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Envisioning the Future for Older Adults: Autonomy, Health, Well-being, and Social Connectedness with Technology Support

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Abstract

Envisioning the future of older adults of 2050 is a challenging task given the heterogeneity of the older adult population. We consider primarily the domains of home, health, and social participation for individuals over age 65 and the potential role of information, communication, and robotic technology for enhanced independence, maintenance of autonomy, and enriched quality of life. We develop several scenarios to illustrate the diversity of circumstances, health, and living situations for older adults in the future. We discuss possible negative outcomes resulting from the proliferation of technology, including increased social isolation and a widening digital divide. However, we focus primarily on envisioning desired situations wherein older adults have autonomy and independence; are easily able to manage their health and wellness needs; have rich and rewarding opportunities for social connectedness, personal growth, continued life purpose, and overall high quality of life. To attain this future, we must be acting now: designing the technology with involvement by today's older adults who represent the needs and capabilities of tomorrow's older adults; developing the necessary infrastructure to support widespread availability and deployment of these technologies; and supporting the integration of technology into people's lives at younger ages with adaptive functionality to support changing needs and preferences.

Keywords

Older adults; technology; health; social connectedness; telepresence

1. Envisioning the Future for Older Adults

Typically, an 'older adult' is defined as over age 65 (Fisk et al., 2009). The number of people living to 100 is increasing (U.S. Census Bureau, 2010) so let us assume that our target population under consideration is between the ages of 65 and 100. That means that if we want to think about the lives of older adults in the year 2050, we are concerned with the individuals who are currently between the ages of 30 and 65. In some respects, 35 years hence seems soon and we might imagine that the changes would be minimal. But if we look

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backwards 35 years ago the changes that have occurred since 1980 are quite remarkable, especially with respect to technology capabilities.

Our objective is to envision the future of older adults with special consideration for facilitation of their autonomy, health, well-being, and social connectedness. Given the likelihood of continued technology advancements, we focus on the role of technology in supporting these goals, primarily information, computer, and robotic technology. To that end, we first consider: the characteristics of older adults in 2050; their needs and goals; and changes in the healthcare system. We then develop scenarios to represent a range of situations in which older individuals will live as well as their needs, capabilities, and limitations. With all of these considerations in mind, we discuss the necessary steps required to make these futures real.

2. Characteristics Older Adults of 2050

Society is getting older, and this trend can be seen worldwide. Projections are that the proportion of older adults in the world population is going to rise substantially in the next several decades, representing 21.1% by 2050 (United Nations, 2014). Thus the sheer number of people in this age group will grow, making it imperative for designers to consider this growing demographic. There will be increased numbers of older consumers of technology with unique demands for services and products as well as needs for support systems and caregivers.

Who are the older adults of 2050? On many dimensions, future older adults will be similar to today. They will want to remain independent as long as possible. Many (currently 30%) will live *alone* in their own home and most will be managing multiple chronic health conditions with up to 40% having serious disabling conditions (Mitzner et al., 2014). There will be more individuals aging with pre-existing disabilities due to vision, hearing, and mobility impairments; for example, in the U.S., 29.5 million individuals aged 21–64 are growing older with a pre-existing disability (U.S. Census Bureau, 2012). They may need assistance with Activities of Daily Living (ADLs, such as bathing, toileting), Instrumental Activities of Daily Living (IADLs, such as preparing meals, managing medications), and Enhanced Activities of Daily Living (EADLs, such as social communication, new learning). They will experience age-related changes in motor, perceptual, and cognitive capabilities (Fisk et al., 2009). Although they will have experience with many technologies, there will be new developments that they will have to learn and incorporate into their daily routines to fully participate in society.

