CHAPTER

20

Technology, Gaming, and Social Networking

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DEFINITION OF TECHNOLOGY AND ICT

We have experienced two revolutionary changes in the past century: marked increases in longevity coupled with accelerating rates of adoption of intelligent technology (Charness, 2004). These two changes could potentially enrich the lives of our rapidly growing aging population or restrict quality of life for those unable to harness this intelligence to serve their goals. In this chapter, we expand on some of the themes introduced in the 6th edition *Handbook of the Psychology of Aging* adaptive technology chapter (Scialfa & Fernie, 2006) as well as in Charness, Fox, and Mitchum (2011). We also try to emphasize recent studies in our overview given the rapidly expanding literature in this area. General reviews are available in Caine et al. (2006), Czaja and Lee (2008), and Wagner, Hassainen, and Head (2010). Aside from considering data and theories of technology adoption, we emphasize two historically recent phenomena: gaming and social networking technology.

We caution the reader that at this point in time there are not many solid research studies to rely on for theory building about gaming and social networking for older cohorts. The lacuna is partly because of current striking cross-sectional age differences in participation rates in such activities. It is difficult to find enough older adults to study and they are likely to be unrepresentative of their age cohort. Also, many surveys lump together very different segments of the aging population (young-old, middle-old, old-old) under the category of age 65+, so we have an undifferentiated picture of ICT use in late life. As demographers have pointed out (Meyer, 2012), even centenarians are growing faster than is the general population in the United States.

We also rely primarily on US data for highlighting technology adoption trends given its density and currency. We would expect similar trends for other developed countries, and lower adoption rates in less developed countries except perhaps for the reliance on mobile phone technology. We turn now to the thorny issue of defining technology.

The Oxford English Dictionary (http://www.oed.com/) provides seven primary definitions for technology, with the one most fitting for our interests being:

> 4a The branch of knowledge dealing with the mechanical arts and applied sciences; the study of this.
>
> 4b The application of such knowledge for practical purposes, esp. in industry, manufacturing, etc.; the sphere of activity concerned with this; the mechanical arts and applied sciences collectively.
>
> 4c The product of such application; technological knowledge or know-how; a technological process, method, or technique. Also: machinery, equipment, etc., developed from the practical application of scientific and technical knowledge; an example of this. Also in extended use.

These definitions remind us that technology is both a product and a process and that engineering is the presumptive approach. That role would be assumed by applied experimental and engineering psychology in the case of our discipline, sometimes termed gerontechnology (Bouma, Fozard, Bouwhuis, & Taipale, 2007). The primary focus in this chapter is on information and communication technologies (ICTs), those often used for social interaction (Charness & Boot, 2009). We provide a brief history of the development and diffusion of ICTs to indicate its relative recency and growing ubiquity. We overview some of the current theories of technology adoption. We discuss trends in adoption and assess research related to adoption. We conclude by offering directions for future research and application.

A CENTURY OF DEVELOPMENT AND DIFFUSION OF TECHNOLOGY

Differences in longevity between our early ancestors and ourselves (or today between people in developing vs. developed nations) are less attributable to genetics than to cultural changes, particularly technology development.

The striking rise in life expectancy at birth in the United States, from 47 years in 1900 to 78 years in 2008 (Arias, 2012) most likely reflects multiple technology advances. Medical technology reduced the risk of incurring childhood diseases and increased the chance of surviving them (vaccination programs, antibiotics). Agricultural technology provided an abundant/inexpensive food supply (e.g., modern tractors). Civil engineering technology provided clean water and effective sewage disposal in growing urban environments.

At least initially, new technology is costly and widespread adoption is difficult to achieve in poor societies. The rapid rate of diffusion of technology products now compared to a century ago (e.g., wired phone vs. mobile phone adoption rates) undoubtedly reflects wealth increases. Enormous gains in economic productivity due to better work technology and a more highly educated labor force (both in terms of job-specific training and in terms of general fluid intelligence gains: Fox & Mitchum, 2013) are likely the main factors that resulted in exponential increases in real income comparing those working today versus in 1900 (Charness, 2008). Educational technology coupled with increasing public participation in advanced education undoubtedly lies behind some of these human capital increases.

Many of the technology tools that have developed in the twentieth century and beyond are fundamentally different than those of prior generations of technology in that they include microchips capable of being programmed, making them multipurpose devices rather than dedicated single-function tools. The invention of the digital computer chip (e.g., Intel's 4004 chip in 1971, http://www.intel.com/content/www/us/en/history/museum-story-of-intel-4004.html), enabled miniaturization of intelligent technology.

Home Computing and Gaming

The ability to manufacture computers for consumer use encouraged added functionality, namely entertainment, and specifically gaming. Early 1980s computers for the home emphasized gaming capabilities, with work capabilities representing almost a secondary feature. It seems likely that diffusion of such technology in the population (see the later section on technology diffusion) was associated with familiarity in office environments leading to adoption at home. Whether the current trend to later retirement ages and partial retirement will change the flow pattern for seniors who have traditionally been isolated from work environments remains to be seen. Also, technology transfer does not always proceed from work to home; smartphone adoption has moved in the opposite direction. The earlier diffusion pattern meant that retired older adults (> age 65) would be left out of the computer revolution. The first "digital divide" report by the US National Telecommunications and Information Administration in 1995, while focused on rural/urban differences in technology adoption (telephone, computer) duly noted "… rural seniors rate lowest in computer penetration" (http://www.ntia.doc.gov/ntiahome/fallingthru.html). Given that education and income were then (and still are, see Figure 20.4) among the strongest predictors of ICT adoption, it is not surprising to see seniors lagging behind their younger working counterparts in many areas. This brief history points to the recency of ICT diffusion, perhaps indicating why we might expect generational differences in adoption, and to the diversity of products. We now review trends in technology adoption by age category to set the stage for discussion of theories of adoption.

