Alternative input techniques to consider, where feasible, include speech recognition and handwriting recognition. There is some evidence that, at least for native

English speakers, speech recognition software is robust with respect to older - adult use (Jastrzembski, Charness, Holley, & Feddon, 2005).

2.3.3 Output Devices: Visual

Given the changes in vision with age, it is critical to ensure legible characters for reading. Emissive devices should be preferred to passive/reflective ones, given the problems with lighting in homes. Backlit devices are particularly helpful here and, because of their higher contrast ratios, modern LCD displays should be preferred to CRT devices. Letter sizes for alphanumeric text should be at least 0.6 degrees of visual angle or greater. (Your thumb at arm's length approximates 2 degrees of visual angle.) For printed materials, choose a font size of at least 12 points in x-height (the height of the character x) for letters. Consider flashing messages that serve as warnings, though do not flash so quickly that the message cannot be read.

2.3.4 Output Devices: Auditory

Try to keep sound signals in the 500–1000 Hz range, given the decline in ability to hear high frequencies with age. Although homes are generally quiet places, it is useful to recall that there is greater masking of target sounds by ambient noise in older adults, so if there are critical alarms to be sounded, be sure that they are of adequate intensity (e.g., at least 60 db). If evaluating the direction of a sound is important and you must use sounds with fundamental frequencies above 2000 Hz (for miniature devices using small oscillators), then try to prolong the warning sound for at least 0.5 s to permit localization by changing head position. Consider providing redundant sources for warnings, such as visual and tactile (vibration) channels in addition to auditory channels. If you need to use speech output, keep speech rates to 140 words per minute or less, and prefer male voices for conveying information given their lower pitch, but female voices for capturing attention. Avoid the use of synthesized speech (e.g., Roring, Hines, & Charness, 2007), preferring the generation of prerecorded human-pronounced words when a limited vocabulary is sufficient.

2.4 Design for Interface

Older adults are less likely to use advanced technological devices than younger adults (Czaja et al., 2006), so they cannot be expected to know many of the conventions adopted for interfaces. Hence, designers need to be careful to educate older users about interfaces, for instance, that there are scrolling options that enable the user to see other parts of a virtual screen that is larger than the actual screen display. Similarly, standard graphic user interface operations are not necessarily going to be immediately comprehended, such as how to resize windows. Older users may not expect or know how to make use of help systems or search capabilities. The mental models of how systems work may be based on simpler technological artifacts (typewriter rather than word processor). Hence, it is particularly important to provide appropriate training materials or tutorials, and to use standard layouts in a consistent fashion across a user interface.

2.4.1 Speed of Operations

Because older adults process information more slowly, standard assumptions about the time required to complete operations before a time-out in the system need to be examined carefully. See below for the case of mobile phone technology and text entry. Typically, the designer should allow for 50–100% more time to complete operations than is the case for younger users.

2.4.2 Navigation Through Menu Structures

In part because of declines in working memory capacity, older adults are more likely to get lost when searching through complex menu structures (e.g., Mead, Sit, Rogers, Rousseau, & Jamieson, 2000). Hence, it is critical to provide navigation tools that can assist users to be aware of where they are and how to backtrack without having to restart from the top of the menu structure. Particularly when there are different modes within a system (e.g., navigating, text entry), it is important to alert the user so that mode errors are avoided.

A common choice point for menu design is how to assign items in terms of breadth or depth of a menu structure. With a visually presented menu structure, breadth is typically preferred to depth as a means of reducing working memory demands. However, greater breadth is often associated with more visual search. Given reductions in working memory and the older adult's greater reliance on environmental cues (also known as environmental support; Craik, 1986), breadth is generally to be preferred to depth for visual menu structures. However, for auditory menus (e.g., automated voice response systems on telephones), for cases where the user does not know in advance the target item to select in a menu, depth should probably be preferred to breadth. Too many alternatives can overtax working memory capacity, though a recent thesis suggests that when the user can employ an updating strategy to guess the likely alternative to select, greater breadth is preferable (Commarford, Lewis, Smither & Gentzler, 2008). Nonetheless, navigation difficulties often arise with deep menu structures, so providing appropriate navigation prompts is essential. Eventually, people do learn menu structures from systems that they interact with frequently. It is important to consider whether you are designing for novice users or experienced users in your choice of menu structure and navigation aids.

