Living Longer

Using today's emerging technology to address issues related to aging in Canada in the year 2032

By
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Abstract

In April 2009, Canada's Special Senate Committee on Aging released its final report listing the issues affecting Older Adults (age 65 and over). This demographic will account for one quarter of Canada's population by the year 2032. The report indicates the need for further research on aging and promotes technology as a tool to address these issues. Using Rogers' theory of Diffusion of Innovations, Riley's theory of Structural Lag, Davis' Technology Acceptance Model and ethnographic research methods to observe trends in attitudinal shifts, this research paper explores the *adoption*, *affinity* and *application* of existing and emerging technology to address the issues related to aging of Canadian Older Adults in the year 2032.

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Dedication

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Canadians Are Living Longer.

"Each of us is aging." So begins "Healthy Aging in Canada" a discussion brief prepared by the Alder Group for the Federal, Provincial and Territorial (F/P/T) Committee of Officials (Seniors). Not only are individual Canadians aging but the population as a whole is as well. Statistics Canada predicts that by the year 2031, nine million Older Adults (aged 65 and over) will represent 25 percent of the country's total population compared to 14 percent in 2009. For the first time in this country's history the number of Older Adults will surpass the number of children. The working-age population (15 to 64 age group) will decrease from 69 percent in 2009 to 60 percent in 2036. The Canadian government recognizes that this shift in demographics will, without a doubt, have significant social and economical consequences.

The traditional model of care for Older Adults in Canada is also changing. More and more seniors can no longer rely on their spouses or their adult children to care for them. Hospitals can no longer afford to house Older Adults until they are fully recovered. These Adults find themselves relying on community services or transitioning to Long Term Care Facilities. However, there are not enough

Long Term Care Facilities to meet the existing demand, access to them is limited and funding for existing community Home Care programs is insufficient. (Golant 3)

As social and health care systems begin to fray, the Federal, Provincial and Territorial Committee of Officials (Seniors) is exploring a new vision for **healthy aging** that addresses Older Adult health issues and celebrates their social contribution in order to combat ageism, social isolation and inequalities.

In parallel to this proposed vision, The Special Senate Committee on Aging indicated in their final report "Canada's Aging Population: Seizing the Opportunity", that technology could play a key role in addressing issues related to aging and ageism - but which technologies and for which issues?

As Canadians age, technology evolves. Emerging technologies like *artificial intelligence* and *robotics* are presently being used to address issues related to aging. As Canada strategically prepares to meet the increase demands of an aging population in the next twenty years, *how can emerging technology help*

Canadian adults over the age of 65 address individual and social issues related to aging in the year 2032?

In “Our Molecular Future”, Douglas Mulhall cautions that investing in technology does not guarantee its commercialization or public adoption. Patent infringements, military interference, commercial, labour or financial disruptions, politics, wars, economic or social collapse, pandemics and natural disasters are all “wild-cards” which can interfere with the ability of Older Adults to access emerging technologies.

Precluding Mulhall’s wild-cards, in order for technology to be effective in helping Older Adults achieve the Federal, Provincial and Territorial Committee of Officials (Seniors) new vision for healthy aging, there must be no structural lag between the issues raised by the Older Adults and the technology offered to them. Congruity can be achieved using the Technology Acceptance Model, which suggests an increased affinity between Older Adults and new technology IF there is perceived usefulness and a perceived ease of use. Furthermore, investment in new technology must be done now so that it can reach maturation in twenty years.

This paper explores the **adoption**, **affinity** and **application** of existing and emerging technology to address issues raised by Older Adults today and those that will be 65 and over twenty years from now. Ethical questions raised by access, class division and environmental impact due to technology are beyond the scope of this paper.

A literature review and expert interviews were used to gain a broad understanding of issues affecting Adults over the age of 65 and emerging technologies. Ethnographic techniques were used to gain deeper, more personal and emotive data on Canadian Older Adults as well as to map future trends in Older Adult technology adoption and affinity.

Defining Audience

Although the main audience for this research paper is Gerontologists, Technologists, Gerontechnologists (multi-disciplinary practitioners who use technology as a tool to better the lives of Older Adults) and Policy Makers, the key findings and reflections apply to all stakeholders who work with, or are affected by issues related to aging. In other words, they concern all of us!

Defining Demographics

In its final report, the Senate Committee on Aging refers to adults 65 and over as *seniors*. (Carstair 3) During the interviews conducted for this research, this term was viewed pejoratively by many of the Older Adults. It conjured for them the image of someone who is frail and sickly. They were in fact healthy, vibrant and engaged adults who happened to be over the age of 65. This paper required demographic terminology that categorized adults as per their age but did not stereotype negatively because of it.

Professor Gari Lesnoff-Caravaglia at Ohio University's School of Health Sciences recommends that aging adults be classified by decade in order to "allow for international understanding and utilization". (Lesnoff-Caravaglia 17) For example, adults in their sixties would be sexagenarians whereas those in their seventies would be septuagenarians and those in their eighties, octogenarians. Since the ethnographic study conducted for this research sought data not relevant by decade but by age group, more generic terminology was required.

This research paper adopts the *preferred* terminology used in social sciences. (Brossoie 21) Adults between the ages of 65 and 75 are referred to as Older

Adults (OA); whereas, adults in their mid-forties are referred to as Younger Adults (YA).

Defining Technology

A literature review did not reveal an authoritative definition on what or which technologies are or are deemed to be emerging. In Diffusion of Innovation, Everett Rogers defines technology as "a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving a desired outcome." (Rogers 13) This definition is very broad in scope. It applies as much to computers as it does to Marxism or a no-smoking policy. For the purposes of this study, technology is defined as "any tool or system that contains a microprocessor chip." (Charness 253)

The National Research Council Canada refers to emerging technologies as innovations in the industrial sector which have economic repercussions. An economic report written by PricewaterhouseCoopers for the Invest Canada-Community Initiatives lists Digital Games, Brazil's Information Communications and Technology (ICT) sector, the Mobile Technology sector and the Clean Technology sector as Emerging Technologies.

The Ontario Emerging Technologies Fund finances businesses that create Clean Technology (i.e. air cleaning, waste water treatment and energy conservation, Life Sciences and Advanced Health Technologies (i.e. drug discovery, medical devices and agricultural biotechnology) and Digital Media and Information and Communications Technology (i.e. software development, peripheral manufacturing and semiconductor design).

In the United States, there seems to be a trend towards convergence of fields of technology and sciences when referring to emerging technology. All of them refer to the enhancement of the human body. In "Our Molecular Future", Douglas Mulhall explores the merger of *Genetics*, *Robotics*, *Artificial Intelligence* and *Nanotechnology* (GRAIN) in order to transform humans. (30) Similarly in "Radical Evolution", Joel Garreau also explores the modification of "human nature" through the "intertwining" of G*enetic*, *Robotic*, *Information* and *Nano* technologies (GRIN). (115) The ETC Group refers to four groups as *Bits, Atoms, Neurons and Genes* (BANG). Finally the United States' National Science Foundation (NSF) sponsored report "Converging Technologies for Improving Human Performance" explores the combination of nanotechnology, biotechnology, information technology and cognitive science (NBIC).

In “Emerging Technologies – from hindsight to foresight”, Einsiedel defines technology as becoming emergent when others in the public sphere are able to examine its development through media or the activities of others. Her work focuses solely on technologies that have been or are about to be commercialized. (4)

This study combines Einsiedel’s definition with Garreau’s GRIN classification system since it is the most recent and encompasses the other taxonomies. Therefore, Emerging Technology refers to any computerized device in G*enetic*, *Robotic*, *Information* and *Nano* technology that is in the prototypical stage or has just been introduced to consumers in the marketplace, with considerable resources allocated to its continued development and production. In other words, barring any of the unforeseen events or barriers as previously described by Mulhall, technology that could be readily available in this research papers 20 year horizon line: **the year 2032**.

An Aging Society

The current global demographic trend is population aging, measured as a decrease in children 15 and under, and an increase in adults aged 60 and over. By 2030, half of the population in Western Europe will be between the ages of 50 and 100. Those who are in their fifties can expect to live an additional 40 years. One quarter of this population will be 65 an over and 15% will be over the age of 75. (Harper, "*Regional Social Security…*" 2)

These changes are attributed to *falling fertility, increasing longevity* as well as the choice of working women to delay, minimize or reject childbirth. (Harper, "*Regional Social Security…*")

This trend continues in Canada where the population is expected to grow from 5 million adults aged 65 and over in 2011 to 10.4 million by the year 2036. Again, this trend is attributed to a drop in *fertility rates*, an *increase in life expectancy.* Human Resources and Skills Development Canada also attributes this increase to the aging of Canada's largest generation: the Baby Boomers. The following graph from Statistic Canada's **Population Projections for Canada, Provinces and**

Territories, 2009 to 2036 illustrates the changing demographic landscape in Canada in 2009, 2036 and 2061.