Some differences in 2050 – the number of individuals over the age of 65 will almost double (United Nations, 2008). Many will have an active aging mindset; their approach to healthcare will be participatory; they will want autonomy, and will have a health and longevity focus. Many will remain in the workforce (Pew, 2014) perhaps for financial reasons, such as reductions in (or the possible absence of) social security and extended lifespans requiring greater retirement savings. Given continued migratory patterns, family members will likely live long-distance. For those who need caregiving, professional options may be limited due to financial constraints and healthcare workforce shortages. Thus, for

these individuals, risk for social isolation may increase, which evidence suggests will have negative health impacts (Holt-Lunstad et al., 2010). Technology capabilities will continue to advance, potentially providing support for all of these activities. However, just as today's technology does not reach its potential to support older adults because of low adoption rates, future technologies may also not fully reach their potential if they do not meet the needs and capabilities of older adult users.

Technology itself could lead to a trajectory of isolation for older adults. Given that older adults are not typically early adopters of new technologies, many technology developers have ignored their demographic in terms of meeting needs and capabilities. If this trend were to continue, new technologies that are integral to health and well-being could be inaccessible to older adults. Further compounding these issues is the growing class divide. The wealth gap will likely continue to grow. The benefits of technology may not be accessible to the poor. Older adults are likely to be overrepresented in the lowest income levels given aforementioned reductions in social security and extended lifespans requiring greater retirement savings. This divide could lead to increased social isolation for older adults and also reduced access to society in general, especially as more services rely on technology.

To avoid these negative possible outcomes, changes need to be made now. Designers need to understand the fundamentals of aging and consider age-related changes at the start of the design process. In addition, older adults should be included early on in the design process to ensure technologies are easy to use and that they are perceived as useful. Although future older adult cohorts may be positively disposed toward the idea of using new technology, new is always new. It is not possible to foresee what the future will bring in terms of technology development. Thus, it is important to keep in mind that experience with today's technology may not transfer to use of tomorrow's technology.

Furthermore, when making predictions about future older adults, it is important to realize that little is known about how demographics explicitly play a role in technology adoption. For example, socio-economic status (SES) is most often conceptualized as the social standing or class of an individual group (thus, related to resources, privilege, power, control), measured as a combination of income, education, and occupation (American Psychological Association, 2013). Although education level and income level have been shown to be positive predictors of technology use (Czaja & Sharit, 1998; Melenhorst et al., 2006; Zickuhr & Smith, 2012), the government statistics do not necessarily investigate in depth the effect of other SES related variables (e.g., occupation, resources) on technology adoption. Furthermore, older adults of tomorrow will be more diverse, with an estimated 24% of older adults in 2020 to be minorities (Administration on Aging, 2011). As certain technologies have become more affordable and prevalent, such as mobile phones, there is some indication that there are racial and cultural differences in adoption and use (Pew Research Center, 2015). These adoption differences could trigger a more segregated future despite the increase of the minority population. For example, in today's world this could equate to one cultural group predominantly using a smart phone and another using a standard mobile phone. These adoption differences could impact which services are accessible to different cultural groups. However, little research has investigated the degree to which ethnicity and culture will influence technology use and acceptance.

3. Needs and Goals

As Americans age, many want to remain as independent as possible while remaining in their homes (AARP, 2010), whether that be a single family home, an apartment, or in a senior living community. To lead independent and healthy lives in their own homes, people must be able to perform a wide range of tasks related to daily living including self-maintenance and instrumental activities of daily living (Lawton, 1990). Self-maintenance activities of daily living (ADLs) are essential to maintaining independence and include the ability to toilet, feed, dress, groom, bathe, and ambulate. Instrumental activities of daily living (IADLs) are usually more cognitively demanding and include the ability to successfully use the telephone; shop; prepare food; do the housekeeping and laundry; manage medications and finances; and use transportation.

About 2.2 million older adults require assistance with IADL tasks, such as cooking, shopping, or going outside of their house (U.S. Department of Health and Human Services, 1998). Moreover, approximately 37% of adults 65 and older reported having a severe disability (e.g., three or more ADL dependencies or severe cognitive impairment), ranging from difficulty in hearing, vision, and cognition to difficulty with ambulation, self-care, and independent living (Administration on Aging, 2009). Furthermore, the number of people reporting a severe disability increases to 56% for adults over 80 years of age (Administration on Aging, 2009). Today, some needs for assistance can be met where older adults choose to live, but other needs may necessitate older adults' relocation to a long-term care residence.

