Aging and Information Technology

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Potential and Barriers

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ABSTRACT—Why are older adults reluctant to adopt new technology, such as the Internet, given its potential to improve the quality of their lives? We review evidence indicating that attitudes and abilities are among the most powerful predictors of technology use. We conclude that normative age-related changes in ability must be taken into account when designing products and training programs for aging adults, and we discuss new tools to support designers. The most promising emerging technologies likely lie in training cognitive abilities and augmenting or substituting for impaired abilities. We discuss reasons to expect that the lag in technology adoption between younger and older adults may lessen but will not disappear in future generations.

KEYWORDS—age; technology; attitude; ability; cognition

We are experiencing two important sociocultural trends. The first is the remarkable increase in longevity that began in the 20th century in many developed countries. For instance, U.S. life expectancy at birth increased from about 47 years in 1900 to about 77 years in 2000 (http://www.census.gov/prod/2006pubs/p23-209.pdf), an increase due mainly, but not exclusively, to improvements in the first few years of life. In conjunction with declining birth rates, such longevity gains have led to aging populations. Second, we are witnessing an accelerated adoption of microprocessor-based technology, initiated with Intel's 4004 microprocessor invented in 1971. Microprocessor-based technology has significant multiplier effects for societal productivity and well-being (Charness, 2008). The confluence of these two trends might lead to beneficial outcomes for an aging population or may widen the so-called "digital divide" favoring younger adopters.

For the purposes of this review, we focus on information technology. We define such technology to mean any tool or system that contains a microprocessor chip. Since the production of the first chip, there has been an exponential increase in such products, with microchips estimated to outnumber people on our planet. (Check this claim by counting the chips in the digital devices that you currently carry, or have discarded, such as watches, phones, or music players.)

Technology can play important roles in work and leisure and in health care provision. One role is in prevention of age-associated impairments. That is, technology such as a lifting device might prevent a back injury early in a blue-collar worker's career, permitting entry to old age in sound health. A second role is augmentation. Large high-contrast monitors can display legible text for those with diminished visual acuity. Augmentation might also come in the form of a computer game designed to train failing cognitive abilities. Finally, there is substitution. For those with mobility impairments, online banking can substitute for a physical visit.

A primary concern in this nascent field, sometimes called gerontechnology, is with understanding the predictors of technology use in older adults, understanding how normative changes with age affect interactions with technology, and determining how to design better technology products (Czaja & Lee, 2007; Rogers, Stronge, & Fisk, 2006). Much of the interest stems from the relatively well-understood changes in perception, cognition, psychomotor performance (e.g., Fisk, Rogers, Charness, Czaja, & Sharit, 2009), and emotion favoring optimizing relationships over acquiring new information (Carstensen, & Mikels, 2005)—changes that take place across the life span. Such changes lead to different interactions with tools and with people. First we review some age-related changes in technology adoption and in abilities that affect technology use. Then we highlight how such changes have important implications for design.

DEMOGRAPHICS OF TECHNOLOGY USE

The prototypical technology system is a computer with Internet access. Successive waves of representative surveys have shown for the United States and elsewhere that use of the Internet falls off sharply with age (Fig. 1A). One obvious route to technology introduction is through work, and those age 65 or over are less likely to be working than are later birth cohorts. Nonetheless, there has also been significant increase in computer use over the past decade (Fig. 1B), though age-group gaps did not close.

Is this reluctance to adopt technology general to all microprocessor-based products? Pew Internet and American Life researchers noted (http://www.pewinternet.org/PPF/p/1099/pipcomments.asp) that whereas around 30% of those over 65 were Internet users in 2004, 46% were mobile phone users. Differential product use corresponds to the different perceived benefits to older adults of different types of technology (Melenhorst, Rogers, & Bouwhuis, 2006). In line with socioemotional selectivity theory (Carstensen & Mikels, 2005), acquiring information via the Internet probably takes second place to mobile phone communication that can enhance personal relationships and feelings of security. But, given the communication benefits offered by the Internet (e-mail, chat, voice over IP, videoconferencing), why don't seniors (and particularly those with disabilities) make greater use of computers and the Internet?