TECHNOLOGY USE AND AGE

It is instructive to consider trends in technology adoption by age/cohort over time using nationally representative data. A useful source for American data is the Pew Internet and

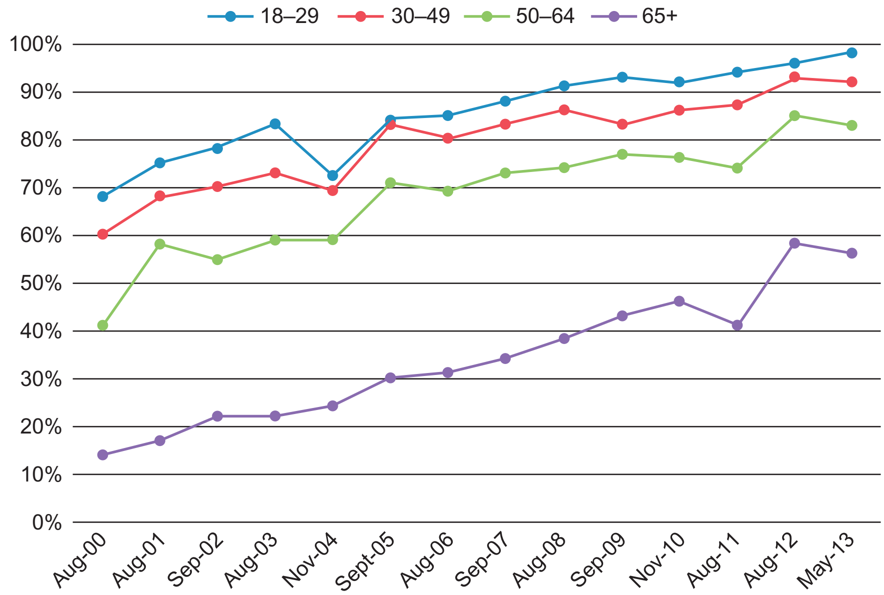

FIGURE 20.1 Percent US Internet use by age group. *Data selected at near annual intervals from the Pew Internet & American Life spreadsheet http://www.pewinternet.org/Static-Pages/Trend-Data-%28Adults%29/Usage-Over-Time.aspx supplemented by http://www.pewinternet.org/Trend-Data-%28Adults%29/Whos-Online.aspx. Accessed 30.12.13.*

American Life project (http://www.pewinternet.org/), which has been conducting representative sample surveys since 2000. Below in Figure 20.1 Internet use is plotted.

Notable is the persistent lag in Internet use by those age 65+ compared to other age/cohort groups. The 65+ cohort in 2013 only reached levels of use exhibited 13 years earlier by those age 30–49 and still lagged behind Internet use registered by those age 18–29 in the year 2000. Even in 2013 about 44% of those age 65+ did not use the Internet. A survey of offline US adults (Madden, 2013) showed that the primary reasons for non-use were lack of interest (21%), not having a computer (13%) and too difficult/frustrating (10%). When asked whether they would be able to start using the Internet in the future, only 13% of those age 65+ indicated that they would know enough to go online, and 66% indicated they would need help.

Although it appears that those age 65+ have shown enormous growth in Internet use, particularly from 2011 to 2012, it is worth noting that these are cross-sectional panels, not longitudinal data. Much of the growth may be due to earlier cohorts shifting over time into new age categories, carrying along their original Internet use habits. As an example, the 50–64 age cohort in 2001 was at about 60% Internet use and 12 years later, when most had moved into the age 65+ cohort, use in the 65+ cohort was also near 60%. There is undoubtedly time-associated growth but it is unclear how much of that is confounded with age category shifts. Nonetheless, as the Baby Boom cohorts (e.g., born 1946–1964) begin to dominate the age 65+ category, it is safe to assume that most of them will have Internet access. How they will access the Internet (devices) and what activities they will pursue on the Internet will be a function of general factors in technology adoption.

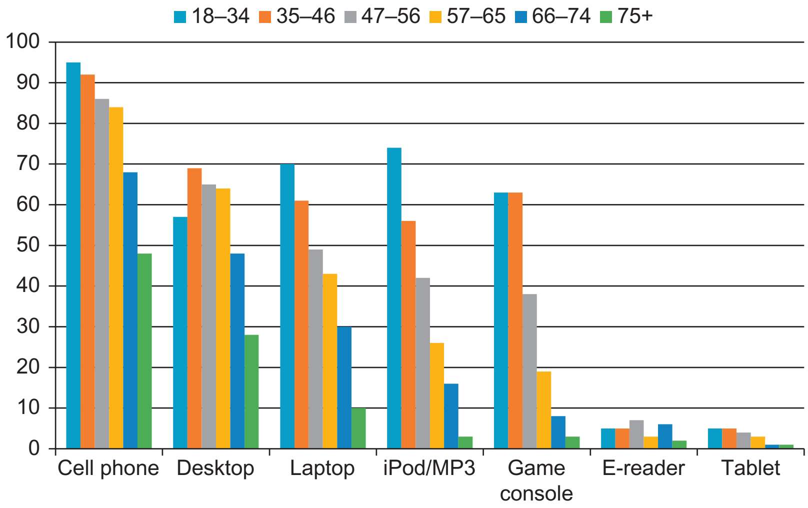

FIGURE 20.2 US percent device ownership in 2010. *Data from Zickuhr (2011), http://www.pewinternet.org/~/media//Files/Reports/2011/PIP_Generations_and_Gadgets.pdf. Accessed 31.12.13.*

Surveys have shown similar trends for adoption in other countries. In Europe, the percent of people who use the Internet at least once a week is 93% for 16–24-year-olds, 78% for those age 25–54, and 42% for those age 55–74 years (Seybert, 2012).