2.4.3 Compatibility Issues

Because older adults are likely to have greater crystallized knowledge, designers should try to take advantage of such knowledge. For instance, population stereotypes in North America often signal increase and decrease in consistent ways. Upward, rightward, and clockwise motions are usually associated with increasing a value. The opposite directional movements usually decrease a value. Stimulus-response compatibility that draws on these assumptions should be preserved. In displays where buttons are used to respond to screen layout of alternative responses, spatial mapping compatibility should be preserved, such that alternatives map to neighboring buttons. Sometimes, for example, automated teller machine buttons do not match the number of alternatives offered on the screen or have inconsistent positioning of options to buttons. Not having a one-to-one correspondence between these features can confuse the user.

Often it is necessary to use words to label menu items. Choosing appropriate labels is always a difficult task when the designer is familiar with jargon but older adults are not as familiar. Confronting a novice user with options such as the old DOS message “abort, retry, fail” is practically guaranteed to lead to a bad result. On the other hand, assuming nontechnical interpretation of common language terms can run into difficulties as well. A classic example is the instruction to “press any key to continue,” where an unsophisticated user searches vainly for a key with the label “any.” Instead, use specific instructions, such as “press the enter key to continue.”

2.4.4 Documentation Issues

Older adults are more likely to seek help and ask questions when using novel technology than are younger adults. Hence, having explicit documentation and well-designed help systems should lead to greater success in use. Similarly, it is important to provide older users with appropriate feedback about their actions (or failure to act at a choice point). Older adults are more likely to make errors in using new systems than younger adults, who have superior experience and more sophisticated mental models of systems. Therefore, it is critical to ensure that error messages are informative (e.g., use plain language that can be found in the manual or help system), and that the system is robust with respect to error correction so that the user can recover without having to restart their task from the beginning.

2.4.5 Adaptive Displays

Because different user groups are unlikely to be equally well served by the same interface arrangements, some degree of adaptability should be offered. For instance, well-designed Web sites provide users with the option of resizing text,[4] thereby accommodating those with low vision. However, it is unwise to assume that if the interface is adaptive, users will necessarily choose the most efficient variant. There are all too often a bewildering set of possibilities for modifying interfaces. User preference and performance may not match up (e.g., Charness et al., 2004). Instead, usability testing should be adopted to offer reasonable default settings based, perhaps, on querying the user about his or her experience level.

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[4] See, for example, http://www.seniorhealth.gov

2.5 Training Considerations

There are very few technological products or services that do not require some amount of training. Hence, it is worthwhile to consider the training needs of older adults.

2.5.1 Design for Training

Older adults learn new material more slowly than younger adults, perhaps twice as slowly (Charness et al., 2001). Therefore, more time needs to be allocated to training programs and, if possible, self-paced training should be arranged. As well, it may be helpful to provide general guidance about the process to be trained, given that older adults may have poorer mental representations of the task to be performed. However, conceptual training (trying to establish a deep understanding about task performance) may be less effective than procedural training (step-by-step instruction; Mead & Fisk, 1998), particularly when time is constrained for training or the user may not be expected to use the system on a regular basis. In general, meta-analyses, such as Callahan, Kiker, and Cross (2003), have indicated that techniques that work well for younger workers also work well for older ones, though having self-paced training and training in smaller groups may be particularly helpful for older adults.

2.5.2 Organization of Training

Some important features of training include the schedule of training (e.g., massed versus distributed practice), and the components of training (part-task versus whole- task training). In general, it is better to space training sessions to promote better retention rather than to mass practice on a procedure to be learned. Such spacing may also counteract the buildup of fatigue in older learners. Keeping sessions to 30–45 min in length and building in rest breaks may be helpful. Also, later training sessions can act as refresher sessions for earlier ones if old tasks are tested along with newer ones. If such review is not possible because of time constraints, then providing memory aids (e.g., note cards) for earlier task processes can be useful.

When tasks involve complex procedures, it is usually helpful to train task components rather than training the whole task at once, though this depends on specific task characteristics. Sometimes it is useful to provide the user with a road map of the process to be mastered so that they can appreciate the ordering of operations before they attempt to train on the components. The type of instructional media needs to be matched to training needs. Simple verbal instructions may work well when the procedure is temporally organized (e.g. “hold down the control key and then press the b key to make the character bold”). Pictorial guides are to be preferred when spatial information needs to be conveyed (show a figure that identifies the icon that needs to be clicked to transform the selected text into italics).