ATTITUDINAL BARRIERS

There are a variety of models of technology diffusion and adoption, but all emphasize access and interest as important factors. Access to technology is critical, and the exponential increase in personal wealth in the United States over time, together with the recent striking gains in efficiency in the information technology industry (Charness, 2008), have lowered access barriers. This has been the case even for senior citizens, who have reduced incomes relative to other age groups. Interest in technology is likely to be the next step toward adoption. Ellis and Allaire (1999) found in a sample of seniors (age 60–97) that interest was directly negatively predicted by computer anxiety and by age. They also found that interest was indirectly negatively predicted via paths from age and education through computer knowledge and computer anxiety. Nationally representative surveys have shown that education and income are consistent positive predictors of use of computers and the Internet, with age being a consistent negative predictor. However, such studies identify patterns of association, not causation.

COGNITIVE BARRIERS

Given the complexity of many technology products, cognitive abilities may be essential to learning how to use and maintain them. Evidence for this was provided by Czaja et al. (2006) for technology use other than computers and the Internet (cell phone, ATM, fax machine, microwave oven, VCR) in a large (n = 1,204), diverse sample of Americans varying in age from 18 to 91 years of age. They found that age was not a particularly strong predictor of technology use after accounting for fluid intelligence (abstract problem solving ability), crystallized intelligence (cultural knowledge), computer anxiety, computer efficacy (beliefs about ability to use computers), education, ethnicity, and some of their interactions. Fluid intelligence was the strongest predictor in the variable set. Czaja et al. also used structural equation modeling to predict both breadth of World-Wide Web use and breadth of computer use, finding in both cases that age, crystallized intelligence, computer anxiety, and use of other technologies were the only direct predictors.

One potential reason for anxiety concerning technology—and hence, a potential barrier to adopting it—is that it can be poorly designed for the capabilities of aging adults. Increasingly, human factors and ergonomics specialists have argued that attention needs to be paid to age-related changes in basic human abilities, to ensure that the demands made by the technology fit the capabilities of the user. Technology redesign and user training are critical tools to ensure a better person–technology fit. Rogers, Meyer, Walker, and Fisk (1998) noted that about half of the difficulties that older adults reported with daily activities could be alleviated by a combination of better design and training.

AGE-RELATED CHANGES AFFECTING TECHNOLOGY USE

When designing technology for older adults, age-related changes in perceptual, cognitive, and motor systems are important considerations (Fisk et al., 2009). In terms of vision, these include changes in visual acuity, color perception, and susceptibility to glare. In the auditory domain, older adults face greater difficulty perceiving high-pitched sounds (including critical speech components) and greater interference from background noise. In a very literal sense, older adults may perceive technology differently than younger adults do. Changes in motor control, including increased difficulty with fine motor control and coordination and the onset of disease processes such as arthritis, can change the way older adults are physically able to interact with technology. Cognition is affected as well; aging is associated with general slowing of cognitive processes, decreased memory capacity, decreased attentional control, and difficulty in goal maintenance. These changes in function can slow performance and result in a greater number of errors as older adults interact with technology that was not designed with their capabilities in mind. However, knowing these constraints, designers can create better products for older adults. For example, a cell phone designer might create a phone for older adults that features simplified menus, large fonts and buttons, and external noise reduction (e.g., the Jitterbug®). Web designers should avoid backgrounds that create low contrast for the text, use larger fonts, minimize scrolling, and provide navigation aids and instructional support (e.g., http://nihseniorhealth.gov/).

Imagine that you are suddenly handicapped by a brain injury that renders you twice as slow at acquiring new information as you were prior to the injury. How would that affect your willingness to learn to use new technology? That is the dilemma faced by the majority of older adults, even though the learning-rate decline from their young adult years is much more gradual. Older adults take roughly twice as long under self-paced learning conditions to learn a new word processor than younger adults do, whether they are novices or even have prior experience with another word processor (Charness, Kelley, Bosman, & Mottram, 2001). However, absolute time to learn is dependent on the increasing knowledge base that older adults continue to acquire. Experienced older word processors acquire skill with a new program about as fast as inexperienced younger adults do. Nonetheless, the time cost of new learning unrelated to prior knowledge increases strikingly with age, necessitating careful attention by those designing instructional support packages for technology products.