Besides sustaining a situation of independence and autonomy, personal growth and development are important aspects of a meaningful life. Activities aimed at life enrichment and self-fulfillment are critical aspects of successful aging (Rowe & Kahn, 1998). Examples of such activities are reading, keeping a scrapbook of grandchildren, watching movies, experimenting with recipes, or learning computer skills. Personal growth activities, including willingness to accept new challenges and engage in lifelong learning, have been termed *enhanced* activities of daily living, or EADLs (Rogers et al., 1998). EADLs primarily aim at personal enrichment, self-fulfillment, and pleasure. In addition, they imply the adjustment to changes, such as keeping up with technological and communicative developments (e.g., Internet, smart phones, telepresence robots).

Social connectedness is a key contributor to overall quality of life and social activities are important for health and well-being. In fact, an AARP (2010) study found that older adults may choose to live near a religious or other social organization to maximize opportunities for social interactions. Thus, social connectedness with family, friends, and communities will likely remain important goals for older adults to enhance life satisfaction.

4. The Changing Healthcare System

In industrialized societies a shift is occurring in the medical model toward health self-management. In the traditional model of the patient-physician relationship, doctors and other health professionals were the experts and the patients' role did not extend much beyond reporting their symptoms and following the "orders" set by health professionals. However,

this relationship has moved toward a patient-professional partnership, in which patients play a more substantial role in their care. A patient-professional partnership involves collaborative care, in which the healthcare provider and patient make decisions together, and is characterized by more education about self-management. Whereas traditionally the provider was usually a physician who educated patients by offering information and technical skills, now a broader range of healthcare professionals are providing self-management education, which includes teaching problem solving skills (Bodenheimer et al., 2002).

An increase in involvement from the patient as compared to the traditional physician-centered medical model has many benefits including reduced costs (Oshima et al., 2013), fewer hospital days (Leveille et al., 1998), reduced hospitalizations (Lorig et al., 1999), reduced physician and emergency department visits (Lorig et al., 2001), and is associated with positive health outcomes (Lin et al., 2012). The potential benefits are reflected by recent movements to empower patients with health management skills. However, the outcomes and relative benefits of such systems have not been proven and human factors design issues remain a concern for many systems (for a review see Czaja et al., 2012).

Health self-management may involve adherence to a diet, exercise regimen, and/or medication schedule, as well as coordination of a care network and use of medical technologies (e.g., activity monitor, blood glucose meter, blood pressure monitor). Self-management can be more or less complex depending on the individual and may involve management of multiple wellness goals or chronic conditions. Difficulties with chronic-disease self-management include medication management, use of complex measuring devices, and limited self-efficacy for some patients (Lake & Staiger, 2010).

Adults 65 and older are most impacted by the shift toward self-management in healthcare. On average, 80% of adults aged 65+ have at least one chronic condition and 50% have at least two (CDC, 2009). The most common are hypertension, arthritis, heart disease, cancer, diabetes, asthma, stroke, and bronchitis/emphysema (Federal Interagency Forum, 2010). People are becoming more aware of the importance of remaining as healthy as possible for as long as possible (Egan et al., 2010). Therefore, health self-management is now more applicable for middle-aged adults (e.g., Weiss & Lang, 2012).

Although we may wish that the prevalence of these chronic conditions will diminish by the year 2050, that is not likely – given that most focus today is on management rather than prevention individuals currently over age 30 are likely to develop similar rates of arthritis, heart disease, cancer, etc. Moreover, projections are that rates of diabetes will increase in the future, especially for older adults (Boyle et al., 2001).

Managing wellness and illness imposes a multitude of demands. Self-management includes the processes of goal selection, information collection and interpretation, decision-making, and action (Bourbeau, 2008). These processes can impose substantial cognitive load on patients, who may also struggle with lack of understanding of disease characteristics and necessary self-management behaviors.