Ideally, training procedures could be adaptive, so that what is presented to the learner depends on their mastery of earlier trained components. However, intelligent human or computer tutors are often needed to be able to "debug" faulty knowledge that is responsible for poor performance. For such systems to work effectively there needs to be informative, constructive feedback available to the learner. Given that older adults tend to ask questions more often than younger adults, having accessible, responsive trainers is essential.

The area of training is a challenging one for the field (see Charness & Czaja, 2006). Although there are sound general principles to draw on, the field needs to refine these principles in order to develop the variety of different training packages required for the diverse set of products that are entering the consumer market.

2.6 Principles of Usability Testing with Older Adults

Even when principles for design are followed carefully in building a technology device, some usability testing is usually necessary to ensure that the product performs as expected with the target user group. Usability principles revolve around five interrelated features: Learnability, Efficiency, Memorability, Errors, and Satisfaction (LEMES). In our context, a useful mnemonic for LEMES is Let Every Mature Elder Succeed.

Learnability refers to the ease of learning, often assessed by the time that it takes a new user to reach a given level of proficiency in device use. Criteria of error-free performance and time to carry out a task are both typically evaluated to assess learnability. Of course, older adults are often a very diverse group in terms of capability for learning, so, as Alan Welford (personal communication, October, 1985) pointed out years ago, they make a superb panel for usability testing. They often show the flaws in a design sooner than more able younger adult samples.

Efficiency indicates the extent to which users can quickly achieve a representative set of task goals with the product. Can they do so without undue frustration, fatigue, or dissatisfaction? Usually efficiency is measured once users have become at least moderately proficient with a product. If there are similar products on the market, efficiency can be assessed by comparative testing.

Memorability is the opposite of forgetting. A product's memorability is determined by the ease with which a product can be used after some time away from initial training or use. Many products are not used on a daily basis, but they must be easy to remember how to use when needed. A good example is a safety-related product, such as the fire extinguisher. In general, older adults do not exhibit much faster forgetting rates than younger adults, though those who learn more slowly apparently do forget a bit more quickly (MacDonald, Stigsdotter-Neely, Derwinger, & Bäckman, 2006).

Errors are a critical feature of product use. Obviously, the design should minimize error rates but, given their inevitability, their negative consequences should also be minimized. Obviously, some errors are more critical than others and catastrophic failures should be designed out. Usability testing often focuses on identifying when, where, and why errors occur. Categorizing errors into types, using a taxonomy, such as that proposed by Reason (1990), is a good first step in trying to eliminate errors. Some important categories are slips (actions not intended, such as when the wrong button is pressed inadvertently), mistakes (action was intended, but the user selected a wrong action), and mode errors (product is in a state that does not permit achievement of a goal, and the state must change first).

Satisfaction with a product or device is usually assessed with questionnaires and rating scales administered after the product has been used. A potential concern is that older adults and younger adults may not use rating scales in the same way, so cross-age comparisons can be problematic for an overall satisfaction measure. It may be better to ask users to evaluate different aspects of product use and incorporate that information into the design process so that improvements can be reached on the various dimensions of product use in iterative fashion.

Usability testing involves a variety of techniques, from passive observation of users interacting with a prototype device, to gathering think- aloud protocols taken during product use, to questionnaires and interviews administered after use. Often product design features are tested initially via focus groups, where small groups of potential users (e.g., 6–12) are brought together and given scenarios about potential product features and asked to comment on them. See Fisk et al. (2004) for more details. The goal is to derive insights about the nascent device in terms of the dimensions for usability (LEMES), and make appropriate modifications to enhance user performance.

Classical usability testing tends to focus on efficiency and safety issues but does not do a good job of addressing other important aspects of a product such as comfort or enjoyment. Often usability testing procedures employ one-item rating scales for enjoyment, ease of use, or satisfaction in an effort to evaluate that aspect of a product. However, paired comparisons of different product models may be a more effective way to evaluate enjoyment and aesthetics. As well, even very successful commercial products, such as Apple's iPod, are probably not very enjoyable to use for complete novices until they become efficient in using the product's interface. So, aesthetics or enjoyment may need to be evaluated over an extended period of use.