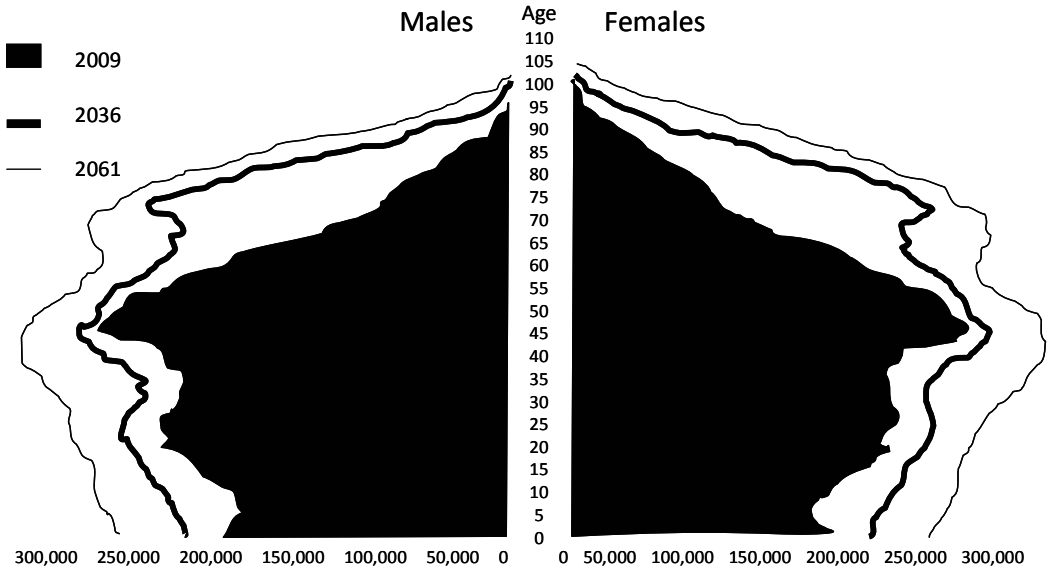

Figure 1 **Aging Pyramids (in number) of the Canadian Population, 2009, 2036 and 2061** (source: Statistics Canada)

Internationally, one quarter of the developed world will be 65 and over and one quarter of the population in Asia will be over 60. In 45 years, there will be roughly 2 billion Older Adults on Earth! (Harper, "*Demography Challenge Paper*" 3)

Healthy Aging – A New Vision

"***An ounce of prevention is worth a pound of cure.***" Benjamin Franklin

In light of this changing demographic landscape, a Special Senate Committee on Aging was created in 2006 to study the impact of an aging society in Canada. In its final report it indicates that it is difficult to speak positively about aging in a society obsessed with eternal youth.

To counteract this message, a new vision on healthy aging is required. One that promotes the positive contribution that Older Adults provide to Canadians and that is similar to the **Healthy Aging in Canada Vision** endorsed by the Federal/Provincial/Territorial (F/P/T) Committee of Officials (Seniors) (Carstairs 15): "A society that values and supports the contributions of older people; celebrates diversity, refutes ageism and reduces inequities; and provides age-friendly environments and opportunities for healthy choices that enhance independence and quality of life." (Edward and Mawani 4)

Underpinning this vision is the understanding that “Healthy aging can delay and minimize the severity of chronic diseases and disabilities in later life, thus saving health care costs and reducing long-term care needs.” (Edward and Mawani 6)

Issues Regarding an Aging Population

Upon formation, the Special Senate Committee on Aging began by reviewing public programs and services for Older Adults and summarizing their findings into four themes: “defining seniors; the diversity of seniors and their needs; promising policy approaches; and the role of the federal government.” To gain a deeper understanding of these four themes, they conducted public hearings and sent a questionnaire to Canadian seniors’ organization. The key issues were categorized using the following framework:

- Active Living
- Housing and Transportation
- Financial Security and Retirement
- Abuse and Neglect
- Health, and
- Care

The report indicates that technology plays a key role in addressing the needs and issues of Older Adults. It also speaks to shifting trends in affinity towards technology between generations:

> Canadians are aging in a changing world. The ways that people age change over time – the baby-boomer generation may not have the same needs and expectations as their parents. Technological advances continue to open up new possibilities. (Carstairs 155)

It continues by indicating a strong need for further strategic research so that limited resources are properly utilized:

> Policy-makers need to base their decisions on sound evidence and a grounded understanding of the many ways people age. This will require ongoing, longitudinal research to understand the process of aging, and the complex ways that economic, social and health factors affect how people age well. Seizing the opportunity of an aging population will also require a better understanding of how technological advances can be used to improve the quality of life of Canadians and to make the most efficient use of limited human resources. (Carstairs 155)

To this effect, the committee's final report acknowledges the research done by the **Institute of Aging** funded by the Canadian Institutes of Health Research (CIHR) as well as introduces the **Canadian Longitudinal Study on Aging**. Under the premise that existing data on aging is flawed because it relates to specific incidents at a specific "point in time", a team of over 200 researchers from 26

Canadian universities propose to gain a deeper understanding on the process of aging by collecting medical, social and economic information of approximately 50,000 Canadian men and women between the ages of 45 and 85 for at least 20 years.

The following research continues the work done by the Special Senate Committee on Aging and supports the Canadian Longitudinal Study on Aging. Using ethnographic techniques, it explores how technology can address issues related to aging using the issues framework devised by the committee and maps trends in technological attitudinal shifts among Older Adult of multiple generations to better gauge its adoption and use in the year 2032.

The Promise of Emerging Technology

Advances in technology[i] are turning science fiction into science fact. In "Radical Evolution", Garreau states that the superpowers of comic-book superheroes of the 1930s and 1940s either exist or are presently being engineered. (5) For example, Eythor Bender's exoskeleton is strangely close in functionality to the suit of armour worn by Marvel Comic's Iron Man. Once commercialized, it could help Older Adults with mobility issues walk or lift heavy objects relegating the

traditional and motorized wheelchair to a relic of the past. Although crude, heavy and a little awkward today, the exoskeleton will surely follow Moore's Law (transistors in a circuit double every 18 months) and the miniaturization trend to become light, streamlined and readily available.

At the University of Reading, Professor Kevin Warwick is conducting research on Cybernetics - the fusion of technology with the human body. He believes that this technology could help reduce the need for prescription drugs as well as increase memory and cognitive abilities – two abilities which often decrease as humans' age. His ideas on cybernetics might seem far fetched to some but the integration of technology within the human body exists today.

For example, the pacemaker is an electrical device implanted in the chest to regulate the heart's rhythm. More recently, Medtronic created a deep brain stimulation device that stops or reduces the tremors caused by Parkinson's disease. In its 2007 list of 10 emerging technologies, MIT's Technology Review introduced Karl Deiseroth's genetically engineered "light switch" which allows scientists to turn off certain parts of the brain. He theorizes that this may

improve treatments for depression — an issue which plagues many Older Adults as a result of disease, ageism or social isolation.

Diffusion of Innovation

Addressing the user's needs does not guarantee the adoption or public affinity towards emerging technology. For example, in 1497 James Lancaster discovered that the use of a lemon juice prevented sailors from contracting scurvy but it took almost 150 years for the British Navy to implement the use of citrus juice as a preventative tool. (Rogers 7)

Why did it take so long for the British Navy to implement this solution? That is how long it took to communicate the benefits of this discovery to other stakeholders.

> Diffusion is the process by which an innovation is communicated through certain channels over time among the members of a social system. (Rogers 24)

In order for emerging technology to successfully address the issues of Older Adults, it must *diffuse* through this population. In Diffusion of Innovation, Everett Rogers suggests that innovation is diffused through social system

through Opinion Leaders and Change Agents. Additionally, Edna Einsiedel in Emerging Technologies remarks that "technology is *both* social and technical" and therefore "an understanding of innovation and particularly the question of how a technology is accepted or rejected is a social-as well as a technical-one." (6)

Opinion Leaders sway public view and behaviour. They are the healthcare and service providers, politicians, policy makers, friends and family members who influence Older Adults. Change Agents, often inventors or academics, are typically responsible for introducing, promoting and enabling innovation. They are the gerontologists, technologists and **gerontechnologists** creating products and services that affect and transform the lives of Older Adults.

Gerontechnologists

Whereas **geriatrics** refers to the "study, diagnosis, and treatment of diseases and health problems specific to older adults" (Brossoie 21), "**Gerontology** is the scientific study of aging that examines the biological, psychological, and sociological (**biopsychosocial**) factors associated with old age and aging. (Brossoie 20)

More recently, a new field of study has emerged linking science and technology to gerontology. **Gerontechnology** was first coined by Jan Graafmans at the Eindhoven University of Technology in 1989. Herman Bouma in 1992 defined it as a *normative interdisciplinary* study of technology and aging "for the improvement of the life quality of older persons". (Pieper 3) In other words, it attempts to establish *standards* between branches of learning when using technology as a tool to achieve or maintain an ideal way of aging! Graafmans adds:

> Gerontechnology includes the research and development of techniques and technological products, based on the knowledge of aging processes, for the benefit of a preferred living and working environment and adapted medical care for the elderly. (Graafmans, "*Gerontechnology, Fitting Task and Environment To The Elderly*" 182)

Gerontechnology promises to be an expanding field of study. Washington State University introduced a new PhD multidisciplinary training program that includes a two-semester course sequence on gerontechnology taught by professors in engineering and clinical psychology. The first cohort included students in computer science, computer engineering, chemical engineering, mechanical engineering, clinical psychology, experimental psychology, human development and neuroscience. (Cook 1)

Gerontechnology conference proceedings and research papers have proven to be a valuable resource for eliciting data on the use and adoption of technology by Older Adults. For example, it provided the concept of **Structural Lag**.