PRIVACY CONCERNS

Even assuming that products are properly designed for older adult capabilities (and are easy to maintain) one further barrier remains, particularly in the developing area of health monitoring: privacy concerns.

To minimize health care costs, many insurers (private and public) are looking to technological advances such as remote monitoring of chronic conditions that appear primarily in old age (e.g., diabetes, congestive heart failure) and to greater adoption of home care solutions. One major concern with remote monitoring is loss of privacy. Studies are sparse and representative data are needed. In a study by Caine, Fisk, and Rogers (2006), seniors toured a high-tech “aware home” equipped with embedded monitoring devices and intelligent “coaches” for activities and they gave ratings of their privacy concerns. Privacy was less of a concern when less invasive monitoring was used (e.g., a camera image showing a de-identified visual shape rather than a clear image of a person) and for scenarios in which people were presented as being more impaired. Beach et al. (in press) in their Web-based survey of older (over 45) and disabled adults showed that privacy concerns even for intrusive monitoring were mitigated by level of impairment. Such results suggest that a balance can be found between monitoring and privacy that will be acceptable to older technology users.

TOOLS FOR IMPROVED DESIGN OF TECHNOLOGY FOR OLDER USERS

Because of age-related changes in cognition, perception, and motor function, current simulation tools (e.g., CogTool, http://www.cs.cmu.edu/~bej/cogtool/, and GOMS, discussed below) to help technology designers may be inappropriate for an older adult population. For example, the GOMS (Goals, Operators, Methods, and Selection rules) modeling system predicts completion time of routine tasks (Card, Moran, & Newell, 1983) and allows designers to compare the efficiency of alternative designs without the need to bring people into the lab and observing their performance. Problematic to predicting the performance of older adults, GOMS predictions are derived from a "Model Human Processor," with the parameters of this processor based almost exclusively on data collected from college undergraduates. Such parameters include working-memory capacity, processing speed, and motor response time, all of which demonstrate clear age-related differences. Recently, Jastrzembski and Charness (2007) have updated the model to include older adult parameters derived by meta-analysis and found that the updated model predicted older adult performance in a mobile phone task quite well. This work clearly demonstrates the value of models and design tools that take into account age-related differences.

TECHNOLOGIES TO IMPROVE PERCEPTUAL AND COGNITIVE FUNCTIONING

In recent years, numerous computer games and software packages have been developed and marketed to older adults seeking to attenuate or reverse age-related declines in perceptual and cognitive abilities (through advertisements featuring older adults and a focus on the relationship between age and cognition). In 2005, Nintendo introduced the video game Brain Age™, which has sold more than 15 million copies. Brain Age™ and similar games target a traditionally nongaming older adult population (according to a recent Pew Internet & American Life survey, 81% of 18- to 29-year-olds report playing video games, while only 23% of adults 65 or older report doing so). Interestingly, although far fewer older adults are gamers compared to their younger counterparts, older adults are among the most active gamers, with many reporting playing almost every day, possibly because many are retired and have more free time. In addition to video games, an increasing number of “brain fitness” software packages sold by companies such as Posit Science® and CogniFit® make it likely that technology-based cognitive interventions will be a part of life for many seniors. These interventions build on the idea that intellectual engagement can lessen cognitive decline (Stine-Morrow, 2007).

How effective are these technologies at improving quality of life and extending functional independence? To date, the evidence appears to be limited at best. Video games and brain fitness software have been shown to improve performance on the specific tasks trained and even on some untrained laboratory tasks (e.g., Basak, Boot, Voss, & Kramer, 2008; Mahncke et al., 2006). Recent promising data come from the IMPACT study (Improvement in Memory with Plasticity-based Adaptive Cognitive Training; Smith et al., 2009). This computer-based intervention improved self-reported cognitive functioning and performance on multiple memory tasks. However, objective evidence that a particular game or computer intervention can improve an individual’s quality of life outside of the laboratory is sparse. Evaluating the effectiveness of these interventions, determining the underlying mechanisms through which they improve memory and attention, discovering the extent to which these improvements increase well-being and prolong functional independence, and creating new and better interventions based on these results (possibly with a focus on tailoring interventions to the specific needs of the user) represent major challenges for researchers. A focus on demonstrating gains in complex, objective outcome measures with direct real-world relevance (e.g., driving, medication adherence, learning software) would represent the best evidence for the utility of technology-based cognitive interventions.