Unless there are radical changes in disease management and prevention – which there very well may be – tomorrow's older adults will have chronic healthcare conditions that require support, care, and monitoring. Moreover, the expectations on the patient may continue to increase, requiring more and more support for the individual at home.

5. Envisioning Future Scenarios

One of our goals in thinking about the lives of older adults in 2050 is to envision future scenarios, with a focus on preferred scenarios and the potential ideal situations (Datar, 1995). However, this is a challenge in part because, as Sarder (2010) expressed in his first law of future studies: "*Almost all the problems we face nowadays are complex, interconnected, contradictory, located in an uncertain environment and embedded in landscapes that are rapidly changing*" (p. 183). Envisioning scenarios for the future of older adults is no different, and in fact quite epitomizes this law. Moreover, this context also conforms to Sarder's (2010) second law, relating to the idea of MAD – mutually assured diversity and the importance of embracing that diversity; in short, "…*there are different knowledge systems, different histories, different forms of living, different criteria of accomplishment and different ways of adjusting to change* (p. 183). This is certainly true for the community at large of older adults.

The older adult segment of the population is heterogeneous, in part due to a lifetime of experiences, illnesses, environmental exposure, education, and so forth. As such, the needs, capabilities, and limitations of particular individuals vary widely. Below we envision three scenarios to reflect possible contexts in which older adults of the future will live. We have focused primarily on how social and health needs could be supported through information, computer, and robotic technology. Our scenario approach is driven by the project goal of exploration; that is, combining intuitive and formal aspects; with a focus on representing the complexity of the situations for the individuals within them (Van Notten, Rotmans, Van Asselt, & Rothman, 2003).

5.1. Ronnie – 72-year-old woman

Ronnie lives alone in a high-rise apartment building. She primarily needs assistance with IADLs (meal preparation, medication reminders) and EADLs. She just had foot surgery so she also has some temporary mobility challenges. Her family lives 500 miles away and her current ability to leave her apartment is reduced. She is less able to participate in her usual exercise class or meet friends. However, technological advances enable her to: actively engage with family and friends; meet her healthcare and nutritional needs; and ambulate easily around the apartment to tend to her personal needs. These supports are seamlessly integrated into her apartment, easy to use, and not intrusive:

- Her personal robot, GOBI, can order food online, based on Ronnie's preferences and dietary restrictions. GOBI can then prepare meals on demand depending on Ronnie's schedule for a particular day. GOBI ensures safety of food preparation, proper storage of leftovers, and cleans up after the meal. While Ronnie eats, she is connected via a telepresence system to her daughter's home where her family is also having dinner, therefore providing a community dining experience.

- GOBI reminds Ronnie to take her medications and brings her the required food and/or water. GOBI records when the medications were taken, side effects experienced, how she feels, and her vital signs. This information is incorporated into Ronnie's electronic health record, which is updated and accessible to her healthcare team as well as to Ronnie to identify patterns of medication effects.
- Her exercise trainer/physical therapist supervises and monitors her exercise routine using a telepresence system attached to a device that accurately and precisely captures Ronnie's movements.
- Her healthcare provider makes house calls via a telepresence system to monitor her overall health and examine her foot to ensure her surgical wound is healing well.
- Ronnie uses a robotic walker in the apartment that helps her get out of bed or up from a chair, is small enough to fit into her bathroom, and is safe to use in the shower. The walker has capabilities to encourage her to walk independently when the environment is safe; this reduces overreliance on the technology and encourages her to remain active with minimal risk.
- When traveling outside of her apartment, Ronnie relies on a hover scooter because her building has steps to the sidewalk outside. The scooter communicates wirelessly with the elevator which improves her maneuverability to the lobby of her building (or to other floors to visit her friends). This scooter also provides her with easier access to shopping centers and medical facilities, as well as her church and volunteering locations.

This scenario illustrates the potential for technology to support the diverse needs of future older adults. This would be a predictable scenario given the current trajectory of technology development. However, for this to be accomplished there remain important research and development efforts. Some of the groundwork has been accomplished but many design, training, deployment, and policy issues are yet to be addressed.