Structural Lag

When observing the relationship between an older adult (the user) and his or her environment, Matilda and John Riley theorize there is the possibility of a *structural lag*.

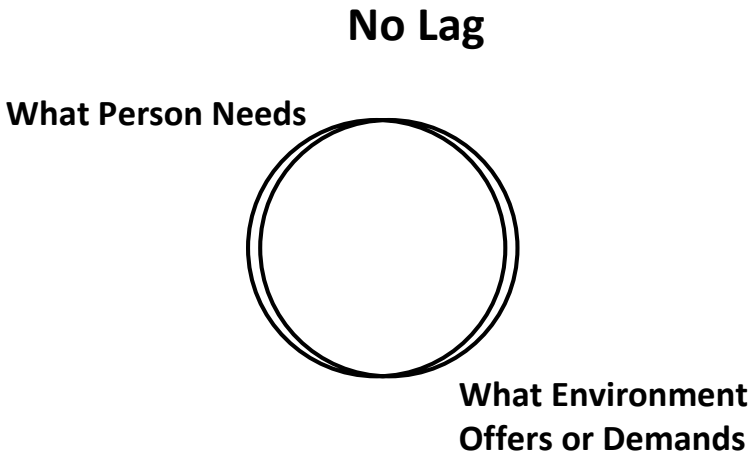

Figure 2 **No Structural Lag** (Powell Lawton 12)

If the environment addresses the needs and abilities of the Older Adult, there is *congruence* between them and no (or very little) lag. If the environment and the needs of the Older Adult change at the same pace, this congruence is maintained (Figure 2). However if the needs of the Older Adult and/or the environment changes at varying speeds, lag occurs. "A typical subjective response to individual lag is anxiety, worry, and a loss of self-esteem." The result of this structural lag is an inability for Older Adults to achieve their "positive goals and social roles". (Powell Lawton 12)

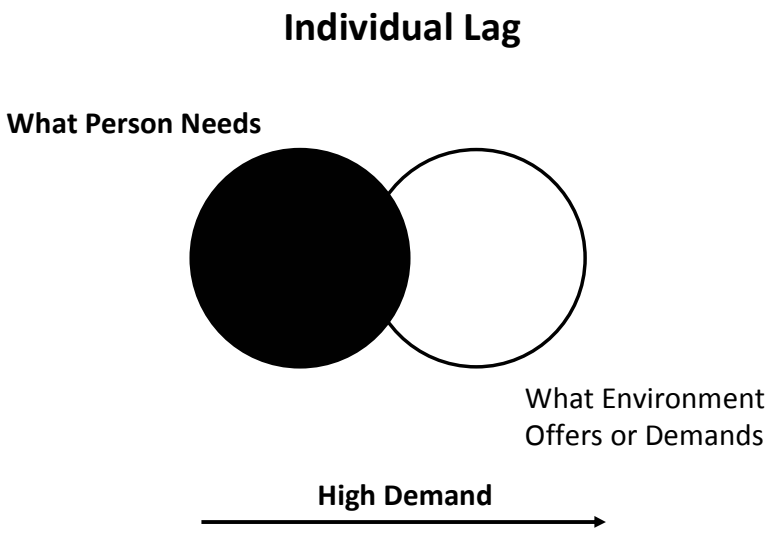

Figure 3 **Individual Lag** (Powell Lawton 13)

There are two kinds of structural lag: individual and social. *Individual Lag* occurs when new technology is introduced but the abilities of the Older Adult remain

the same or decline. During this research, an Older Adult shared in an interview that their child wanted them to only "text" using Short Message Service (SMS) in order to not disrupt their workday. The Older Adult owned a flip phone with no user manual and had difficulty learning how to write and send messages using the complicated T9 text input technology. This created an Individual Lag caused by what the Environment (child) demanded and what the Older Adult could provide. (Figure 3)

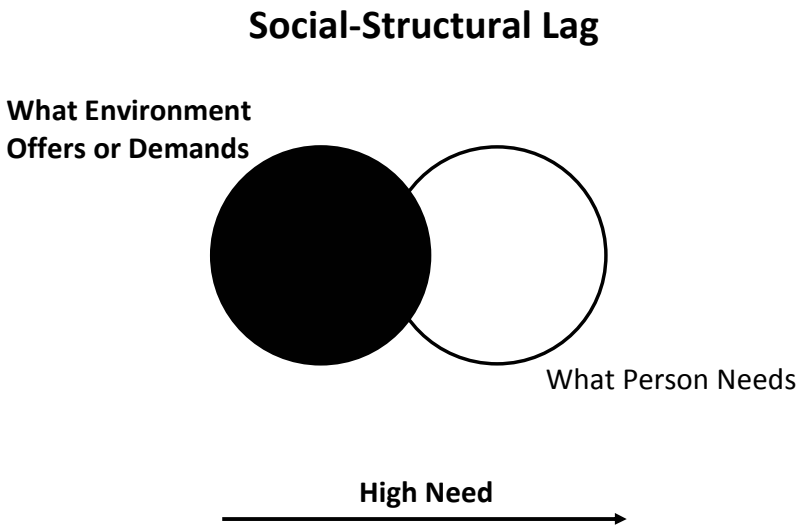

Figure 4 **Social-Structural Lag** (Powell Lawton 13)

Social-structural lag happens when the environment is unable to meet the needs of the individual. (Figure 4) Following the prescribed emerging technology

investments of the PricewaterhouseCooper (PwC) Hot Sectors/Hot Markets Economic Forecast report would create a Social-Structural lag for Older Adults. PwC suggest investing primarily in the Digital Games and the Mobile Sectors, two sectors which hold little interest or value to the Older Adults interviewed for this paper. In contrast, investing in usable technology that addresses memory loss would reduce or remove Social-Structural lag.

Individual Lag often creates feelings of "insecurity, anxiety or depression". *Social-Structural Lag* "block feelings of confidence, hope, enjoyment, and exhilaration". (Powell Lawton 15) Therefore, Structural Lag interferes with the diffusion of technological innovation because it reduces, destroys or blocks user affinity toward technology.

Creating technology that addresses the needs and issues of Older Adults helps counter Social-Structural Lag. Creating technology that is usable by Older Adults counters Individual Lag. Two tools that might help reduce or avoid Individual Lag and help diffuse technological innovation for an aging population are the Technology Acceptance Model and Human Factors.

Technology Acceptance Model (TAM)

Developed by Davis and modified by Venkatesh, TAM was initially developed to assess the adoption of technology in the workplace but has since been used to measure the adoption of technology by Older Adults.

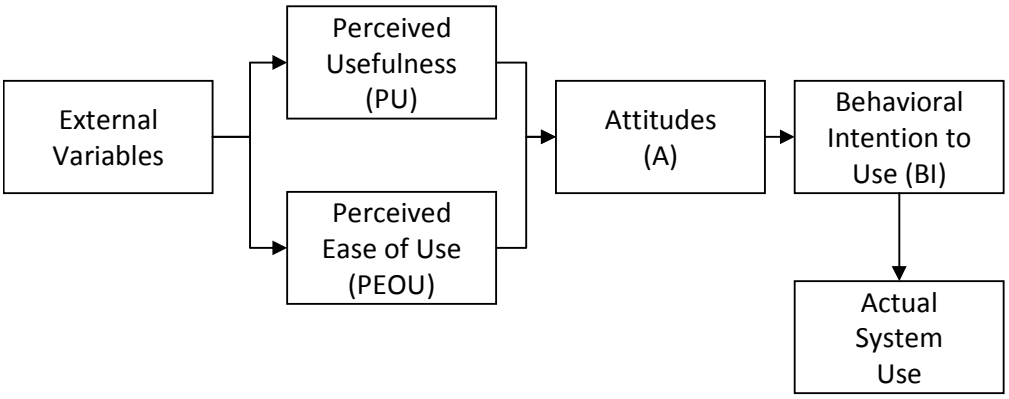

Figure 5 **Technology Acceptance Model** (Openauer 83)

In this model (Figure 5), Older Adults are first influenced to adopt new technology by Opinion Leaders (external variables). They will then try it themselves only if it appears useful (perceived usefulness) OR easy to learn (perceived ease of use). This perception will influence their attitude towards the new technology which in turn guides their behaviour (behavioral intention to use) and results in technology use (actual system use).