PERSISTENT LAGS IN TECHNOLOGY USE?

We are often asked whether the pattern of low use of technology by seniors (e.g., Internet use) is going to disappear over time because future cohorts of older adults will have grown up with the Internet and with computers. We suspect that Internet use lags will diminish over time as current young users age. However, it is reasonable to assume that technology will continue to advance rapidly. Also, perceptual, cognitive, and psychomotor declines will continue to occur with aging, in concert with life-span sensitive changes in motivational factors. Hence, future cohorts of older adults are likely to continue to lag in technology adoption. For instance, today’s seniors grew up in an era of telephony (patented in 1876), yet, as seen in Pew data sets, they lag behind later birth cohorts in terms of mobile phone adoption (patented in 1946) but not in land-line phone adoption. Our expectation is that age/cohort lags will also lessen if psychologists can provide better guidelines and tools to designers enabling them to create technology products better attuned to older adult capabilities. Otherwise many seniors may fail to benefit from technological advances (particularly those providing efficient health monitoring: Coughlin, Pope, & Leedle, 2006) that could significantly improve their independence and well-being.

Recommended Reading

Czaja, S.J., & Lee, C.C. (2007). Information technology and older adults. In J.A. Jacko & A. Sears (Eds.), *The human-computer interaction handbook* (2nd ed., pp. 777–792). New York: Erlbaum. A clearly written, user-friendly, and comprehensive review for readers who wish to expand their knowledge on technology and aging.

Fisk, A.D., Rogers, W.A., Charness, N., Czaja, S.J., & Sharit, J. 2009). *Designing for older adults: Principles and creative human factors approaches* (2nd ed.). Boca Raton: CRC Press. A primer aimed at the design community, containing guidelines as well as short tutorials on topics such as how to conduct focus groups, use and interpret basic statistics, conduct usability testing and task analysis, and carry out GOMS modeling for older adults.

Harrington, T.L., & Harrington, M.K. (2000). *Gerontechnology: Why and how*. Maastricht, The Netherlands: Shaker. A very readable book defining the field of gerontechnology and highlighting its goals.

Mayr, U. (Ed.). (2008). Cognitive plasticity in the aging mind [Special section]. *Psychology and Aging*, *23*, 681–786. A special issue discussing evidence for the efficacy of videogames and other cognitive training procedures for older adults in more detail than the current paper.

Pew Internet and American Life Project reports: http://www.pewinternet.org/. An ongoing research project providing representative sample data for the United States on technology use trends, focused on use of the Internet; the Pew project also makes their datasets available for reanalysis.