There are similar findings for other ICT devices. A cross-sectional example of US use in 2010 is plotted below, showing rapid fall-off with age/cohort for all but relatively new products such as e-readers and tablets. That is, there is a consistent age/cohort-based technology lag (reminiscent of societal structural lag that sociologists such as Riley, 1998, have discussed) (Figure 20.2).

It is worth noting that older adult cohorts sometimes lead younger ones, though for older forms of technology. As an example, a Gallup Poll (http://www.gallup.com/poll/166745/americans-tech-tastes-change-times.aspx?) in the United States in December 2013 showed that VCR ownership was higher in the age 65+ category than the 18–29-year-old category (74% old vs. 41% young) and the same was true for basic cell phone ownership (61% old vs. 24% young) but the reverse was true for smartphone ownership (88% young vs. 25% old). We turn next to theories of technology adoption to assess potential reasons for these age differences.

THEORIES AND MODELS OF TECHNOLOGY ADOPTION

Over the past few decades a variety of models have been proposed to explain the diffusion of technology and technology acceptance by individuals. These models are briefly reviewed to frame the subsequent discussion of the adoption of digital games, social networking sites (SNSs), and other ICTs by older adults. In general these models aim to capture the attitudinal and contextual factors that work to facilitate or impede the adoption of new technology.

Rogers Diffusion of Innovation (Rogers, 1995)

Rogers (1995) described the five-stage process a non-user of technology progresses through to become a technology adopter or non-adopter, starting with the process of obtaining basic knowledge related to the existence of a technology and what it does (knowledge stage). Importantly, during the persuasion stage the individual forms a positive or negative impression of the technology, driven in part by factors such as the perceived advantage of using the technology and the perceived difficulty of using the technology. At this stage the ability to try a new piece of technology can have an important influence, as well as the opportunity to observe others using the technology. This is followed by a decision stage in which the pros and cons of the technology are weighted and a decision is made, at which point the technology is either rejected or incorporated into the individual's life (implementation stage). Following implementation, an individual reevaluates the outcome of deciding to use a piece of technology and decides to maintain or discontinue use (confirmation stage), resulting in either adoption or rejection of the technology. In sum, Rogers highlights that the decision to adopt a technological innovation is a complex one, involving many attitudinal, social, and environmental factors.

Technology Acceptance Model

Technology Acceptance Model (TAM; Davis, 1989) has been one of the most influential models of technology acceptance, with two primary factors influencing an individual's intention to use new technology: perceived ease of use and perceived usefulness. An older adult who perceives digital games as too difficult to play or a waste of time will be unlikely to want to adopt this technology, while an older adult who perceives digital games as providing needed mental stimulation and as easy to learn will be more likely to want to learn how to use digital games. While TAM has been criticized on a number of grounds, it serves as a useful general framework and is consistent with a number of investigations into the factors that influence older adults' intention to use new technology (Braun, 2013).

Unified Theory of Acceptance and Use of Technology

Unified Theory of Acceptance and Use of Technology (UTAUT; Venkatesh et al., 2003), a more complex offshoot of TAM, includes similar factors of perceived ease of use (effort expectancy) and perceived usefulness (performance expectancy), but also explicitly recognizes that broader contextual factors may facilitate or inhibit technology adoption. These factors include facilitating conditions such as the perception that technical support would be available if needed, and social influences, such as the perception that other individuals expect them to adopt new technology. According to this model, an older adult is more likely to sign up for a Facebook account if he or she felt social pressure to do so, and if he or she felt that family and friends would be available to help.

Other Factors in Technology Acceptance and Use

Contextual factors can be varied. Charness (2003) suggested that a useful framework would include factors such as access, motivation, ability, design, and training. Caine et al. (2006) surveyed 50 years of research on acceptance of high technology and provided a heuristic tool for factors that designers of technology should keep in mind in addition to perceived usefulness and ease of use. The factors they stressed included perceptions about compatibility, complexity, fun and enjoyment, self-image, newness, privacy, relative advantage, and risk of harm. Barnard, Bradley, Hodgson, and Lloyd (2013) argue that different models are needed to account for variables affecting perceptions about ease of learning and those influencing technology acceptance/rejection. Ease of learning factors include self-efficacy, perceived difficulty, and attitudes toward learning. System and user acceptance of technology factors include system characteristics affecting usability (transparency, affordance, feedback, error recovery, and training support) as well as user experience factors involving transfer of prior knowledge. We next apply these frameworks to try to understand factors in adoption of gaming and social networking.

OLDER ADULT GAME USE AND GAME PREFERENCES

Gamer Demographics

According to the Entertainment Software Association, video game sales in the United States reached approximately 15 billion dollars in 2012, exceeding domestic movie ticket sales for the same year by 4 billion dollars. These figures highlight digital games as a dominant form of entertainment and a pervasive form of modern technology. In addition to increased sales we are also witnessing a trend for the diversification of the gamer population. Contrary to the stereotype of the teenage male gamer, the average gamer is 30 years old and is almost as likely to be female as a male. However, data suggest that video game use is still relatively rare among older adult cohorts (according to a 2008 Pew survey, only 23% of adults 65+ reported playing digital games compared to 53% of all individuals 18 or older; Lenhart, 2008).