3 Simulation as a Supplement for Usability Testing

Simulation as a method of modeling human performance, particularly cognitive performance, has about a 50-year history, starting with the computer simulation work of Newell and Simon on theorem proving in the late 1950s (described in Newell & Simon, 1972). Simulation modeling expanded from serial symbolic process modeling to parallel neural net modeling in the late 1980s (McClelland & Rumelhart, 1988). Current influential models, such as Adaptive Control of Thought (ACT; Anderson, 1996), State Operator and Result (Soar; Newell, 1990) and Executive Process/Interactive Control (EPIC; Meyer & Kieras, 1997) have a hybrid structure, consisting of both parallel and serial components. A virtue of these more complex simulation models is that they account for both low-level performance features of behavior (speed, accuracy) and higher- level cognitive features such as perceived workload. We look at one type of modeling system here.

3.1 The GOMS Modeling System

One of the most popular modeling tools in human–computer interaction is GOMS (Card, Moran, & Newell, 1983), a model that has also served as a foundation for higher -level architectures. It stems from their seminal book, *The Psychology of Human-Computer Interaction* (Card et al., 1983), which meshed psychology with a human engineering approach to offer a quick, first-approximation, informal modeling tool for designers to deliver reliable, quantitative predictions of human performance. Typical parameter estimations of human information processing were culled from empirical psychological literature to construct a simulated user with known capabilities and limitations (dubbed the Model Human Processor), which could then be used to model routine, technology-related tasks, specifically described at the grain of key-strokes and mouse movements.

The basic ingredients for description of tasks depended on a simplified cognitive structure consisting of four components: *G*oals, *O*perators, *M*ethods, and *S*election rules (GOMS). Rationale for this structure hinged on the principle that the model human operator efficiently pursues goals according to constraints on knowledge, ability, and task situation, so that high-level goals are then decomposed into subgoals and units tasks and expressed in the form of very basic motoric actions, such as depressing a key on a keyboard or using a mouse to move a cursor a fixed distance on a screen to acquire a target. Actions serve as the end result of a chain of mental operations that engage perceptual and motor processors around a cognitive processor, and each processor possesses its own cycle time (e.g., 100 ms), storage capacity, and decay rate, gleaned from the psychological literature. Many tasks lend themselves well to GOMS-level decomposition, as routine tasks often have nested goal states that can be reduced to initial states, subgoal states, and final states (John & Kieras, 1996).

GOMS relies on a fairly orthodox model of human information processing involving different memory systems (iconic/echoic, short-term, long-term) and laws of human performance (e.g., Fitts' law, power law of practice, as described in Card et al., 1983), that help the model provide reliable quantitative and qualitative predictions of routine, human performance across different design specifications or task scenarios. The underlying philosophy behind GOMS and other human-computer interaction (HCI) cognitive architectures is to provide engineering models of human performance. Models of this ilk are distinguished from traditional, psychologically oriented cognitive models in several key ways: (a) they seek to optimize a priori predictions; (b) they are usable and useful for both practitioners and researchers; (c) they apply to real-world, relevant tasks; and (d) they are approximate to handle a task at the minimal level needed to describe it.

The goal of many simulation modeling exercises is to estimate the time it would take to carry out a task under different design specifications, and comparing alternative designs is one of the most obvious uses of the GOMS technique. Due to the nature of the model's output, the most efficient design may be selected by comparing alternate designs for estimated completion times on representative tasks that a user may carry out. Furthermore, GOMS analyses may provide a rationale for why one design is more user-friendly (e.g., requires less working memory strain or requires fewer visual fixations) or more satisfying (e.g., buttons are easier to navigate as a function of size), or why one design feels more sluggish than another (e.g., the overall pathway analysis is longer or requires more time to complete than another). Since GOMS analyses are able to make a priori predictions of performance, they can be performed not only on existing systems already developed and in use, but they may also be utilized early in the design process to evaluate notional, simulated designs, before they are ever implemented or even prototyped. Such modeling holds the promise that low-level design decisions may be made without having to test actual users and, further, such first-approximation modeling efforts have been consistently validated across a variety of real-world tasks and have the potential to serve as the building blocks of more formal computational cognitive process models, such as Adaptive Control of Thought-Rational (ACT-R; e.g., John, Prevas, Salvucci, & Koedinger, 2004).