Human Factors

As Older Adults age and their faculties fail through disease or senescence, their environment shrinks. (Lesnoff-Caravaglia 28) Technology has the ability to reverse this effect but only if it is usable. As per Edna Einsiedel assumption that technology is both technical and social, Human Factors adopts a systems thinking approach when designing technology. In other words, it observes the relationships between system elements, in this case Older Adult behaviour, and technology. (Vicente 46)

Kim Vicente created the Human-Tech Ladder, a multi-perspective framework for designing technology that addresses human problems. Using the analogy of rungs on a ladder, he invites designers to envision the use of the technology from a physical, psychological, team-based, organizational and political perspective – with the underlying understanding that not all products affect all rungs. (61)

Gerontechnology is cognizant of the Human Factor**.** It adopts an inclusive approach when designing technological tools that address issues related to aging.

Gerontechnologist Jaana Leikas, Senior Research Scientist at the VTT Information Technology supports this philosophy in his design of the user interface:

> To adopt the User-Centered Design approach to user interface design and development is the way to develop usable software and ensure the usage of it. (Leikas 115)

Leikas' quote touches on the two key points in the design of practical technological solution in gerontology: "usable and usage". **Usable** refers to the adoption of the technology by the user. It can be improved or influenced through the adoption of Human Factor principles which impacts the Perceived Ease of Use of the Technology Acceptance Model. **Usage** speaks to the user's *affinity* towards the technology. *Affinity* can also be improved by applying Human Factor principles which in turns influences the Older Adult's Perceived Usefulness as per the Technology Acceptance Model.

Looking Forward

Technological tools developed today address existing needs and/or problems. However, the design and production of these tools takes months if not years to complete. So by the time this technology is available to consumers (Older Adults), both the user and the environment have changed. Existing Older Adults have aged, and Younger Adults are now Older Adults.

In a world of limited resources, where the aging population is about to dramatically increase and technological innovations are continuously being developed, how can policy makers, gerontologists, manufacturers and technologists create future tools for Older Adults that are widely adopted?

The Special Senate Committee on Aging stresses the importance of additional research in order to effectively address the issues pertaining to Older Adults and indicates the potential for technology to address these issues. In 2032, Canada will benefit from an increased Older Adult demographic. Commercial technology available at that time will be today's emerging technology.

How can emerging technology help Canadian adults over the age of 65 address individual and social issues related to aging in the year 2032?

To answer this question, a research was conducted to elicit two important streams of data:

1. **Older Adult Issues** — to define the problems pertaining to aging and in turn design a more effective technological solution – one that renders its application useful!

2. **Technology Use and Affinity** — to discover the External Variables and define the Perceived Usefulness that affects the attitudes and behaviour of Older Adults that in turn influence Actual System Use.

Methodology

1. Literature Review

To begin, an extensive literature review including reference books, conference proceedings, periodicals, journals and websites was conducted in order to acquire fundamental knowledge on the current health and social issues relating to aging as well as to gain a better understanding of emerging technology and advancements in digital computing.

Key sources regarding issues on aging included demographic information from Statistics Canada, the final report from the Special Senate Committee on Aging, the **Discussion Brief** and **Innovations In Best-Practice Models of Continuing Care For Seniors** report from the F/P/T Committee of Officials (Seniors) as well various international Gerontechnology journals and conference proceedings.

Key resources used to locate emerging technology included MIT Technology Review, AI Magazine, Discover Magazine, TechCrunch.com, CNET.com, Mashable.com, The Globe and Mail, TED Talks, Fast Company, the works of Edna F. Einsiedel, Joel Garreau, Douglas Mulhall, Kevin Warkick and the US National

Science Foundation as well as the various labs dedicated to the research and commercialization of technology including the University of Toronto's Technologies for Aging Gracefully Lab, Toronto's MaRS Discovery District, Ryerson's Digital Media Zone and MIT's Media Lab.

Data Analysis:

Following Schensul and LeCompte's prescription in **Essential Ethnographic Methods** for coding qualitative data (Shensul and LeCompte 196), the information collected through the literature review was annotated on post-it notes affixed to a working surface and then classified through inductive reasoning and data synthesis per the following domains: Demographic Research, Gerontology, Gerontechnology, and Emerging Technology.

2. Expert Interviews

Exploratory interviews were conducted to elicit information on tools and technologies presently being developed or researched for Older Adults. One was with Mike Massimi in a human-computer interaction (HCI) researcher at the University of Toronto's Technologies for Aging Gracefully Lab.

Another expert interview was conducted by telephone with Terry D'Silva of Tertec Enterprises. They are the manufacturers of Mon Ami – a computerized Artificial Intelligence system that transforms a home into a Smart Home.

A third technology expert interview was conducted with Christopher Emerson, a PhD Candidate at Newcastle University who has conducted research on the use of SatNav (GPS Systems) with Aging Adults.

Another interview was conducted with Jan Aase of General Motors Research and Development. His research suggested that Older Adults were not interested in tools designed specifically for them. They felt these tools segregated them from other adults.

Other expert interviews were conducted with gerontologists in order to gain further insights on the issues pertaining to Older Adults. One was with Sarah Boehle of Cincinnati (also a PhD Candidate with Miami University) and one with Sylvain Gagnon, Associate Professor of the Faculty of Social Sciences, School of Psychology at the University of Ottawa.

Data Analysis:

Of the issues listed in the Special Senate Committee on Aging final report framework, experts felt that the main ones were: Housing and Transportation, Financial Security, Health and Care. The technological tools being developed to address these issues are initiated by the needs observed by engineers and PhD students. Finally, some experts felt there was an overly optimistic view of technology, like medicine, of being able to cure all issues related to aging.

3. Participant Sample

The initial research protocol called for 6 Older Adults and 6 Younger Adults, half men and half women of varying technological proficiency. A short survey questionnaire was used to determine the technological use of potential candidates. This questionnaire was inspired by Czaja's survey tool designed when completing the research for his paper "Factors predicting the use of technology: Findings from the Center for Research and Education on Aging and Technology Enhancement (CREATE)".

His questionnaire included 17 questions scanning the use of everyday commercially-available common technology, including: automated tellers, fax

machines and videocassette recorders. I revised this questionnaire to include more recent technology such as tablets, smart phones and email. The Questionnaire is provided in Appendix A.

Data analysis: Recruitment

OCAD University's Research and Ethics Board established that Older Adult participants were deemed a vulnerable group. In order to validate consent, the six participants were recruited through an external party: the Toronto Council on Aging. Recruiting from the same social system resulted in a homogenous sample population in terms of health, finances, interests and technological ability. This allowed for a deeper and more intimate ethnographic study of one group.

Younger Adults were recruited using an ad on *facebook*. Interested adults contacted me by email and had their spouses participate as well. This resulted in two groups from two different generations who were of the same socio-economic class. Precluding any of Mulhall's wildcards listed in the introduction, the Younger Adults could very well live a similar aging process as the Older Adult research participants. This recruitment process allowed for observations in generational shifts of attitudes toward technology.

Reflection: Recruitment

It was incredibly difficult to recruit Older Adults. Most community centers or organizations which cater to Older Adult only post recruitment posters on their billboards. It is up to the individual members to contact the researcher. Although nine different organizations were contacted, this research was possible because of the generous recruitment help of a single champion: Beverley McClelland, a member of the Toronto Council on Aging!

Data analysis: Pre-Screening Questionnaire

Each answer received a numerical value from 0 to 4 depending on the question. Values were added to each other so that the total would give the researcher a preliminary indication of the participants existing technology use. A high score (maximum 41) indicates a high use of technology. The following tables provide the pre-screening scores for each participant:

Technology Use Pre-Screening Questionnaire - Results

Participant ID	Sex	Score
Older Adult 01	F	22
Older Adult 02	F	24
Older Adult 03	F	21
Older Adult 04	M	19
Older Adult 05	M	36
Older Adult 06	M	6

Table 1 **Older Adult Participants**

Participant ID	Sex	Score
Younger Adult 01	M	18
Younger Adult 02	F	34
Younger Adult 03	F	27
Younger Adult 04	M	25
Younger Adult 05	F	31
Younger Adult 06	M	34

Table 2 **Younger Adult Participants**

The Mean for Older Adults is 21.33. The Mean for Younger Adults is 28.16. These averages indicate an increase in use between the Older and Younger Adults. However, the highest score (36) belongs to an Older Adult male participant whose career was in the technology industry. The lowest score (6) also belongs to an Older Adult male who uses only his HD Television regularly. All the Younger Adult participants scored high on the questionnaire with two scoring 34 – 2 points lower than the top overall score.

Reflections: Pre-Screening Questionnaire

The pre-screening questionnaire was an efficient tool to assess if people used technology as well as the number and type of devices they used. Overall, there

was a negligible increase in scores between the Older and Younger Adult participants.

Scores were not, however, a clear indicator of the participants' proficiency with technology. The technology interview with the participants revealed deeper data on their daily use of technology. For example, some participants were comfortable coding software or setting up wireless network routers. This information was not captured using the questionnaire. One younger female adult used multiple devices at once and used the same device (her tablet) for multiple uses including reading, watching television, surfing the web and emailing yet scored lower than the highest Younger Adult female score.