A push by the gaming industry to reach "casual" gaming audiences may account for an increased interest by older adults to explore digital games (in addition to an increase in female gamers). Casual games do not require the gamer to invest large amounts of time to learn, are often modeled after familiar non-digital games, and can be played in short sessions. Although older adult gamers are relatively rare, it is also true that they are among the most active gamers with over a third reporting playing almost every day or more. With respect to gaming platform, console game use (e.g., Playstation 4, Xbox One) is especially

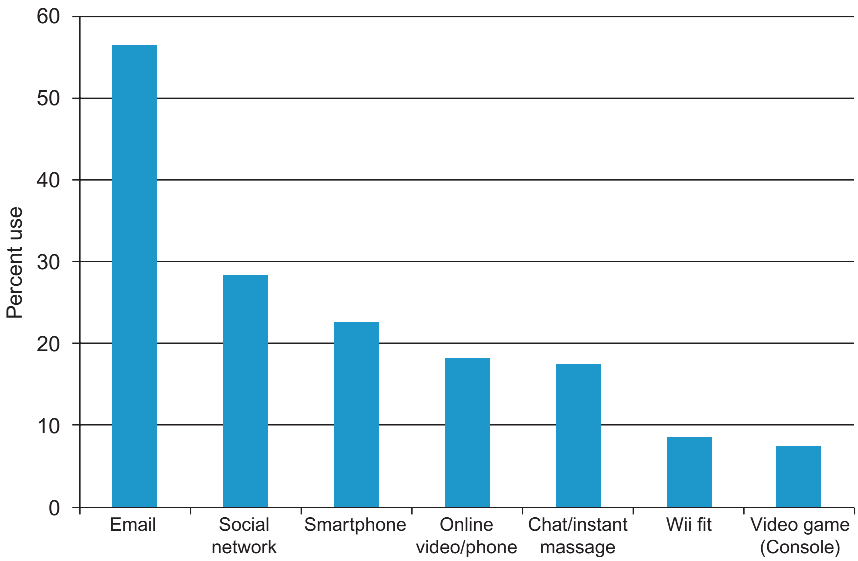

FIGURE 20.3 Communication and game use of a representative sample ($N = 1740$) of retired individuals (age 50+) from the Health and Retirement Study 2012 data set.

rare among older adults (Figure 20.3; also, the aforementioned Gallup Poll in 2013 showed 18–29-year-old ownership at 64% and age 65+ at 10%), with the majority of older gamers relying on computers to play. In addition to gaming platform, it is also clear that the types of games older cohorts enjoy playing are different from some of the most popular game genres enjoyed by younger players.

Game Preferences of Older Adults

Action/shooter games and sports games tend to be the most popular console video games, and strategy and roleplaying games tend to be most popular non-console games as indicated by the top selling games of 2012. In 2013, the violent action game Grand Theft Auto V became one of the best-selling games of all time, with sales reaching over a billion dollars faster than any other entertainment property. However, several survey and focus group studies suggest that the types of games that older gamers play, or would like to play, are different from the games that are most popular among younger gamer cohorts. For example, De Schutter (2011) surveyed older adults (ages 45–85) and found that PC-based casual games were most popular among this sample, with the need for challenge being the primary motivation for game play. Games included in this category were puzzle games, computerized versions of card/board games, and games with simple dynamics and controls. De Schutter partly attributed the popularity of casual games among older adults to the ease with which these relatively simple/familiar games can be learned. Fast-paced and violent first-person shooters, one of the most popular game genres overall, tend to be unpopular with older adults (De Schutter, 2011; Nap, de Kort, IJsselsteijn, 2009; McKay & Maki, 2010). Instead, slower-paced games that emphasize intellectual challenge tend to be popular with older gamers (Pearce, 2008).

This may not be surprising given the potential mismatch between the visual, attentional, and processing speed demands of popular action, sports, and strategy games and older adults' poorer perceptual/cognitive abilities. Unfortunately, older adult game preference and gaming habits have been a relatively understudied topic. Additional research is needed to better understand older adults' motivation to engage in game play and predictors of game preference. Digital gaming represents a novel domain with which to explore and validate new and existing models of technology adoption and adherence.

Benefits of Gaming

In addition to the obvious entertainment value of games, gameplay may engender other meaningful benefits in terms of keeping older adults mentally engaged and physically active. A topic that has generated excitement (and some controversy) recently is the potential of video game play to improve a variety of perceptual and cognitive abilities (Green & Bavelier, 2008; Bavelier & Davidson, 2013; Powers et al., 2013; but see also Boot, Blakely, & Simons, 2011; Boot, Simons et al., 2013). Both cross-sectional studies comparing gamers to non-gamers, and game training studies that have trained non-gamers to play video games, suggest that video game play (especially fast-paced action game play) provides more than just entertainment: games may be good for you. While much of this work initially focused on college-aged adults there is growing interest in whether or not video game interventions can reduce aspects of age-related cognitive decline. For example, Basak, Boot, Voss, and Kramer (2008) found that training on a complex strategy game called *Rise of Nations* resulted in improved performance on laboratory tasks of memory and reasoning ability in a sample of older adults.

