Technologies for Aging Gracefully

Ronald M. Baecker
University of Toronto | ron@taglab.ca

Karyn Moffatt
McGill University | karyn.moffatt@utoronto.ca

Michael Massimi
University of Toronto | mikem@dgp.toronto.edu

We all know the world is aging. Yet the figures are staggering. The United Nations recently quantified the phenomenon as follows: Whereas 5.2 percent of the population was over 65 in the year 1950, this percentage is projected to grow to 15.9 percent in 2050, to 27.5 percent by 2150, and to 32.3 percent by 2300 [1].

The good news is modern medicine has made it possible for people to live longer. The bad news is most individuals who live a long life must combat sensory, motor, cognitive, and social challenges such as vision loss, poor hearing, mobility difficulties, memory loss, social isolation, and loneliness.

Technology by itself cannot solve these problems. Yet technology designed to empower older adults and to make them more capable, resourceful, and independent can help.

In response to this opportunity, in 2009 we formed the Technologies for Aging Gracefully lab (TAGlab). Our mission is to enable full participation in society by individuals with special needs—for example, people afflicted with Alzheimer's disease (AD), mild cognitive impairment (MCI), amnesia, aphasia, strokes, multiple sclerosis (MS), or vision loss—as well as normally aging senior citizens. We identify "sweet spots" where technology seems relevant to human need, and envision ways in which we could address a problem, then design, build, test, and, where possible, commercialize solutions. In other words, TAGlab conducts research for the journey through life (see also http://taglab.utoronto.ca/).

Technology development to improve the lives of senior citizens may appropriately be framed in terms of the psychologist Abraham Maslow's hierarchy of human needs (Figure 1). (TAGlab focuses on the top three levels, but we will describe projects at all five levels.)

Biological or *physiological* needs include oxygen, food, water, warmth, fitness, and health. *Safety* needs are to feel safe and to be free from real or perceived danger. *Love* or *social* needs encompass the need for affection and a sense of belonging to family and a circle of friends. *Esteem* needs include the need to feel satisfied, self-confident, and valuable; to engage in meaningful work and activities; and to continue personal development. *Self-actualization* refers to the need for a sense of vocation, a calling, or a cause. We will now give examples—both from our own work and that of others—to highlight promising technologies at each level of the hierarchy.

Physiological Needs

Two burgeoning examples of technology addressing physiological needs are health-information websites and health-support social media. The majority of Americans now use the Web to gather information about topics including diseases, treatments, alternative medicine, medications, doctors, hospitals, and health insurance [3]. Increasingly, on newsgroups, websites, and blogs, people are posting their own experiences and also commentaries about health or medical issues. These developments have the potential to enable senior citizens, as well as other members of society, to be more knowledgeable as they try to maintain a healthy lifestyle, and also to be better-educated consumers of healthcare. Challenges include being able to judge whether or not data that appears

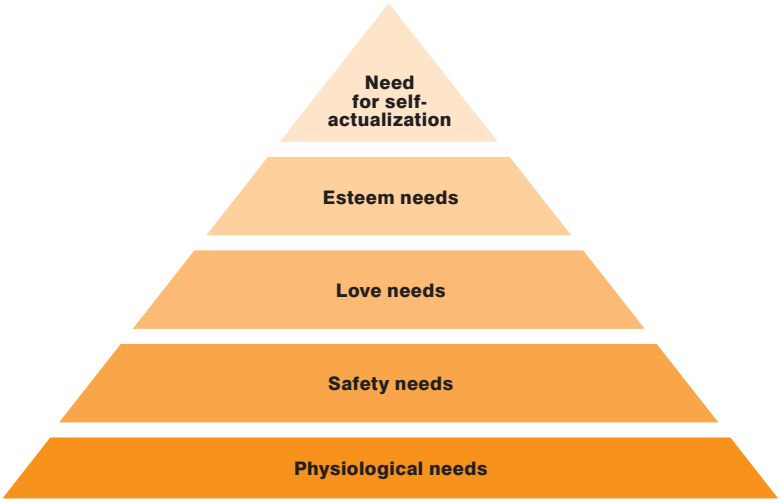
on the Web or on health blogs is valid, and knowing how to interpret and act on the data. Patients going to their doctors with pages of Internet printouts also pose new opportunities and challenges in the relationship between physicians and their patients.

Safety Needs

A major health concern of senior citizens is falling in the home, which has serious implications, including death. Many seniors use devices that allow them to signal to a monitoring service that he or she has fallen and cannot get up. Yet many forget to carry the devices or are unable to activate them. Current research (see, for example, [4]) is directed at developing artificially intelligent systems using consumer-grade cameras fitted with wide-angle lenses that automatically detect if a person within the field of view has fallen. Another thread of research in this level aims to use embedded assessment technologies to provide early detection and/or continuous monitoring of health conditions. For example, Ivorra, Daniels, and Rubinsky developed a wristwatch-size device that aims to detect changes in cognitive function through frequent, minimally obtrusive measurement of reaction time [5].