For both Younger and Older adults, the common answer to "What technologies do you use?" was limited to computer, Internet and cell phone. However when probed, they revealed their use of other domesticated technology including Digital Video Recorders, Digital Cameras, portable digital music players, blogs, self-service checkout counters and word processing, spreadsheet and photo-manipulation software.

To improve its yield, the questionnaire could be redesigned to include a more exhaustive list of commercially available technologies as well as include questions on the use of each technology.

4. Interviews

Aging Open-ended Interview

A 60 to 90 minute open-ended interview on Aging was conducted with the six Older Adult participants in their own homes. Adopting the Human Factors methodology, the goal of this interview was to elicit personal and individual problems (issues) related to aging in Canada's Greater Toronto Area.

Data Analysis: Aging Interview

Participants did not see themselves as frail or as seniors. They appeared financially secure, owned cottages (vacation homes), were mostly healthy, engaged and active adults who, just like their younger counterparts, suffered not from senescence but from being time deficient!

Technology Semi-Structured Interview

This 60 to 90 minute semi-structured interview was conducted with both Older and Younger Adult participants in their home. In accordance with the Technology Acceptance Model, this interview captured data on technology use and affinity towards technology in order to better understand the external variables and perceived usefulness which influence the participant's attitude towards technology.

1. **Existing Personal Technology Use**

   The interview began with 20 minutes of open-ended questions to help gain an understanding of the participants' existing use of technology.

2. **Introduction to Emerging Technology**

   During the next 40(+) minutes, the participants were introduced to emerging technology through the use of probes (3 videos). Afterwards, they were invited to answer a survey questionnaire and open-ended qualitative questions.

Emerging Technology Probes

The first two videos were on Cybernetics and the third on Robotics[ii]. These videos were chosen as a result of the literature review on emerging technologies. They were selected following these guidelines:

- The technology introduced in the video needed to adhere to the established definition of emerging technology
- The technology should address an issue related to aging or ageism
- The technology should be futuristic yet plausible
- The length of video clips should be short

Survey Questionnaire

After viewing the videos, participants were asked to answer a questionnaire inspired by "Jay and Willis' Attitudes Toward Computers Questionnaire". [iii] Since this research was focusing primarily on possible adoption, affinity and application of technology, only the questions regarding *comfort, interest, efficacy and utility* were used for this study. The word computer was replaced by the emerging technology being introduced: cybernetics ("the chip") and robotics ("the robot").

Data analysis:

Technology Interviews

All participant interviews were captured on notes and video using an iPad. Again following Schensul and LeCompte's process in "Essential Ethnographic Methods" for coding qualitative data (Shensul and LeCompte 196), the videos were transferred to a secure external drive then reviewed, time coded, annotated and classified through data synthesis and inductive analysis using the issues framework provided by the Special Senate Committee on Aging as well as the framework for this study: adoption, affinity and application. Research notes were reviewed to corroborate or enhance data.

Emerging Technology Questionnaire

All questionnaire data was tabulated per emerging technology (robotics and cybernetics) and then cross-referenced.

Reflections: Combine Interviews

Although all retired, the Older Adult participants were just as time deficient as the Younger Adults. Combining both the aging and technology interviews would have been a better strategy.

Reflections: The Revised Attitude Towards Computers Questionnaire

Although greatly efficient to record individual attitudes toward the technology presented in the videos, the revised Attitude Towards Computers Questionnaire proved inefficient when comparing attitudes between generations. Results were more or less similar between older and younger participants. Open-ended qualitative questions proved a more efficient tool yielding richer results.

Research Findings: Aging

"Aging is a journey." POA05

The Older Adult Participants interviewed were neither sickly, nor frail, nor dependent! They were in fact role models for the Healthy Aging Vision adopted by the F/P/T Committee of Officials (Seniors). They were healthy, not in (*or marginally in*) need of care, mobile (*they all drove*) and seemingly financially secure. Some were affected by senescence-related health issues such as memory and hearing loss, heart and knee problems and loss of physical strength. However, this did not preclude them from enjoying active lives. They volunteered, ran private small businesses, socialized and traveled the world.

Although the Aging Open-Ended Interview was initially used to elicit issues related to aging, it inadvertently served as a model to illustrate Older Adults in congruence with their environment. They did not see aging as a process or a sickness but as a journey – or simply as part of life!

Of note, their leisure time was filled with the same activities enjoyed in their youth and in fact, much of the same activities performed by most Canadian adults today.

Activities

Here are the activities reported by the Older Adults interviewed for this study. These activities are classified using the framework provided by the Special Senate Committee on Aging with one new category elicited from the field data: *Entertainment.* Since most of the Older Adults were models of the vision endorsed by the F/P/T Committee of Officials, these activities could serve as a behavioural benchmark for Healthy Aging.

THEMES	ACTIVITIES
Active Living	▪ Walking the dog ▪ Gardening and/or yard work ▪ Cutting Firewood
Housing & Transportation	▪ Trips to the cottage ▪ International and local travel
Financial Security and Retirement	▪ Work ▪ Paying bills

Abuse and Neglect	▪ *Not Applicable*
Health	▪ Exercise
Care	▪ Spending time with family ▪ Volunteering ▪ Laundry ▪ Cleaning ▪ Socializing with friends
Entertainment	▪ Reading books and newspapers ▪ Playing games ▪ Hobbies ▪ Attending Lectures ▪ Attending Film Festivals ▪ Listening to music ▪ Watching movies & television ▪ Researching online ▪ Golf

Table 3 **Aging Activities: Older Adults**

Issues

Many of the issues raised by the Older Adults were both issues they personally suffered from and those reported by their peers. The resulting list serves to guide the application of technology to address issues related to aging.

THEMES	ISSUES
Active Living	▪ Boredom ▪ Keeping up with healthy spouse ▪ Loneliness
Housing & Transportation	▪ No longer able to drive ▪ Relocation/Downsizing ▪ Maintaining property or lifestyle
Financial Security and Retirement	▪ No work ▪ Identity theft ▪ Affordable housing ▪ No retirement fund ▪ Complex payment systems ▪ Children moving far away
Abuse and Neglect	▪ Abuse ▪ Social Isolation
Health	▪ Chronic Illness ▪ Depression ▪ Stroke / Heart Attack ▪ Loss of eyesight ▪ Loss of hearing ▪ Loss of memory ▪ Loss of mobility (hip, legs, knee) or strength ▪ Loss of teeth

Care	▪ Children no longer caring for parents ▪ Breakdown of the family unit
Entertainment	▪ Cannot see or hear television ▪ No friends or company ▪ Social Embarrassment

Table 4 **Aging Issues: Older Adults**

Further Research

This study would benefit from further research on mindsets of aging and the sources of ageism as well as comparing and contrasting the results of the same research process conducted with Older Adults of other socio-economic groups and with varying health issues.

Research Findings: Technology

In order to gain a better understanding of how emerging technology can address issues related to aging and ageism in the year 2032, the Technology Research Findings are presented in conjunction with this paper's exploration of technology adoption, affinity and application.

Adoption: Technology Used by Older and Younger Adults

The following section explores technology presently adopted by both Older and Younger Adults. Domesticated technology has become so integrated in modern life that both the Older and Younger Adult participants forgot some of the digital tools they regularly used. These included: Digital Video Recorders (DVR)/ Digital Cable Boxes, Digital Cameras, Portable Music Device, Automatic Banking Systems and Self-Service Check-out Counters. They remembered when questioned.

All of the participants had high-speed Internet access at home and high definition television connected to a DVR or a digital cable box. What varied most was the frequency and proficiency of use and the participants comfort level with technology.

Of note, the major difference in use of technology between Older and Younger Adults was with mobile devices. The Younger Adults used a plethora of mobile digital devices including iPods, iPads and smartphones. However, only two Older Adults used eReaders. One Older Adult used a cell phone for business purposes only. The others used them for emergencies only. Cost was cited as the main reason for not using this device regularly.

The following graphic (Figure 6) illustrates technology use by Older and Younger Adults. Devices positioned on the center line were equally used by Older and Younger Adults. Devices positioned closer or farther to the median line indicates which ones were used more, or less by each group. For example cell phones were owned by both Older and Younger Adults. However, more Older Adults used cell phones whereas only Younger Adults used smart phones.