3.2 GOMS Modeling Parameters for Older Adults

GOMS modeling is predicated on a normative user, the so-called Model Human Processor, which in turn is based on data collected almost entirely from college undergraduates. However, older adults vary in important ways from younger adults, as seen above, thus what is seen as an optimal, user-friendly environment will likely change in the future (Koncelik, 1982). Hence, to implement GOMS modeling in older user populations, the parameter estimates for the simulated user need to be modified. Charness and Bosman (1990) made an early attempt to estimate Model Human Processor parameters for older adults, but due to the sparseness of the cognitive aging literature at the time, estimated values for some parameters were probably unreliable. More recently, Jastrzembski and Charness (2007) updated these parameters by means of meta-analyses to construct a simulated older user. With proper application to the human engineering field, these basic perceptual, motor, and cognitive building blocks (see Fig. 1) can inform designers as to what products would suit the older user in the earliest stages of design and help create better environments for older users.

Some fairly straightforward predictions are possible from Table 1. It is worth noting that estimates for cognitive, motor, and perceptual processor cycle times are nearly twice as long in older than younger adults. In GOMS modeling, such cycle times are iterated quite often when a task is modeled, and hence tend to dominate in predicting response times. Thus, a good rule of thumb would be to predict that, when using the same strategy for performing a task, older adults will typically take 1.5–2 times as long as a younger adult (e.g., Fisk et al., 2004).

However, task components will skew the estimates for response time, so, for instance, when eye movements play a weighty role, old–young differences may be considerably smaller, given the much smaller 1.2:1 ratio observed for saccade duration. As aptly stated by Welford (1958),

> Where age changes do impinge upon performance some relatively trivial factor may often be limiting what can be done, so that comparatively small changes in the task could bring it within the capacities of older people. . .and would benefit both young and old. (p. 287)

Table 1 Information processing parameter estimates for younger and older adults and their old-to-young ratio

Parameter of interest	Younger adult estimate (Card et al., 1983)	Older adult estimate (Jastrzembski, 2006)	Ratio of old to young
Duration of saccadic eye movements	230 ms (70–700)	267 ms (218–314)	1.2
Decay half-life of visual image store	200 ms (90–1000)	159 ms (95–212)	0.8
Cycle time of the perceptual processor	100 ms (50–200)	178 ms (141–215)	1.8
Cycle time of cognitive processor	70 ms (25–170)	118 ms (87–147)	1.7
Cycle time of the motor processor	70 ms (30–100)	146 ms (114–182)	2.1
Power Law of practice constant	0.4 (0.2–0.6)	0.49 (0.39–0.59)	1.2
Fitts' law slope constant	100 ms/bit (70–120)	175 ms/bit (93–264)	1.75
Effective capacity of working memory	7 items (5–9)	5.4 items (4.9–5.9)	0.77
Pure capacity of working memory	2.5 items (2.0–4.1)	2.3 items (1.9–2.6)	0.92

Note. Numbers in parentheses represent the range for younger adults and two standard deviations of means for older adults (see Jastrzembski & Charness, 2007).

Clearly, designers may use these estimates to inform design of critical pathways and ultimately help minimize performance differences between young and old.

Another straightforward prediction is that older adults will show steeper improvements with practice than younger adults, given the higher value for their learning exponent and the likelihood that they have more to gain with continued effort. Designers may apply this to guidelines or recommendations for use, so that older adults may be made aware of how much practice will be needed to become proficient in a given task.

In summary, by estimating typical perceptual, motor, and cognitive parameters for the older adult, designers may be provided with a tool to optimize design specifications that suit the environment to the older user. If better modeling occurs, it is likely that older adults will feel more comfortable participating in this technology-laden society, be more likely to test out newer technologies as they arise, and be more likely to adopt new technologies that could, in theory, allow them to live independently longer, communicate with friends and family more easily, or take care of routine tasks digitally. It is also arguable that designing with the older user in mind may in fact produce better designs for people of all ages, as modifications to aid the older individual may also ease task demands for others.