There has also been a focus on developing games that target specific abilities that are known to decline with age (Anguera et al., 2013), and a variety of game-based "brain fitness" programs are now commercially available for purchase and are being marketed to older adults. While direct evidence that game-based interventions can meaningfully improve cognition (i.e., result in cognitive improvements that prolong functional independence) is limited at this time, it is likely that interest in "brain fitness" games will continue to be popular. It will be especially interesting to observe longitudinal changes as younger gamers become older gamers (do game preferences change?), and to observe whether frequent gameplay in young adulthood and afterward is associated with less steep cognitive decline. In addition to cognitive abilities, there is also preliminary evidence that digital gameplay among older adults is associated with higher levels of well-being (Allaire et al., 2013). Additional research is required, however, to establish a causal relationship between gameplay and increased levels of well-being as a number of plausible non-causal relationships might explain this association.

Of particular interest with respect to current research on gaming and cognition is the general tendency of older adults to dislike the games which have been associated with the greatest benefits to cognition (fast-paced action games). This may present challenges for game-based interventions intended to improve cognition (Boot, Champion et al., 2013). McLaughlin, Gandy, Allaire, and Whitlock (2012) reviewed a number of factors that may discourage older adults from engaging in digital gameplay. Barriers to gameplay included usability issues arising from games and gaming devices not designed with the physical and cognitive abilities of older adults in mind and a belief by older adults that they cannot or should not be playing video games due to their age. However, McLaughlin et al. (2012) point out that good design and sufficient training may be able to overcome these barriers, allowing older adults to access the potential cognitive benefits of games as well as benefit from meaningful social interactions which video games can facilitate.

Less controversial is the connection between physical activity and improved physical, mental, and even cognitive health (Voss, Nagamatsu, Liu-Ambrose, & Kramer, 2011). Exergames incorporate physical motion into game play (e.g., the balance board of Nintendo Wii, Kinect motion sensor of Xbox) and represent a growing trend in the gaming industry. While research on the benefits of exergaming is still in its very early stages, preliminary evidence supports that exergame interventions with older adults are feasible, with promising cognitive and physical benefits (Bleakley et al., 2015; Larsen, Schou, Lund, & Langberg, 2013). There is also potential for these games to be used to promote motor, balance, and injury rehabilitation (Pessoa, Coutinho, Pereira, Ribeiro, & Nardi, 2014). However, as with any line of new research on an emerging technology, there are still many questions to be answered regarding the efficiency and effectiveness of exergaming interventions compared to more traditional interventions.

Since the release of Pong in 1972 (with the first home version being released in 1975), we've witnessed an extremely rapid increase in the sophistication of digital games and a rapid proliferation of this technology among the public. There is little reason to doubt that these two trends will continue. Next we turn from digital gaming technology to another rapidly expanding communication technology: SNSs.

Communication

Spurred by US military investment in computer networking (to allow communication paths to persist when parts of the communication infrastructure might be destroyed in war or natural disasters), the rise of computer-to-computer communication protocols, particularly TCP/IP and Ethernet standards helped develop early networks such as ARPANET followed by non-military networks such as Bitnet. As local and national networks merged, the Internet emerged as a world-wide network for communication. The development of protocols such as HTML for displaying information in a common format across different computer systems permitted scientists to exchange information efficiently, and quickly led to commercial development of the world-wide web.

Although e-mail messaging was the main way to communicate on Bitnet, other instant messaging protocols were in evidence early in computer networking (for communication in real time among multiple users of a single computer system), and became popularized through bulletin board systems and specialized software that could communicate across different computer platforms using a mix of closed then open standards for transmitting information. As bandwidth grew for Internet connectivity, voice (voice over IP) and video capabilities became available to computer users with broadband connections to the Internet. Streaming technologies also developed to permit broadcast of voice and video to multiple end users. Real-time communication became one of the more valuable features of the Internet.

However, just as in the case of initial consumer computer adoption, older adult cohorts lagged other population segments as users. But for communication technology, there seems to be less of a concern with motivation as a barrier. If anything, declining mobility with age makes remote communication particularly important. At present, of the many forms of communication available for those age 65+ in the United States who report using the Internet, e-mail takes priority: 87% report using e-mail, with 46% receiving or sending e-mail on a typical day (Purcell, 2011).

SOCIAL NETWORKING AS A NEWLY EMERGING COMMUNICATIONS TECHNOLOGY

We are observing a trend for diversification in the ways that individuals communicate through technology, with younger adults shifting away from more traditional communication technology such as e-mail to SNSs (e.g., Facebook, Twitter, Instagram, Pinterest, LinkedIn, and Google+). With SNSs like Facebook reporting over a billion users in 2013 it is likely that SNSs will continue to play a large role in facilitating communications and information gathering in the future. Recent data show that 73% of online adults use an SNS (Duggan & Smith, 2013). Yet, like many other forms of ICT, older adults have been relatively slow to adopt SNSs and participation in SNSs lags substantially compared to younger cohorts.

In 2013, 45% of older adult internet users (65+) participated in the Facebook SNSs compared to 84% of 18–29-year-old internet users and 71% of all internet users (Duggan & Smith, 2013). Although older adult internet users are disproportionately less likely to use SNSs compared to younger adults, social network use among this population is on the rise (compare the 43% use in 2013 to the less than 10% of reported SNSs use before 2009: Brenner & Smith, 2013). However, SNS use still represents a substantial digital divide between younger and older adults (57% of 65+ internet users do not use these sites *in addition* to the 44% of older adults who do not use the internet at all). Additionally, it is not clear whether adoption is driving the increase in older adults' use of SNSs, or whether younger cohorts of SNS users are aging into older age categories. Interestingly, the reported motivation for use differed between younger adults and older adults, with older adults being motivated by a desire to keep in touch with family, and younger adults being more motivated by a desire to interact with friends.