The Need for Love

Belonging is a fundamental human need. Technologies can provide mechanisms for social connection to augment the usual methods. They can connect family and friends with shared experiences that accommodate different roles and kinds of communication. For example, many grandparents now chat regularly with children and grandchildren using Skype.



▸ Figure 1. The Maslow Hierarchy of Human Needs [2].

Technology can bridge gaps across physical and social distance (such as a hesitation to interact in times of grief, loneliness, or declining health or mobility). Several TAGlab projects have therefore focused on strengthening interaction and bonds with community, friends, and family.

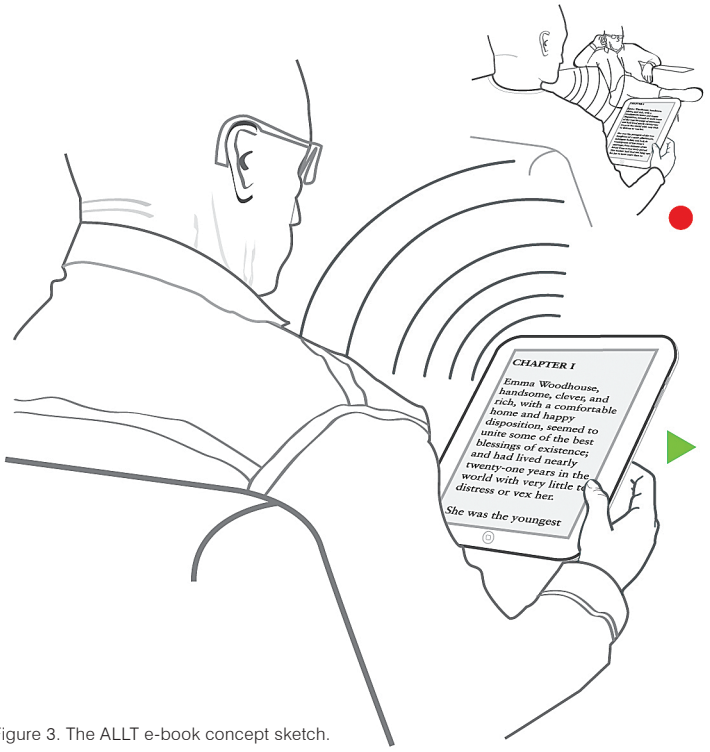
One aspect of social fulfillment is to have strong connections with one's peers. Within this theme, we developed a social gaming environment called Tabletalk Poker, and carried out an experiment studying the role of conversation in animating play and aiding learning by seniors [6].

For some individuals, participating in mutually reciprocal interactions can be challenging. Informed by a study of communication patterns and the needs of isolated individuals [7], we are developing and testing new versions of Families in Touch, a digital communicating picture frame and Web portal (Figure 2) [8]. Individuals who are isolated (e.g., because of chronic pain, long-term hospitalization, or 24/7 care responsibilities) signal a desire to hear from family with a single touch; relatives easily record video messages that soon appear in the frame.

Significant life events additionally affect our feelings of connection and our ability to connect with others. A recently completed Ph.D. thesis by the third author employed interviews and focus groups with people who are grieving to guide the design and testing of Besupp, a website for online peer-support bereavement groups. Recognizing that part of the journey through life involves loss and sorrow, this project seeks to help the bereaved feel a sense of normalcy and connection with others who have also experienced a loss. In this case, technology provides an ongoing and continually available option for commemorating a loved one and learning to cope with grief [9].

For many seniors, establishing and maintaining meaningful connections across generations is of great importance. While a postdoctoral fellow at TAGlab, the second author began a project to elicit design opportunities for linking grandparents and grandchildren [10]. Cross-generational pairs sometimes find it difficult

► Figure 2. The Families in Touch picture frame concept sketch.



► Figure 3. The ALLT e-book concept sketch.

to identify and sustain conversation topics of common interest. In face-to-face interactions, this challenge is commonly resolved by engaging in a shared activity, such as playing a game, collaborating on a project, or even watching a TV program. Unfortunately, current communication technologies, such as the telephone and email, do not readily support these kinds of activities. We are beginning to explore the design of shared online activities, especially around the theme of family history.

The Need for Esteem

The desire for independence develops at a young age and lasts a lifetime. Some of our projects focus on keeping older adults autonomous, and on empowering them to communicate for themselves, when aging, stroke, brain injury, or other impairments have made language problematic. Other projects seek to help seniors keep emotionally, mentally, and physically fit, in spite of cognitive or physical challenges and decline.