3.3 Example Modeling for Mobile Phone Tasks

Jastrzembski and Charness (2007) validated the above parameters by developing GOMS models for mobile phone tasks for younger and older adults using two different mobile phones with distinct hardware and software differences to evaluate menu hierarchy structure, integration of information across screens, screen and text size, button sizes and locations, and critical pathways to successfully complete each task. These hardware and software differences helped determine how perceptually, motorically, and cognitively taxing each device was with regard to users of different ages.

Jastrzembski (2006) also extended the capability of GOMS modeling to predict error rates, rather than simple task completion times alone, using base error rates on operations in a less complex mobile phone task (a text messaging task) to estimate those in a more complex one (an appointment-scheduling task). An example decomposition of a simple dial-a-number task is shown in Table 2.

In user testing, 20 younger and 20 older participants were familiarized with each phone, shown the procedure, and required to practice the procedure until it became consistent (see Jastrzembski, 2006, for details). This extensive orientation and practice procedure was necessary for validation purposes, as GOMS modeling applies not to novice users who usually are problem solving in order to accomplish tasks, but to experienced users for whom the activity is routine.

Table 2 GOMS task analysis for mobile phone #1 in the dial-a-number task

Assumptions: In default mode the user is holding the phone in the preferred hand, dialing with preferred thumb.	Operator	Time young	Time old	Total young	Total old	Button press number
Goal: Dial number (268-413-0734) and send call.						
Method: Press numbers and hit green call button.						
Step 1: Fixate first chunk of numbers on paper (first 3 numbers)	F	230	267	230	267	
Step 2: Encode first 3 digits	3 C	3(70)	3(118)	440	621	
Step 3: Fixate keypad	F	230	267	670	888	
Step 4: Decode first chunk	C	70	118	740	1006	
Step 5: Fixate first digit	F	230	267	970	1273	
Step 6: Dial first digit	M	70	146	1040	1419	1
Step 7: Fixate second digit	F	230	267	1270	1686	
Step 8: Dial second digit	M	70	146	1424.8	1980	2
	Fitts	84.8	148			
Step 9: Fixate third digit	F	230	267	1654.8	2247	
Step 10: Dial third digit	M	70	146	1824.8	2568	3
	Fitts	100	175			
Step 11: Fixate second chunk of numbers on paper (second 3 numbers)	F	230	267	2054.8	2835	
Step 12: Encode second 3 digits	3 C	3(70)	3(118)	2264.8	3189	
Step 13: Fixate keypad	F	230	267	2494.8	3456	
Step 14: Decode second chunk	C	70	118	2564.8	3574	
Step 15: Fixate first digit	F	230	267	2794.8	3841	
Step 16: Dial first digit	M	70	146	2964.8	4162	4
	Fitts	100	175			
Step 17: Fixate second digit	F	230	267	3194.8	4429	
Step 18: Dial second digit	M	70 0	146 0	3264.8	4575	5
	Fitts					
Step 19: Fixate third digit	F	230	267	3494.8	4842	
Step 20: Dial third digit	M	70	146	3697	5219	6
	Fitts	132.2	231			
Step 21: Fixate last chunk of numbers on paper (last 4 numbers)	F	230	267	3927	5486	
Step 22: Encode last 4 digits	4 C	4(70)	4(118)	4207	5958	
Step 23: Fixate keypad	F	230	267	4437	6225	
Step 24: Decode last chunk	C	70	118	4507	6343	
Step 25: Fixate first digit	F	230	267	4737	6610	
Step 26: Dial first digit	M	70	146	4955.5	7016	7
	Fitts	148.5	260			
Step 27: Fixate second digit	F	230	267	5185.5	7283	
Step 28: Dial second digit	M	70	146	5281.3	7475	8
	Fitts	26.3	46			

Table 2 (continued)

Assumptions: In default mode the user is holding the phone in the preferred hand, dialing with preferred thumb.	Operator	Time young	Time old	Total young	Total old	Button press number
Step 29: Fixate third digit	F	230	267	5511.8	7742	
Step 30: Dial third digit	M	70	146	5740.3	8165	9
	Fitts	158.5	277			
Step 31: Fixate fourth digit	F	230	267	5970.3	8432	
Step 32: Dial fourth digit	M	70	146	6188.8	8838	10
	Fitts	148.5	260			
Step 33: Return with goal accomplished	C	70	118	6258.8	8956	
Step 34: Fixate green send button	F	230	267	6488.8	9223	
Step 35: Press green send button	M	70	146	6558.8	9369	11
Total time				6.59 s	9.37 s	

Note. In the Operator column, F refers to an eye fixation, M refers to a motor processing cycle, Fitts refers to the amount of time added to the motor processing cycle to press a button with a movement to a target of a given width and distance from the starting position, and C refers to a cognitive processing cycle. Highlighted cells represent activities that have overt responses, here a key press. Other steps represent assumed activities. Such activities could become observable, for instance, if eye-tracking equipment were used to examine fixation durations.