Benefits of SNS Use?

The opportunity for social interactions is clearly a part of successful longevity. Social engagement has been linked to greater well-being, higher cognitive functioning, and reduced risk of dementia in old age, while feelings of isolation have been associated with steeper cognitive decline (see Hertzog, Kramer, Wilson, & Lindenberger, 2008, for review). Social isolation has also been linked to poorer health outcomes, increased depression, and increased risk of mortality (Steptoe, Shankar, Demakakos, & Wardle, 2013). Given these potential benefits, SNSs may serve as promising means for older adults to engage in social interactions with friends and family members. This may be especially true for the 29% of older adults who live alone in the United States and may be at risk for social isolation as a result. Currently, there have been few rigorous systematic studies on whether social interactions occurring through SNSs might be associated with the same benefits as face-to-face social interactions. This line of research is still in its infancy, and there is a need for both correlational research to explore potential effects of using SNSs and experimental research to confirm causal relationships between SNSs and improvements on psychosocial outcome measures. Although benefits are relatively clear for communication technologies we now turn to specific barriers to ICT adoption that may explain non-use by seniors.

BARRIERS TO TECHNOLOGY ADOPTION BY SENIORS

Perceived costs and benefits dominate decision-making for technology adoption in both younger and older individuals (Davis, 1989; Morris & Venkatesh, 2000). For older adults in particular, on the cost side, financial (Carpenter & Buday, 2006) and cognitive costs (Czaja et al., 2006) have been shown to be salient predictors, as have self-efficacy beliefs (Czaja et al., 2006). Further, poor technology design that fails to account for age-related changes in perceptual and psychomotor abilities can also increase perceived costs for adoption. We also want to point to concerns about privacy/confidentiality as a barrier that may be particularly problematic for health technology adoption.

Financial Cost

Pensioners on fixed incomes may not have the economic resources to adopt a technology product, such as a tablet or smartphone, even if it is perceived as being beneficial. Mobile phones are important in part because texting, a form of instant messaging, has become very popular for communication in younger cohorts (social networking) and smartphones are also useful for gaming. Smartphones are now becoming a critical tool for accessing the Internet, particularly for racial minorities such as Blacks and Hispanics in the United States, who showed higher smartphone ownership than the majority group (64% Black, non-Hispanic, 60% Hispanic, 53% White, non-Hispanic: Smith, 2013). Other countries have shown strong age trends for accessing the Internet through mobile devices (portable computer, handheld device). Seybert (2012) found that 58% of those age 16–24, 36% of those age 25–54, and 12% of those age 55–74 accessed the Internet from a mobile device. Financial barriers to ownership may be surmounted with financing plans that enable smartphones to serve as both primary telephonic communication devices and Internet access devices.

Studies with representative samples from the population have shown that ITC product use is strongly associated with income as well as age, as seen in Figure 20.4 for smartphones.

Cognitive Cost

Cognitive cost refers to the difficulties in problem solving (e.g., troubleshooting) how to use a complex, intelligent device. Czaja et al. (2006), using a large, diverse, cross-sectional sample aged 18–91 years, showed in structural equation modeling that composite measures of cognition, such as fluid ability and crystallized

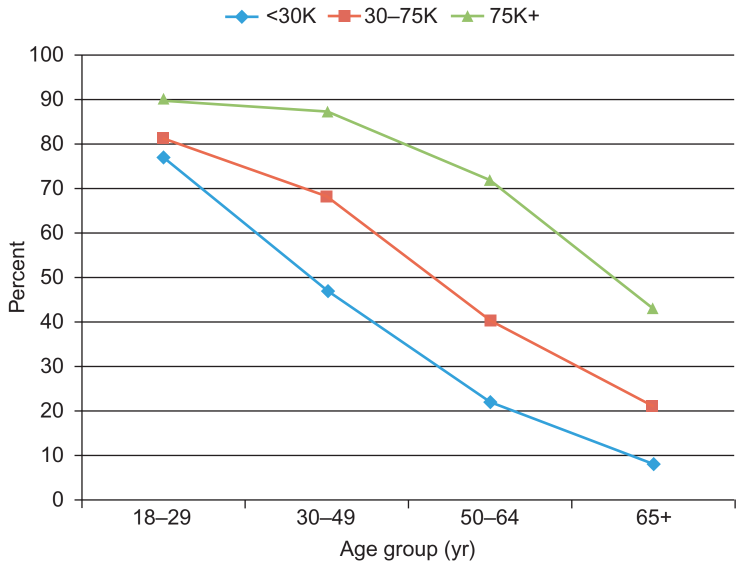

FIGURE 20.4 US smartphone ownership in 2013 by age and income. *Data from Smith (2013).*

ability, predicted technology use, breadth of computer use, and breadth of Internet use independently of other significant factors such as age, education, attitudes toward computers, and self-efficacy beliefs. Similarly, a study using a representative sample of midlife Americans (age 32–84) showed a significant relationship (beta = 0.286) between computer use and cognition (memory, speed, and executive functioning measures) controlling for age, education, gender, gender × computer use, and health status (Tun & Lachman, 2010). A recent study (Elliot, Mooney, Douthit, & Lynch, 2013) using a US nationally representative cross-sectional survey, the National Health and Aging Trends Study (NHATS), showed in a structural equation model that ICT use (combined variables measuring e-mail/text use and computer/internet use) was predicted by socioeconomic statue (SES), age, and cognitive function (clock test, immediate and delayed recall). A significant relationship between cognition measured in high school and Internet use at age 65 was also found in the Wisconsin longitudinal study (Freese, Rivas, & Hargittai, 2006). Although many a frustrated ITC device user would like to believe that problem-solving on their device leads to improved cognition, at least one clinical trial suggests that this is not the case. Slegers, van Boxtel, and Jolles (2009) assigned non-computer-using seniors interested in using a computer and the Internet to computer training or no training, then split the training group into a group given a computer system to use at home and a group with no computer provided, and also kept a no-interest control group for comparison. They found no differences in cognition across the four groups after a year of computer and Internet use. Thus, the most likely explanation is that those with poorer cognitive abilities are less willing or able to learn to use a complex device rather than that using a computer system improves general cognitive abilities. As Davis (1989) noted, perceived ease of use is a primary cost consideration for adoption; hence, the lower the actual or perceived cognitive ability, the greater the perceived cost is likely to be for technology devices.