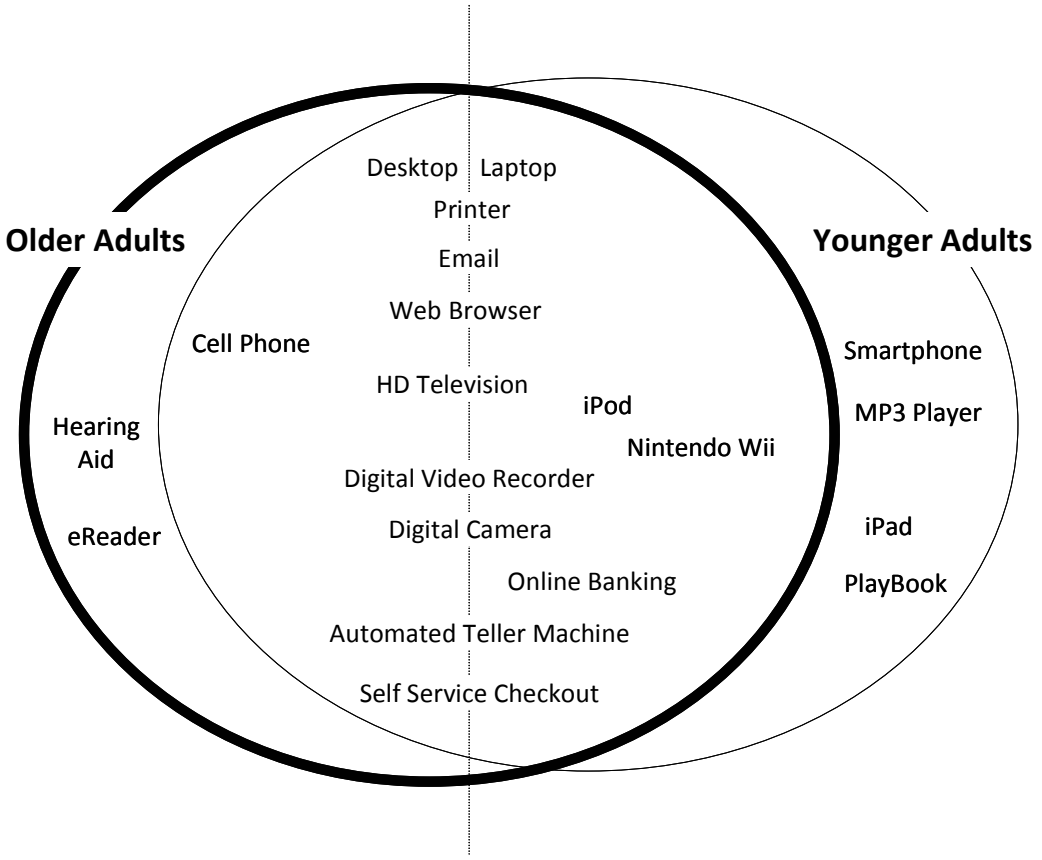

Figure 6 Devices Used by Older and Younger Adults

Further Research

As demonstrated in the Technology Acceptance Model, technology use was influenced by external environmental exposure either at work or through family members — as illustrated by the Older Adult forced to learn how to send and receive text messages using her cell phone. This might explain why Older Adults are laggards when it comes to using mobile devices. The two Older Adults who

owned eReaders did so through perceived usefulness and happenstance. One Older Adult - an avid reader - purchased a Kindle because it could carry more books for trips to the cottage. The other Older Adult received a Kobo with books pre-installed as an in-store purchase gift.

Further research is required to map out the various Older Adult social systems, their Change Agents and Opinion Leaders.

APPLICATION: Emerging Technology for Older Adults

The following section explores how emerging technology can be applied to resolve issues related to aging in Canada. Once a list of aging-related issues had been drawn from a sample population, digital devices built with emerging technology were researched online, in literature reviews and expert interviews. They were classified using Garreau's G*enetic*, *Robotic*, *Information* and *Nano* technology framework[iv].

The application of technology was determined by cross-referencing the aging issues to the functionality of each device. The aging issues were sorted using the Special Senate Committee on Aging Issue's framework with the addition of 'Entertainment' as a category. The digital devices were further sorted by technology that was domesticated, commercialized and prototyped. Doing so provided temporality in regards to product availability. Since domesticated technology is widely used and adopted, it is anchored in the present. Commercialized emerging technology has just been introduced to the market. Although available, it still needs to go through the process of diffusion before it is widely adopted. Technology that is prototyped is still being researched and

developed. It must then be commercialized and diffused. Its availability and adoption is therefore positioned farther in the future.

For example, one of the Older Adults has a hearing aid. The device's functionality is to enhance hearing. Its related aging issue is 'hearing loss' which falls under the 'Health' category of the aging issues framework. Emerging technology that could help this issue in the future is BioPrinting, inkjet printers that create living tissue.

Using this example, the data is sorted as follows:

Issues	**Domesticated Technology**	**Emerging Technology**	
		Commercial	**Prototype**
Health			
Hearing Loss	**Genetic**: Hearing Aid		**Nano**: BioPrinting

Table 5 Sample Technologies & Aging Issues Table

This table is a work in progress. It changes as new issues arise, new technology is introduced and old devices retired. Empty cells in the table indicate areas where further research is required, investment is needed and which issues are not being addressed. Completing each cell of the table ensures that existing issues

are addressed during the next twenty years. Omitting cells increases the likelihood that these issues will still be prevalent in the year 2032.

The following table further exemplifies this tool by cross-referencing the issues raised by the Older Adults and emerging technology that is prototyped and produced or commercially available in the Greater Toronto Area:

	Domesticated Technology	**Emerging Technology**	
		Commercial	**Prototype**
Financial Security and Retirement			
▪ Complex Payment Systems	**Information**: Automated Teller Machine, Online Banking, Self-Service Checkout		
Abuse and Neglect			
▪ Social Isolation			**Information**: Combating Social Isolation App
Health			
▪ Stroke / Heart Attack	**Genetic**: Pacemaker		
▪ Loss of hearing	**Genetic**: Hearing Aid		
▪ Loss of memory		**Information**: Cogniciti	
▪ Loss of mobility (hip, legs, knee)		**Robotic**: Bionik's Walking Tools	

Care			
▪ Children no longer caring for parents		**Information**: MonAmi **Robotic**: Roomba	**Robotic**: Brian, the Robot Care Provider
Entertainment			
▪ Cannot see or hear television	**Information**: eReader/iPad/Playbook, HD Television		**Information**: Accessible Large-print Listening and Talking App

Table 6 Technologies & Aging Issues Table

Preliminary analysis of table 5 indicates that the bulk of domesticated technology in Canada is used by Older Adults for 'Entertainment' purposes. Missing from the table are devices which address issues related to 'Active Living' and 'Housing and Transportation'. Additional research is required in order to uncover how (or if) emerging technology is being used to address Financial Security and Retirement and Health.

This table creates a planning tool for Gerontologists to understand which aging issues will be addressed with emerging technology. Technologists gain an inspirational tool to help them plan, design and develop tools that are market-driven and therefore have a higher propensity for adoption. Policy

makers have access to a strategic tool that helps them plan and invest resources and Gerontechnologists have a framework for multidisciplinary team members to study and develop technological tools that better the lives of Older Adults.

Further Research

Further research is required to elicit issues related to aging above and beyond those of our sample group. Additionally, more extensive research is required in order to build an extensive list of digital devices being developed in Canada and abroad. The scope could be increased to include other technologies that were not designed for, but could be used to help Older Adults.

AFFINITY: Trending Changes in Attitudes Towards Technology

"If it could give me the memory I had when I was 21…" POA01

This section explores the affinity of adults towards technology. Addressing the needs of Older Adults was only the first step in assessing the role emerging technologies could play in the future. In order to minimize structural lag between the Older Adult and the Environment, it was important to understand the users' attitude toward technology.

Trending Shifts in Attitude Using Ethnography

Aging is intrinsically related to time. While stakeholders create and implement policies and solutions, people are aging. Therefore, the solutions they create today affect the Older Adults of tomorrow.

In order to fully grasp attitudes towards technology in the year 2032, two cohorts of two different generations needed to be interviewed: the Older Adult

participants aged 65 + who would be 85 + in twenty years and Younger Adult participants presently in their mid-forties who would then be in their mid-sixties. The participants were of the same socio-economic group which allowed me to trend shifts in attitudinal changes between generations.

There was a marked difference in attitude between the Older Adults and the Younger Adults —one that was emotionally influenced by their affinity towards the emerging technology newly introduced to them. The Older Adults reacted to the videos on Cybernetics and Robotics with a certain detachment while the Younger Adults were excited yet cautious about the possibilities these emerging technologies offered. Therefore, adult 85+ will be less likely and adults 65+ will be more likely to adopt cybernetic and robotic tools in 2032.

The use of ethnographic methods with multiple generations to record or observe attitudinal trends could be formalized as a tool for stakeholders to strategically choose projects, allocate resources, assess marketability and public adoption. Furthermore, this foresight technique could be used as a tool to map or measure social shifts in behaviour and attitudes in other domains such as: financial

outlook, world views, and purchase decisions. There is also an opportunity to research the use of ethnographic methods in other foresight work. [v]

Technology Acceptance Model

The data collected from these interviews was then sorted and analyzed using the Technology Acceptance Model in order to determine actual system use.

Older Adults & Cybernetics:

External Variables:

Cybernetics was introduced to participants by the researcher using 2 video clips. Two of the Older Adults had been exposed to the concept of cybernetics during their previous careers. One Older Adult worked in Information Technology and the other worked in a Science & Technology-related field.

Perceived Usefulness

They distrusted the intrusion of digital technology within the body but could see its positive use for extreme medical cases.

Perceived Ease of Use

One participant in particular believed that the benefits provided by this technology could be reached by other means. In contrast, the Older Adults raised issues of cost, access and control as well as the potential development of a new societal class division between those who have a regular intellect and those who have a higher enhanced intellect.