5.2. Dave – 78 year old man

Dave lives alone in remote rural cabin in the northwest. He cannot drive due to vision limitations and the weather conditions often prohibit others from coming to visit. As a result, he is rather isolated and has difficulty getting to appointments. He is in relatively good health but he does have a serious heart condition that requires continuous monitoring and periodic electrical stimulation.

- His transportation needs can be met in a variety of ways depending on the weather and his plans for the day. He can use a ride-share application to find out if any of his neighbors are going to town that week. Or he can reserve the community-shared autonomous car to take him on his errands.
- His telepresence system is a holograph that enables family members to visit "in person" throughout the day. The system transmits visual, auditory, olfactory, and haptic information.

- Physical therapists visit him every day via touch transmission technology that enables them to remotely provide physical therapy and rehabilitation exercises that require hands-on manipulation and guidance.
- His personal robot can perform medical procedures such as detecting heart rhythm irregularities and administering defibrillation in emergency situations.
- The robot determines the calibration of his heart medication (which sometimes changes weekly) and requests automatic delivery via drone.
- His everyday activities and physiological status are continually recorded and analyzed to predict functional changes and the need for technology interventions.
- Although Dave has some risk factors for depression, loneliness, and morbidity, he is not likely to suffer from these negative outcomes. His emotional state is assessed through voice detection during his telepresence conversations and evaluated for deviations from his personal norm. If a deviation occurs, a therapist will contact him to provide any needed support.
- Dave is actively involved in social networks where he can engage in cognitively stimulating activities through multiplayer games he plays with his college buddies. The games are designed to provide incrementally challenging levels to maintain and advance cognitive function.

This scenario is possible for the future but many more hurdles to be overcome before it would be realistic. There are technology challenges, insufficient knowledge of health trajectories, and the data analytic side is underdeveloped.

5.3. Carol and Jerry – married couple both in their mid-80s

Carol and Jerry live in a multi-generational community. They are both very healthy, having been lifelong exercisers. They adopted wellness management technologies in their 50s, which have helped them to maintain a beneficial level of exercise and a healthful diet. They have few chronic illnesses, partly from their healthy lifestyle and partly from medical advances. Neither of them take any medications. They are both still working, albeit part-time; Jerry in a management role in the police department where they rely on his many years of experience and Carol as a midwife. They are both also very active in their community as volunteers. Carol is the resident “Grandma” to the kindergarten and first grade classes. She also meets regularly with new moms and provides guidance and support based on her experiences raising six children. Jerry loves his position as a “storyteller” to the older high-school children, regaling them with tales of his Navy service during the war as well as his 25 years of experience as a police officer. Both Carol and Jerry are early adopters of new technologies, in part because they regularly engage with younger generations who show them the benefits and support their learning.

- The multi-generational community includes many opportunities for exercise, including classes in which robotic instructors can give customized instruction to each person for those who like to exercise in groups, and individual instruction for those who prefer to exercise alone.

- Carol uses telepresence systems to visit the homes of new mothers to provide advice. She can easily integrate instructional videos to illustrate childcare activities.
- Jerry does most of his work remotely – he is in charge of planning workforce distribution in the city and uses real-time data from satellites and advanced analytics to guide his decisions.
- To supplement Jerry's storytelling, a smart screen, presents photographs and videos that are relevant from a database of historical media.
- Carol and Jerry have virtual visits with their large family using holographic images integrated with embodied robotic telepresence technologies. Their children live in different parts of the world (hence different time zones) but time-lapse technology enables seemingly real-time dinner conversation.

This scenario requires technology changes as well as social changes. Development efforts will need to focus on capitalizing on the wisdom and knowledge of elders and ensuring that transgenerational living and learning opportunities are supported.