Beliefs

Perceived cost may involve both technology-specific self-efficacy, beliefs that a product can be used successfully, and beliefs about time-to-learn cost. Czaja et al. (2006) and others (Reed, Doty, & May, 2005) have shown that older adults are less likely to exhibit high self-efficacy about technology use and that self-efficacy can be an important predictor of performance. Cognitive aging researchers have shown that older adults learn more slowly than younger adults (Salthouse, 2010). Rational models of behavior would predict that learning to use a product that is novel (e.g., novel ICT device) would be less appealing to older adults (compared to younger ones) if they realize that they are slower to learn new information. Best (2011) showed that older adults have a higher discount rate for learning investment than do younger adults. That is, they self-report being less willing to engage in additional learning to become more competent with a product (such as learning new features that take more time). However, for the discount rate for value of money, the reverse finding was obtained, with younger adults more reluctant than older adults to invest money (compared to time), suggesting that discounting is context-specific, not that older adults always show a higher discount rate.

Design Costs

Another cost within perceived ease of use is perceptual and psychomotor cost. Poorly designed miniaturized devices such as smartphones (using small screens with virtual keyboards) can tax basic cognitive, perceptual, and psychomotor activities more in older compared to younger adults (Boot, Nichols, Rogers, & Fisk, 2012; Fisk, Rogers, Charness, Czaja, & Sharit 2009) given normative age-related declines in those capabilities. Disability increases exponentially with age and impairments in vision, hearing, and psychomotor function have been shown to be negative predictors of technology use, although properly designed technology could be very helpful (Schulz, 2012). Using the NHATS sample, Gell, Rosenberg, Demiris, LaCroix, and Patel (2015) showed that even after controlling for demographic variables (age, sex race/ethnicity, education, marital status, and health variables) disability indicators were significant negative predictors of technology use (e-mail and Internet use), although pain and difficulties with breathing were associated with greater likelihood of technology use. This may be a case where a powerful motivator (uncontrolled pain and breathing difficulty) increases perceived usefulness and becomes a driver for technology adoption.

Privacy Concerns

Privacy loss can be considered a negative "facilitating condition" in a UTAUT model. In an age where technology makes it possible to monitor virtually all electronic communications (e.g., by the US National Security Agency), and where providing permission to be tracked is a condition for downloading and using many "free" smartphone applications, privacy concerns may be an important barrier to technology adoption. A 2009 survey (Hoofnagle, King, Li, & Turow, 2010) of Internet users showed few age differences across age bands for refusing to give information to a business thought to be unnecessary or too personal, or in whether there should be laws for right to know and right to delete stored information. However, older adults age 65+ were significantly more concerned about levels of privacy now compared to 5 years earlier (67% vs. 54% for 18–24 year olds). A Pew study in 2000 showed that adults age 18–29 were less likely to be "very concerned" about keeping their information private compared to those aged 50–64 (46% vs. 67%) and there was a clear age gradient in belief about online tracking with younger adults less likely to believe it to be harmful than those aged 30–49 and 50–64 (Fox, 2000).

A recent study with a representative US sample revealed that older adult Internet users show a complex pattern of concerns and behaviors with respect to privacy and security for online information (Rainie, Kiesler, Kang, & Madden, 2013). Despite the earlier finding of greater concern about privacy for their information, older adult Internet users in 2013 were less likely to take steps such as clearing and disabling cookies and browser history, or using temporary usernames and e-mail addresses than younger adults. They were less likely, however, to post material on the Internet using their real names or post with recognizable usernames than younger cohorts. Older adults were much less likely than younger adults to report having key information about themselves online such as photos, date of birth, group membership, videos, or their cell phone number. This combination of findings suggests that older users lack knowledge about how to safeguard privacy (e.g., use complex settings on browsers to block cookies, clear history) rather than lack the desire for privacy. Middle-aged adults, those aged 30–49, express the greatest eagerness to control access to personal information such as content of emails, websites browsed, etc.

In terms of actual harm suffered, by having e-mail or SNSs compromised, or being stalked or harassed, young adults report the greatest incidence, except for having had important information stolen such as a credit card, bank information, or an SNS, where those age 30–49 report the highest frequency. Lower income was also a predictor of harm suffered.

With the requirement to cede privacy to participate in some aspects of modern technological life (e.g., being tracked, providing phone and e-mail contact), people must balance costs and benefits, and there is some evidence that older adults weight benefits more highly (Melenhorst, Rogers, & Bouwhuis, 2006). The salience of benefits can be boosted by functional impairments. The more disabled, the more willing older adults may be to accept technology that lowers privacy/confidentiality (such as aspects of health status) if they believe the technology will contribute to independence and quality of life (Beach et al., 2009). This result points to the critical role that motivational factors play in adoption.