For example, Kent Fenwick developed a context-aware app called Friend Forecaster that employs information about one's social network to provide reminders of the names of people one might plausibly encounter in a particular location [11]. Following on from this project, we (led by Alex Levy and Aakash Sahney) have commercialized a context-aware cellphone app originally called Marco Polo and now called MyVoice (see http://myvoiceaac.com/) that uses location to suggest useful words and phrases to individuals with anomic aphasia, which often results from stroke, or to children with communication challenges.

We have also created two prototypes of an accessible large-

TAXONOMY OF RESEARCH

	Automatic Fall Detection	*Families in Touch*	*Friend Forecaster and MyVoice*	*ALLT*	*Tangra*	*Multimedia Bios*
Place in Maslow hierarchy	Safety	Love	Esteem	Esteem + love	Esteem	Self-actualization
Cognitive/social process	Physical well-being?	Social interaction	Recall of words and names	Reading, access to information	Cognition	Reminiscing
Participant population	(Frail) older adults	Socially isolated individuals	People with anomic aphasia	People with print disability	Older adults	Mid- or early-stage AD or MCI
Goal	Diagnostic	Assistive	Assistive + rehab	Assistive, possibly rehab and health-preserving	Diagnostic	Assistive + rehab
Users, usage	Individuals	Individuals + families + friends	Individuals	Individuals + families + friends	Individuals	Individuals + families
Design method	UCD	UCD	UCD	UCD	UCD	Participatory design + UCD
Technology	Smart cameras	Digital picture frames	Smartphones	e-books	Web portal	Multimedia on DVDs

▸ Table 1. A framework for the research described in this article.

print listening and talking e-book (ALLT), designed for people who have experienced vision loss or who are struggling with other obstacles to reading, such as motor challenges (Figure 3) [12]. A field trial of the effectiveness of this technology in supporting reading by oneself and reading together with family members is under way with an individual who has multiple sclerosis and her family.

Finally, we have developed and will soon release an open source Web portal called Tangra, which allows randomized controlled trials over the Internet of the effectiveness of new and sometimes prematurely hyped brain-fitness exercises and games [13].

Self-Actualization

Being able to draw upon your experiences is critical to lifelong learning, growth, the development of wisdom, and the pursuit of a calling or cause. Tools to help individuals regenerate and share memories of their lives help them to maintain dignity and a sense of self, despite memory loss or dementia. Several TAGlab projects have focused on enabling people to use visual digital media to reminisce and reflect upon past and recent experiences, which is key to maintaining one's identity and therefore supports the goal of self-actualization.

For example, we developed an effective method for creating digital multimedia biographies of individuals with AD and MCI, and tested its impact on those individuals and their family members. Viewing the media aided recall and reminiscence, brought much joy along with a few moments of sadness, stimulated conversation and engagement with family, and was valued by family and third-party caregivers [14].

Finally, we recently completed a systematic study of two methods of having AD- and MCI-afflicted individuals use automatically captured images from the Microsoft Research SenseCam "lifelogging" camera worn on their chest to aid their episodic memory of recent experiences, as well as to yield other psychosocial benefits [15].

Our Work in Context

Some of these projects address multiple themes. For example, ALLT enables families to read together, thereby strengthening a family's shared purpose, autonomy, and esteem.

All of these projects involve innovative software and systems design based on understanding needs, deriving requirements, and evaluating success through the use of methods from the social and behavioral sciences.

Technologies such as those described here may have different goals: diagnostic, assistive, rehabilitative, or health-preserving. Diagnostic technologies warn individuals, family members, caregivers, and care staff about

dangerous conditions. Assistive or prosthetic technologies substitute for some capability that is impaired, much as a crutch may be used after one breaks a leg. Rehabilitative systems are used to strengthen or revitalize an impaired capability. An example is working with a physiotherapist after one breaks a leg to enable walking without the crutch. The most ambitious goal for technology is to preserve health. An example is the vigorous commercial activity in the realm of brain-fitness exercise and game vendors, who claim that regular use of their software can slow mental aging, just as regular exercise delays physical decline.

These distinctions enable us to describe research in terms of a taxonomy, illustrated in Table 1.

Conclusion

We have learned much from our work to date. The challenges and opportunities for technology are about not just memory, cognition, and communication, but also identity, self-reliance, and self-worth. Beyond aiding individuals, the task is to support a system that includes people who have challenges along with their family members, caregivers, and clinicians (see [16]).

Although the research projects we have described assist users primarily in single tasks (such as reading or speaking), they can be situated more holistically. As the world's population continues to age, technology designers will benefit from viewing seniors not simply as users with singular impairments to human-computer interaction, but rather as human beings with rich and diverse sources of motivation, pride, and fulfillment. Creating technologies that allow seniors to remain active members of their family and community while pursuing their interests is just as important as improving interface-level mechanics.