Across these possible scenarios there will be additional complexities that must be considered including the cost of technology and policy dictating financial responsibility (e.g., private pay, Medicare). These details will influence how much disparity is realized. Without policy to ensure equality in technological resources and supports, the wealth divide will dictate who receives needed supports. In these scenarios we have also focused on computer and robotic technology supports yet there is much research and innovation in smart homes and embedded technology that will likely also be part of the environmental context. There are advances in the healthcare industry that we have only minimally touched upon. Additional healthcare innovations include cognitive therapy technologies (e.g., cognitive "exercise" games, dementia treatments), chip implants, nanobots used in blood, 3-D printed biological materials, optogenetics, and digestible sensors.

6. Accomplishing the Goals (Making the Futures Real)

One clear value of a futures perspective is in the present. As was well-explained by Sarder (2010):

> *"…the real relevance of the discourse lies in the present. All futures activities … have a direct impact on the present: they can change peoples' perceptions, make them aware of dangers and opportunities ahead, motivate them to do specific things, force them to invent or innovate, encourage them to change and adjust, galvanise them into collective social action, paralyse them with fear, empower them, marginalise them, or tell them they and their cultures and belief systems are important or unimportant"* (p.184)

How then, do we use these scenarios to affect the now? One way is to think about the facilitators and barriers for the successful development and deployment of these technologies. These considerations can be organized into three general categories: technology characteristics, person characteristics, and contextual factors.

Good design of future technology is going to follow the same basic principles and processes for good design of any technology with which a human will interact. Identify the needs of the user, design in an iterative fashion to correct problems, follow good human factors principles, and involve the target user group from start (formative evaluation) to finish (summative evaluation).

What is important to recognize is that older adults represent a unique population in terms of their needs, preferences, experiences, and lifestyles. What is the best way to design systems, products, and environments for older adults? First, designers must understand the user population – that is, follow the maxim of know thy user. We do not mean to imply in any way that all older adults are the same. In fact, we emphasize the reality that older adults do not represent a homogeneous group. There are differences in rates of change, patterns of changes, life experiences, compensatory strategies, motivations, attitudes, and more. However, there are normative age-related changes that tend to occur and designers who understand these general patterns will develop systems that are more easily usable by older adults, and probably by other user populations as well. Involving older adults in the design process is a useful approach (Jones, Winegarden, & Rogers, 2009).

Second, the tools and techniques of human factors should be used to develop prototypes that can then be tested with representative users, doing representative tasks, in representative contexts (see Fisk et al., 2009, for more detail). Rather than starting from scratch, designers should be able to restrict the solution space for features of the design based on older adults' capabilities, needs, and preferences. Using this knowledge as a base to develop initial prototypes should yield more useful and usable technology but appropriate user testing is invaluable and very necessary for successful deployment.

Third, it is important to recognize the complexity of older adults' needs and wants; capabilities and limitations; attitudes and motivations, etc. Our scenarios illustrate the range of situations that older may find themselves in and designers must recognize the issues that will need to be considered, in terms of the characteristics of the human, the technology, the task itself, and the context of the interaction.

Lastly, and perhaps most challenging for all of the scenarios is integration. The need for integration arises in various ways: integrating mobile and home-based technologies; integrating wellness and chronic care; integrating information across sources; integrating people in care networks; and integrating technology into people's lives (without disrupting their activities).

7. Conclusion

When we think about the future for older adults we are in essence thinking about our own futures. We envision the situation where older adults have autonomy and independence; are easily ably to manage their health and wellness needs; have rich and rewarding opportunities for social connectedness, personal growth, continued life purpose, and overall high quality of life. To attain this future, we must be acting now: designing the technology with involvement by today's older adults who represent the needs and capabilities of tomorrow's

older adults; developing the necessary infrastructure to support widespread availability (e.g., policy) and deployment of these technologies; and supporting the integration of technology into people's lives at younger ages with adaptive functionality to support changing needs and preferences.

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Highlights

- We envision the future of older adults (over age 65) in the year 2050
- We consider home, health, work, leisure, and social participation
- We highlight the role of technology for independence, autonomy, and quality of life
- We develop scenarios to illustrate diversity of circumstances, health, living