TECHNOLOGY AS A FACTOR FOR SUCCESSFUL LONGEVITY

One reason for being concerned with the cohort lags in technology adoption is that older adults may miss out on opportunities to fully participate in society and also to have technology augment or substitute for declining abilities (e.g., memory: Charness, Best, & Souders, 2012) and support quality of life (Schulz, 2012). We next outline three examples where critical information or services have become available mainly through ICT access: travel, government services, and home health care.

Travel tickets used to be booked almost exclusively through travel agents. In much of the developed world, train tickets are most easily purchased through automated kiosk systems (or via the Internet) and there may be added cost for a purchase involving a human agent. In the United States there is a surcharge levied by most airlines if a consumer books an airline ticket with a human instead of on the Internet. As shown earlier (Figure 20.1), more than 40% of older Americans do not use the Internet and so either must pay higher prices for tickets or find others to book their fares (e.g., family members or friends). Not surprisingly, a Spanish study showed that older adults were more likely to use human check-in for flights versus Internet or airport kiosk check-in (Castillo-Manzano & López-Valpuesta, 2013). This trend to encouraging consumers to substitute their labor for employee labor will likely intensify (e.g., increased deployment of automated check-out kiosks in retail stores) and older adults may suffer, particularly those with limited financial resources.

A second critical area for older workers and retired adults is interacting with government services. The push to improve efficiency, by substituting technology for human responders, makes it increasingly time-consuming to apply for and to access services through routes other than the Internet. This is occurring for everything from tax advice to unemployment benefits to health care benefits. One example is that those seeking tax advice from the Internal Revenue Service (IRS) in the United States by telephone face at least a 20-min wait for service and the IRS estimated that 39% of calls in 2013 would go unanswered: http://www.taxpayeradvocate.irs.gov/userfiles/file/2013-Annual-Report-to-Congress-Executive-Summary.pdf. Those without Internet literacy skills risk being left behind and will face increased costs to access services.

A third area where ICT is becoming critical is in health care, through telemedicine/telehealth (Charness, Demiris, & Krupinski, 2011). ICT can improve access to health care and improve outcomes as a large UK randomized clinical trial has shown (Steventon et al., 2012). Rather than relying on patients visiting clinics or hospitals, health care providers are migrating services into homes. Chronic conditions which disproportionately affect older adults (e.g., arthritis, hypertension/heart disease, diabetes, cancer) can be monitored remotely. Remote telecare devices, such as videoconferencing systems, weight scales, pulse-ox monitors, blood glucose meters, and blood pressure devices, can communicate with health care professionals to provide continuous monitoring of health conditions via home Internet connections or through cellular network connections. Such systems are reaching reasonable levels of reliability (Charness, Fox, Papadopoulos, & Crump, 2013). However, telehealth systems can make demands on user capabilities that are typically impaired by age, for instance, requiring skillful psychomotor interaction (e.g., for battery maintenance). Health applications on smartphones and tablets can also tax older adult perceptual and cognitive capabilities. To the extent that seniors are not able to take advantage of such advances in health care they may become disadvantaged in achieving successful longevity.

CONCLUSIONS

The current generations of older adults lag younger cohorts significantly in the use of recent ICT resources, particularly the use of the Internet and features such as social networking and digital gaming. One can argue, based on surveys of non-users, that such activities may evoke little interest or have little value for older adults. As the research literature reminds us, some of these activities can promote improvements in cognition (gaming) and social integration (SNS).

So, why are older individuals less likely to engage in these activities? Theories of ICT adoption stress that a potential user perceives significant benefit (relative to cost) and perceives low barriers to entry (perceived ease of use). Learning cost is certainly an age-dependent barrier and theories about lifespan changes in motivation to learn would predict diminished interest in learning to use ICT, such as selective optimization with compensation (Baltes & Baltes, 1990) and socioemotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999). Better training support for ICT learning is going to be a critical feature for promoting adoption (Czaja & Sharit, 2012). Better design of hardware and software interfaces is critical too (Fisk et al., 2009).

Current theories of ICT adoption are more frameworks than theories in the sense that they have difficulty predicting (post-dicting) technology adoption without first (retrospectively) assessing someone's motivational and cognitive state with lengthy surveys. Having shorter instruments to assess user capabilities can help (Boot, Charness et al., 2015). The literature has identified many potential mediators and moderators for generally robust predictors such as perceived usefulness and perceived ease of use, with privacy a potentially important one for ICT adoption in health care situations. One approach to address this concern is to conduct applied studies such as interventions that build multiple technology applications based on different theoretical frameworks, looking for differential impact (King, Hekler, Grieco, Winter, & Sheats, 2013).

The ultimate test of a good theory is that it makes predictions that are borne out in real-world settings. The psychology of aging provides considerable data about older adult capabilities (Verhaeghen, 2013) that can provide design guidelines for ICT (Fisk et al., 2009). As Birren and Renner (1977) pointed out in the first *Handbook of the Psychology of Aging*, chronological age is a proxy variable for other causal variables that needs to be replaced. For example, the predictive value of chronological age for tasks like information seeking on the Internet by older adults can sometimes be totally subsumed by other variables, such as cognitive abilities and knowledge (Sharit, Hernández, Czaja, & Pirolli, 2009). One goal for theories of ICT adoption should be to replace age with better predictors, as seen in UTAUT frameworks. Another is to provide quantitative theories that can predict which of two potential technology designs leads to better performance (Jastrzembski & Charness, 2007). Such knowledge should help designers of technology products (and training and support packages) to provide greater benefit to older adult users.

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