Attitudes

The Older Adults reacted either viscerally with fear and disdain or with mild intellectual curiosity to the video of Kevin Warwick's cybernetic experiments and with *detachment* to the video clip on deep brain stimulation for Parkinson Disease.

Behavioral Intention to Use

There was no intention to use cybernetics.

Actual System Use

The use of this technology is unlikely by all Older Adult participants.

Cybernetics & Younger Adults:

External Variables:

Cybernetics was also introduced to participants by the researcher using 2 video clips.

Perceived Usefulness

Two of these participants were incredibly excited regarding the prospect of cybernetics replacing pharmaceutical drugs. One in particular was willing to have a 100 chips installed in her ***if*** it replaced her need for prescription drugs! Another liked the idea of a chip to cure depression as well as having the opportunity to download knowledge instead of learning the traditional way.

Perceived Ease of Use

Although they felt cybernetics held great promise, the Younger Adults raised issues regarding security and privacy of behavior and thought, and infections caused by the fusion of inorganic materials with the body.

Attitudes

The younger adults were fully engaged and saw promise in both these technologies.

Behavioral Intention to Use

They were willing to try — provided it met a certain need. They were also *cautious,* saying they would require additional information regarding its functionality. Some preferred to wait for others to adopt these technologies before using them.

Actual System Use

It is highly likely that the Younger Adults will use cybernetics.

Older Adults & Robotics:

External Variables:

Robotics was introduced to participants by the researcher using a video clip.

Perceived Usefulness

They could see its positive contribution to Alzheimer patients but could not see any personal use for them in their daily lives.

Perceived Ease of Use

The Older Adults did not comment on Ease of Use.

Attitudes

The Older Adults reacted with *amusement* to the newscast introducing robots in a Long Term Care Facility. One participant loved the robot! Another was more cynical toward the prospect of robots as human assistant. She said that this technology had been promised to them since the 1950s but had yet to materialize.

Behavioral Intention to Use

Only one participant wished she could purchase it and have it as a companion.

Actual System Use

Most of the Older Adults interviewed were unlikely to use this technology.

Robotics & Younger Adults:

External Variables:

Robotics was also introduced to participants by the researcher using a video clip.

Perceived Usefulness

All of the Younger Adults applauded the use of robots in long-term care facilities. However, two participants stated that robots would never replace the need for human contact. When watching the video on robotics, most of the Younger Adults mentioned and expressed a desire to purchase a Roomba (a robot vacuum cleaner). They could easily see practical applications of the technology in their everyday lives.

Perceived Ease of Use

One Younger Adult felt that both these technologies were primitive and would be viewed as such in the future.

Attitudes

The Younger Adults were *excited* and some *elated* by the prospect of robotics.

Behavioral Intention to Use

If they could afford them, they would likely use them.

Actual System Use

The Younger Adults are very likely to use robots.

Recommendations

As previously stated, the Special Senate Committee on Aging indicated that further research on aging was required and that technology could play a pivotal role in addressing these issues. This paper provides foundational tools for the Canadian federal government to achieve their Healthy Aging Vision. The use of these tools help develop policies that address the needs of Older Adult Canadians and strategize deployment and resource allocation through a sound understanding of future technology affinity and propensity for adoption.

As per Edna Einsiedel's premise that technology is both technical and social, the adoption of technology requires *application* and *affinity*. Using the Technologies and Aging Issues Table and Kim Vicente's Human-Tech Ladder, policy makers can ensure that emerging technologies are applied to Older Adult needs to create congruence between Older Adults and their Environment and avoid Structural Lag.

The use of multi-generational ethnographic research and the Technology Acceptance Model can help the government determine technology *affinity*.

Ethnographic research provides deeper insight into the needs and behaviour of Older Adults. Sample data collected using these tools indicates that existing Older Adults in Toronto are unlikely to adopt cybernetics and robotics. However, the Older Adult Torontonians of 2032 will adopt this technology as long as they can afford it, that it is proven effective and secure, and that it has been adopted by others. Also in 2032, the Canadian Longitudinal Study on Aging will have concluded its research and may offer further insight in the adoption and diffusion of emerging technology with Older Adults.

The interviews with the Older Adults in Toronto also elicited the need for a new category, Entertainment, to be added to the aging issues framework used by the Special Senate Committee on Aging. Entertainment plays a key role in the lives of the Older Adult participants. A lack of entertainment can cause anxiety as it did for the Older Adult who suffered from hearing loss. It can also lead to boredom, depression and isolation from culture and arts.

Edna Einsiedel defines technology as emerging once it is available in the public sphere. Whereas, Technologist, Gerontologist and Gerontechnologist are the Change Agents that create innovation, Government policy makers and

administrators are the Opinion Leaders who influence adoption. In order for emerging technology to diffuse through Canada (the public sphere) by 2032, the government should start educating existing and future Older Adults by communicating the existence, benefits and use of emerging technology through public service announcements, billboards, fairs, websites, print and online editorials conferences as well as through tax breaks or purchase incentives.

The adoption of emerging technology can help Older Adults who suffer from issues related to aging remain active and engaged and help policy makers achieve the goals set in the Healthy Aging Vision! Furthermore, as these technologies become commercialized they fit the National Research Council Canada's definition of emerging technology: innovations in the industrial sector which have economic repercussions.

Conclusion

By the year 2032, adults age 65 and over will account for one quarter of Canada's population. In light of a changing demographic landscape, the Special Senate Committee on Aging conducted a national research in order to elicit the issues pertaining to Canadian Older Adults. The committee's final report indicated the need for further research on aging and promoted technology as a tool to address these issues. This research continued the work of the committee by exploring how emerging technology could help Canadian adults over the age of 65 address individual and social issues related to aging in the year 2032.

Emerging technology was defined as any computerized device in G*enetic*, *Robotic*, *Information* and *Nano* technology that is in the prototypical stage or has just been introduced to consumers in the marketplace, with considerable resources allocated to its continued development and production.

Addressing the needs of Older Adults using emerging technology does not guarantee its diffusion. A structural lag between Older Adults and their environment deters the adoption of technology. If the Older Adult is unable

to operate or use the technology, it creates an individual lag leaving them insecure, anxious and depressed. If the needs of Older Adults are not met through the proper application of technology, a social-structural lag is created and blocks healthy aging. The Technology Acceptance Model and Human Factor principles reduce, minimize or eliminate structural lag.

The Technology Acceptance Model provided a framework to improve the adoption of emerging technology. It postulates that new technology is introduced through external variables (like family and friends or work requirements). In addition, for Older Adults to accept this new technology there must be a perceived usefulness and a perceived ease-of-use. Human factor principles as exemplified by Kim Vicentes Human-Tech Ladder provide a framework for designing products that benefit humans and society.

A literature review and expert interviews with academics, gerontologists and engineers elicited national and international data on gerontology and emerging technology. An ethnographic research provided sample data on technology **adoption**, **affinity** and **application**. Issues raised by Older Adults were categorized using the Special Senate Committee on Aging issues framework.

Existing technology use was compared between Older and Younger Adults. Interviews using video clip probes on cybernetics and robotics helped observe shifting trends in affinity towards technology between generations.

Cross-referencing the issues framework designed by the Special Senate Committee on Aging against the functionality of new digital devices helped determine the application of emerging technology to address the issues of Older Adults. Further classifying this data by product availability (domesticated, commercialized and prototyped) created a foresight tool for stakeholders to determine technology availability, flag blind spots and discover new opportunities.

In line with the new vision on Healthy Aging endorsed by the F/P/T Committee of Officials (Seniors) and introduced in the Special Senate Committee on Aging, Genetic, Robotic, Information and Nano technology can address issues related to Active Living, Housing and Transportation, Financial Security and Retirement, Abuse and Neglect, Health, Care and Entertainment as long as it is adopted. If Older Adults demonstrate affinity towards emerging technology and if its application addresses their needs, it has the potential to keep them active,

engaged, working longer (if required) and living independently in their own homes — reducing the strain on public services, healthcare and caregivers and their associated physical, emotional and financial costs.

In order for emerging technology to have an impact in the year 2032, investments must be made now since it will take a minimum of twenty years for prototyped devices to be manufactured, marketed and diffused.

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Appendix A – Research Protocol

Pre-Screening Survey - Technology Use

The following pre-screening questionnaire was inspired by the research method used by Czaja (et al.) to determine his participants "general use of technology" (Czaja, p. 8). He created a 17 item questionnaire asking what everyday common technology they had used. This list included automated tellers as well as fax machines and videocassette recorders. The following questionnaire has been created to include more recent technology.