Users were timed and evaluated for accuracy as they carried out the task across multiple trials. The GOMS model captured human performance very successfully for both younger and older users, as seen in Fig. 3, for the time estimates plotted for each of the 11 required keystrokes.

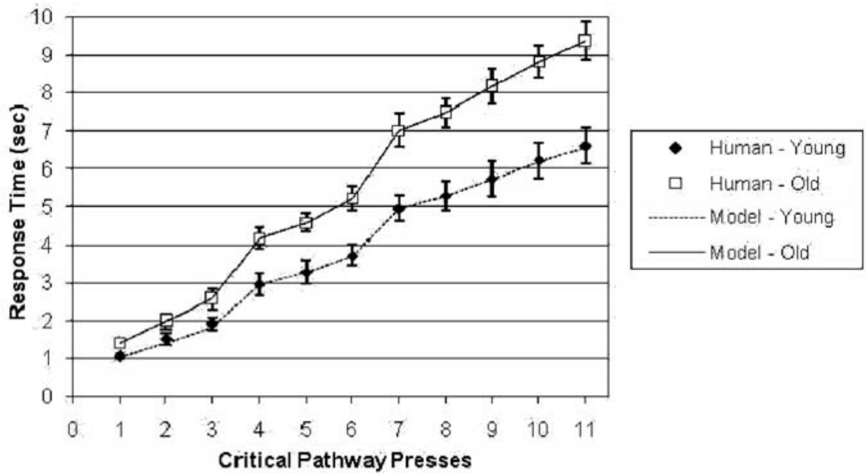

Fig. 3 GOMS model fits for mobile phone #1 in the dial-a-number task. Standard error bars (+/– 1 SE) are given for the human data

However, contrary to the popular belief that designing with the older user in mind will create better designs for users of all ages, data from Jastrzembski (2006) revealed that phone-specific factors, such as the default time-out value for screen cursor movement after a keystroke (during text entry), had different effects on younger and older errors that were predictable from GOMS modeling. If the time-out value was long enough to accommodate older users, for instance, younger users made more errors due to impatience, and the system undoubtedly felt sluggish to them as a result. If the time-out was shorter, slower older users made more errors when they pressed keys too slowly and the cursor moved ahead before they had completed the number of repetitions on a key necessary to select their desired alphanumeric character.

Each phone had design strengths and weaknesses that made them superior for one task and inferior for another in ways that were also predictable using the GOMS technique. For instance, the miniaturized keypad on one phone was superior for performance in a simple dialing task for users of all ages, but performed very poorly on more complex tasks requiring fine motor control and precision. This exercise showed that using GOMS to build models was both enlightening and very successful in evaluating existing mobile phone devices across specific tasks.

In sum, using predictive models to simulate trained users is a powerful approach to testing design specifications. Although Jastrzembski and Charness (2007) investigated usability of existing products, simulations may also provide a valid means of testing prototype models with hypothetical critical paths for younger and older adult populations.

4 Perspectives on Development of Gerontechnology over the Next Few years

Although gerontechnology has made a promising start, there are several critical challenges ahead. Much of the modeling activity emphasizes speed of processing. However, older adults are more likely to be concerned with accuracy than speed, so modeling needs to be extended to predict errors and designers should try to minimize their occurrence. Also, more effort is needed to identify the individuals and environments that can benefit the most from gerontechnological interventions.

4.1 Optimizing Design for Time or Errors?

It can be relatively expensive (time, money) to conduct usability testing for every possible new product. Also, not all firms have the capability to do such testing (or even know where to turn to outsource such testing). Hence, modeling and simulation offer an effective technique for choosing among possible designs early in a design process. As Jastrzembski (2006) demonstrated, if specific tasks with a product can be analyzed at the level of keystroke-based behavior, it is possible to use a GOMS-style model to make predictions that match human performance fairly closely on both time and error bases. However, there is a need for much more theoretical work to supply reliable human performance parameters from existing data, as well as for creating better models of error generation. So, it seems likely that the research community and the practitioner community would both benefit from the development of easier-to-implement modeling techniques.