Doing this successfully requires interaction professionals to work intensively with professionals in gerontology, neuropsychology, social work, speech/language pathology, nursing, and other disciplines; community groups; and, most important, older adults themselves. For, as we know, studying systems in use by real users doing real tasks in real environments is the key to inspired design.

Acknowledgements

We are thankful for financial support from NSERC, the GRAND Networks of Centres of Excellence of Canada, Microsoft Research, Google Research, the Alzheimer's Association, the University of Toronto Connaught Fund, and MyVoice Inc.; and for the excellent work of the many grad and undergrad students, research associates, and academic and clinical collaborators who have contributed to the research. We are especially grateful to the older adults who have graciously donated their time and energy to participate in our studies.

ENDNOTES:

1. United Nations Dept. of Economic and Social Affairs. *World Population to 2300*, Table 15. (2004).

2. Maslow, A.H. A theory of human motivation. *Psychological Review 50*, (1943), 370-396.

3. Fox, S. and Jones, S. The social life of health information. Pew Internet & American Life Project, 2009.

4. Belshaw, M., Taati, B., Snoek, J., and Mihailidis, A. Towards a single sensor passive solution for automated fall detection. *International Conference of the IEEE Engineering in Medicine and Biology Society* (Boston, MA). Aug.-Sep. 2011.

5. Ivorra, A., Daniels, C., and Rubinsky, B. Minimally obtrusive wearable device for continuous interactive cognitive and neuro-logical assessment. *Physiological Measurement 29,* 5 (2008), 543–554.

6. Shim, N., Baecker, R.M., Birnholtz, J., and Moffatt, K. TableTalk Poker: An online social gaming environment for seniors. *Proc. Future Play.* 2010, 98-104.

7. Benjamin, A., Birnholtz, J., Baecker, R.M., and Gromala, D. Impression management work: How seniors with chronic pain address disruptions in their interactions. *Proc. ACM CSCW 2012*, 799-808.

8. David, J., Benjamin, A., Baecker, R.M., Gromala, D., and Birnholtz, J. Living with pain, staying in touch: Exploring the communication needs of older adults with chronic pain. *Ext. Abs. ACM SIGCHI 2011*, 1219-1224.

9. Massimi, M. and Baecker, R.M. Dealing with death in design: Developing systems for the bereaved. *Proc. ACM SIGCHI 2011*, 1001-1010.

10. Moffatt, K., David, J., and Baecker, R.M. Connecting grandparents and grandchildren. To appear in *Connecting Families: The Impact of New Communication Technologies on Domestic Life.* C. Neustaedter, S. Harrison, and A. Sellen, eds. Springer, 2012, in press.

11. Fenwick, K., Massimi, M., Baecker, R.M., Black, S., Tonon, K., Munteanu, C., Rochon, E., and Ryan, D. Cell phone software aiding name recall. *Proc. ACM SIGCHI 2009,* 4279-4284.

12. Snelgrove, W.X. and Baecker, R.M. A system for the collaborative reading of digital books with the partially sighted. *Proc. BooksOnline'10.*

13.Pandeliev, V. and Baecker, R.M. A Framework for the evaluation of mental fitness games. *Proc. 6th Annual Games for Health Conference*. 2010.

14. Damianakis, T., Crete-Nishihata, M., Smith, K.L., Baecker, R.M, and Marziali, E. The psychosocial impacts of multimedia biographies on persons with cognitive impairments. *The Gerontologist 50,* (2009), 23-50.

15. Crete-Nishihata, M., Baecker, R.M., Massimi, M., Ptak, D., Campigotto, R., Kaufman, L.D., Brickman, A.M., Turner, G.R., Steinerman, J.R., and Black, S.E. Reconstructing the past: Personal memory technologies are not just personal and not just for memory. Special issue of *Human-Computer Interaction on Designing for Personal Memories*. 2012, to appear.

16. Wu, M., Birnholtz, J., Baecker, R.M., Richards, B., and Massimi, M. Collaborating to remember: A distributed cognition account of families coping with memory impairments. *Proc. ACM SIGCHI 2008,* 825-834.

ABOUT THE AUTHORS

Ronald M. Baecker is a professor of computer science, Bell Chair of Human-Computer Interaction, and also founder and director of TAGlab, at the University of Toronto.

Karyn Moffatt, recently associate director of TAGlab, is now assistant professor in the School of Information Studies at McGill University.

Michael Massimi, associate director of TAGlab, just completed his Ph.D. in computer science at the University of Toronto.

DOI: 10.1145/2168931.2168940