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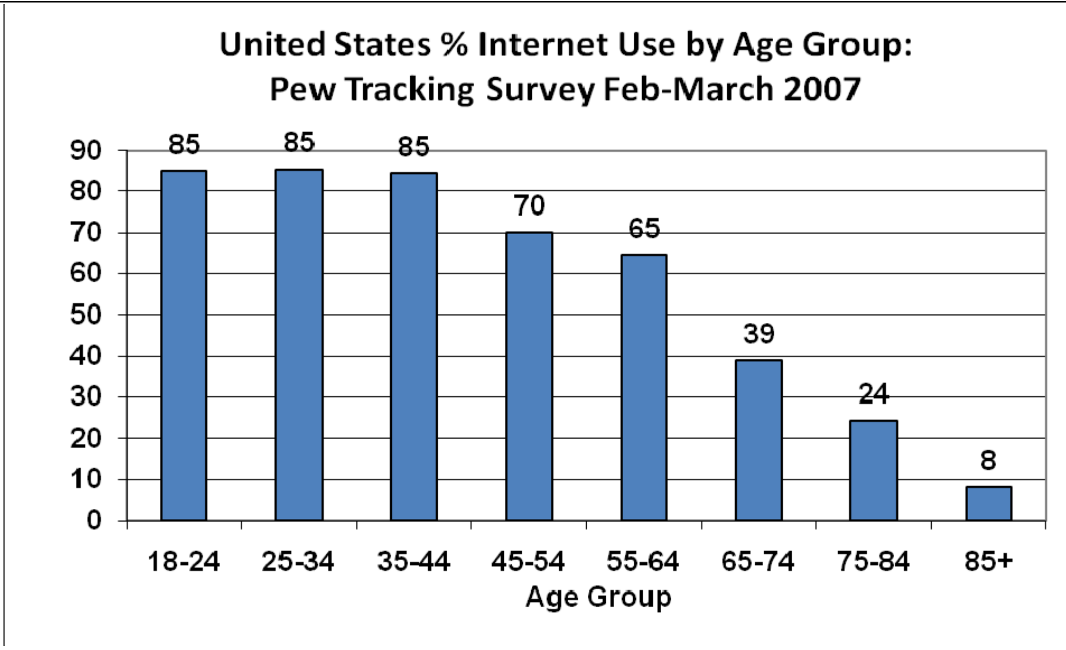
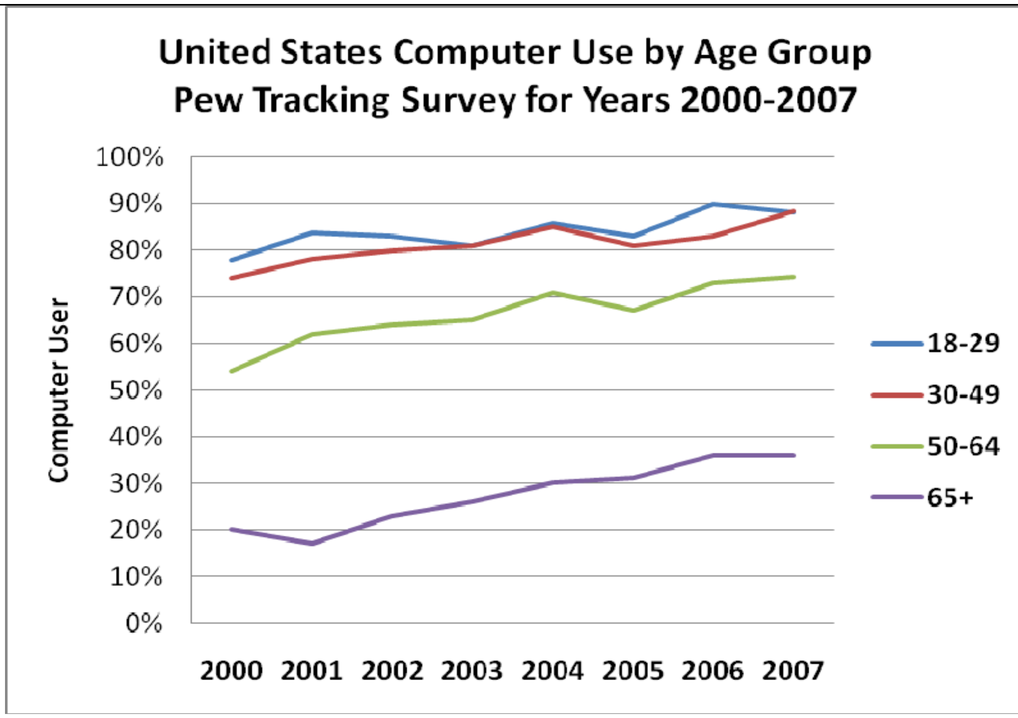
Figure Captions

Fig. 1. Internet use (panel A) and computer use (panel B) in the United States by age group. Internet use (percent assenting to a question of whether they had used the Internet in the past year) is from a survey conducted February–March 2007). Computer use (those saying they had used a computer in the past year at least occasionally) is shown for the years 2000 through 2007. We gratefully acknowledge provision of data from the Pew Foundation Internet and the American Life Project.

Figure 1

Panel A



Panel B	

United States Computer Use by Age Group
Pew Tracking Survey for Years 2000-2007
Computer User
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
2000
2001
2002
2003
2004
2005
2006
2007
18-29
30-49
50-64
65+