Much of the theoretical work in the psychology of aging has been aimed at understanding performance in speeded tasks using prototypical cognitive psychology paradigms. However, the ecology of everyday activities for older adults seems to be dominated not by an emphasis on completing tasks quickly, but rather by ensuring that tasks are performed in error-free fashion. A good example is medication adherence behavior (e.g., Park & Jones, 1997), which emphasizes taking prescription drugs in the right amounts at the right time of day. You need not take them as quickly as possible within a short time limit (with the exception of acute medical emergencies), but you do have to take them in the right amount. Here problems with prospective memory, the ability to plan for future actions (Einstein, McDaniel, Smith, & Shaw, 1998), may dominate the performance function.

Similarly, when designing transportation systems for aging populations, it would be useful to have better estimates for how long it takes an aged adult to cross a street safely, in order to set appropriate signal durations for pedestrians, yet be mindful of the need to ensure a smooth flow of vehicles through streets. Errors in these tasks (walking, driving) can lead to tragic consequences. Vehicle crashes result in over 40,000 fatalities annually in the US and older drivers and pedestrians are disproportionately affected (Evans, 2004).

4.2 Critical Design Environments

Work, health, and home environments are important venues where good design can make a difference for older users. For a variety of reasons, but mainly to ensure that pension systems are able to meet the pressures of so-called baby boom cohort retirements, people will likely have to work longer before becoming vested in pension systems such as social security. In the US, the age of entitlement for a full pension has already moved from 65 years old to 67 for those born after 1960. Hence, work environments need to accommodate age-related changes in human capabilities in order to ensure that older workers remain productive. A good example is the cleaning industry, where in the EU about 50% of the workers are older women, aged 45+ (Louhevaara, 1999). Reorganization of work and design of better tools can provide a safer work environment. Although there is little relationship between age and productivity (e.g., McEvoy & Cascio, 1989; Sturman, 2004; Waldman & Avolio, 1986), rapidly changing workplaces may imperil older workers who tend to learn new skills more slowly. An aging work force will necessitate attention to design for hardware, software, and training.

As well, given the accelerating cost of health care systems to governments (and employers in the US), it is pretty evident that individuals are going to become more and more responsible for managing their own health and particularly the management of chronic diseases that develop in old age. Health care is migrating away from hospitals and into homes, given the cost differential between inpatient and outpatient care. Older adults will be required to learn to use fairly sophisticated medical devices at a time when their abilities are waning. Poor fit between user capabilities and system demands could literally lead to life-and-death situations for patients. A large-scale study in the US suggested that poor system design characteristics may be contributing to about 95,000 unnecessary deaths every year in US hospitals (Kohn, Corrigan, & Donaldson, 2000). Hence it is apparent that health care product and environment design are going to be crucial areas for gerontechnology.

Finally, the desire to remain in a familiar home environment is a goal for many elderly adults. Smart home technology (e.g., Berlo, 2002) or, as it is also called, aware- home technology (Mynatt, Melenhorst, Fisk, & Rogers, 2004), is going to grow in importance for maintaining independence at home in old age. As Mynatt et al. (2004) argue, homes can become coaches for older adults for tasks ranging from medication adherence to food preparation. Another approach is to offer smart robotic assistants to aging residents (e.g., nursing home robots that provide medication advice; Matthews, 2002), though so far only robotic cleaning units have seen much commercial success in the US.

5 Summary

Gerontechnology is a new approach to melding basic research on aging phenomena with the application of research findings to design more effective products. It requires the cooperation and collaboration of a variety of disciplines—such as psychology, human factors engineering, and design—to ensure that products meet the needs of an aging population. We have outlined some of the normative changes that occur as people age. We also provided some guidelines for design. We also argued that some of the short-term goals for this discipline should include extending our knowledge of basic human performance parameters as a function of adult age, emphasizing design for error-free performance over speeded performance, and developing easier-to-apply modeling and simulation techniques. Even with better simulation techniques, there will still be a continuing need to do usability testing, particularly for products that incur high costs when errors occur, such as in the health care field.

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