Time: 15 minutes

Location: Phone or In-Person

Goal: To find 6 participants for this study

Method: Survey all participants. Calculate Score. Choose the 2 participants who scored the highest, 2 who are in the median, 2 who scored the lowest

Survey Questions	Answers	Score
1. Do you own a personal computer (laptop or desktop)?	Yes, No	1 for Yes
2. Do you use your personal computer for business or pleasure?	Business, Pleasure	1 for Business, 1 for Pleasure

3. How often do you use your personal computer?	Hourly, Daily, Weekly or Monthly	4 for Hourly 3 for Daily 2 for Weekly 1 for Monthly
4. Do you own a mobile telephone?	Yes, No	1 for Yes
5. Do you own a smartphone (iPhone, Android, BlackBerry, Windows)	Yes, No	1 for Yes
6. How often do you use your mobile telephone or smartphone?	Hourly, Daily, Weekly or Monthly	4 for Hourly 3 for Daily 2 for Weekly 1 for Monthly
7. Do you own a tablet (iPad, Playbook, Android)	Yes, No	1 for Yes
8. How often do you use your tablet?	Hourly, Daily, Weekly or Monthly	4 for Hourly 3 for Daily 2 for Weekly 1 for Monthly
9. Do your own a high-definition HD television?	Yes, No	1 for Yes
10. Is your HD television connected to the Internet?	Yes, No	1 for Yes
11. Do you have Internet access at home?	Yes, No	1 for Yes
12. Do you have access to the Internet outside of home? (work, library, community centre, friend)	Yes, No	1 for Yes
13. How often do you access the Internet?	Hourly, Daily,	4 for Hourly

	Weekly or Monthly	3 for Daily 2 for Weekly 1 for Monthly
14. Do you have an email account?	Yes, No	1 for Yes
15. How often do you email?	Hourly, Daily, Weekly or Monthly	4 for Hourly 3 for Daily 2 for Weekly 1 for Monthly
16. Do you have a social media account (facebook, twitter, tumblr)?	Yes, No	1 for Yes
17. How often do you use social media?	Hourly, Daily, Weekly or Monthly	4 for Hourly 3 for Daily 2 for Weekly 1 for Monthly
18. Do you read newspapers online?	Yes, No	1 for Yes
19. Do you bank online?	Yes, No	1 for Yes
20. Do you use automated tellers at the bank?	Yes, No	1 for Yes
21. Do you watch videos online?	Yes, No	1 for Yes
22. Do you shop online?	Yes, No	1 for Yes

Expert Interviews

Time: 90 minutes

Location: At participants domicile

Population: Engineers, Gerontechnologist(s), Gerontologist(s)

Goal: To get expert opinion on research question

Method: Site Visit and Open-ended interviews

Engineers, Gerontechnologist(s)

Project Questions

What projects are you and your colleagues presently working on?

How do you keep track of technological innovation?

When do you predict this technology will be available?

What might stall or stop the development or production of this/these technology/ies?

Field Questions

Who are the present thought leaders in technology invention and innovation and what are they presently working on?

Who funds the development and production of technology for seniors?

Who purchases technology for seniors?

Who are major Canadian players in this field?

Gerontologist(s)

Aging

What are major issues affliction aging Canadian adults today?

How will these issues be different twenty years from now?

Does the experience of aging differ depending on where you live? Can you please elaborate?

Tools & Services

What services or tools are being considered or developed to address these needs?

Who is developing and producing these services and tools?

How do Canadian adults between the ages of 65 and 75 learn about them?

Technology

What role does technology play in the process of aging?

What technology is being developed to address issues related to aging and who is developing them?

Open-Ended Interview #1 – Personal Effects of Aging

Time: 90 minutes

Location: At participants domicile

Population: 6 participants between the ages of 65 and 75

Goal: To get a firsthand account of the physiological, psychological and social experience of aging

Method: Open-ended individual interviews

Interview Questions

Although this is an open-ended interview, these questions are used as probes to spark conversation.

- How would you describe the process of aging?
- What has changed for you over time?
- What tasks have become difficult and what do you do to compensate?

- What do you think are the main issues facing adults aged 65 and over today?
- How is aging for you different than for your parents?
- Do you still work? If so, how long do you think you will continue working?
- Describe an average day for you.
- What are your hobbies? Are they different then when you were younger?
- How and where do you socialize?
- If you could talk to yourself when you were twenty, what would you say?
- What has become easier for you over time? What has become more challenging?
- Describe what you think is a great day.
- Describe what you think is a terrible day.
- How do you get from place to place?
- What are the challenges you face when you are traveling?

Semi-Structured Interview #2 – Technology Use

Time: 2 hour

Location: At participant's domicile

Population: 6 participants (adults 65+ y.o.), 6 participants (adults 45 y.o.)

Process:

1. Personal introduction
2. Review Project Goals
3. Review Interview Method and Process
4. Review Consent Form including:
    - Potential benefits and risks
    - Confidentiality
    - Voluntary Participation
    - Publication of Results
    - Permission to videotape (see checkbox on consent form)
5. Sign Consent Form
6. Interview
7. Conclusion

Give Tim Horton's Gift Card

Thank you

Part 1 – Existing Technology

Goal: To gain a deeper understanding of the participants existing use of technology

Method: Open-ended individual interviews

Interview Questions

These questions are general in nature. They will be customized for each participant and may be reversed.

- What technologies do they use?
- How often do they use them?
- How did they learn to use them?
- How long have they been using them?
- What purpose does it serve?
- How do they purchase or pay for this technology?
- Why do they not use certain technology?
- How do they choose which technology to use?

List of technologies covered:

- Personal Computer (Desktop, Laptop)
- Tablet
- Cell Phone
- Smartphone
- Portable Digital Music Player (iPod, MP3, Zune)
- Internet
- Email
- Video Streaming
- Video Downloads
- E-Commerce
- Online Banking
- Travel Booking
- Blogs
- Newspaper Websites
- Social Media (facebook, twitter, tumblr)
- Mobile Applications (apps)
- HD Television
- Connected Television
- Digital Video Recorder
- Game Consoles
- Automated Teller Machine (ATM)
- Self Service Check

Part 2 – Emerging Technology

Goal: To observe the introduction of new technology to our target audience

Method: Participants are presented with a number of pictures evoking future technologies. They are then asked to answer the following questions:

Quantitative Questions:

The following questionnaire is inspired by Jay and Willis' Attitudes Toward Computers Questionnaire. It was designed to address the following "7 dimension of attitudes towards computers": comfort, efficacy, gender equality, control, dehumanization, interest, and utility. (Jay 252). In order to contain the length of this interview, questions pertaining to gender equality, control, dehumanization and utility were deemed out of scope and therefore omitted.

Each question is measure against the following scale:

1 = Strongly agree

2 = Agree

3 = Neither agree nor disagree

4 = Disagree

5 = Disagree strongly

x = technology represented in the image presented to the participant

1. I felt comfortable using the x.
2. Learning about to use the x is a worthwhile and necessary subject.
3. I know that if I worked hard to learn how to use the x, I could do well.
4. The x made me nervous.
5. Life will be harder with the x.
6. I don't care to know more about x.
7. The x is fun to use.
8. I don't feel confident about my ability to use a x.
9. Everyone could get along just fine without the x.
10. The x is dehumanizing.
11. The x was not too complicated for me to understand.
12. I think I am the kind of person who would learn to use a x well.
13. It is not necessary for people to use a x in today's society.

14. I think I am capable of learning to use a x.

15. Learning to use the x is a waste of time.

16. The x was confusing.

17. The x will make the work done by people more difficult.

18. The x made me feel dumb.

Qualitative Questions:

Describe in your own words how you feel about the x.

Describe how the x could help you in everyday tasks.

When and why would you purchase and use the x?

Endnotes

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[i] Drivers of Technological Change

As per Daniel Briere on networkworld.com, in 1965, Gordon Moore the director of Fairchild Semiconductor's Research and Development department famously predicted that the number of *transistors* in a circuit would double every 18 months – a phenomenon now referred to as **Moore's Law.** Since then, the information technology landscape has evolved creating new *laws* - not rules and regulations but industry-coined term for **trends.** In 1995, the *Internet* began to grow both in size and in number of users. As more and more users accessed the Internet, it grew in value – a phenomenon referred to as **Metcalfe's Law**. As it grew in value, advances in *wireless* technology gave users the ability to access the Internet anytime and anywhere. It was the "Age of Mobility" (**McGuire's Law of Mobility**).

Current trends in computer technology are *miniaturization* and *cloud computing*. As devices are becoming lighter and more compact, technologist are moving "from computer processing-centric systems to distributed networks". (Darrin,

Garrison and Carkhuff 343) With a sharp decline in hardware costs and the ubiquity of Internet access, information technology is moving away from a focus on devices to one of data and service, and from user-centricity to virtual community. Case in point, in its Technology Vision for 2011, international management consulting firm Accenture provided 8 trends driving information technology which clearly demonstrated a focus on data, its value, its analysis, its security and privacy and its collection through social platforms and an engaging user experience.

[ii] **Cybernetics Video**

Two videos were chosen for the Cybernetics segment of this interview. The first is an infomania.tv interview with Kevin Warwick where he describes his experiments in cybernetics, the fusion of digital technology with the human body. The first experiment included the insertion of an RFID tag in his body. This tag allowed him to be digitally recognized by sensors when he walked into a room.

The second experiment involved the fusion of a chip in his nervous system. He was then able to communicate information produced by his nervous system to

a computer network as well as his wife (who also had a chip implanted) “nervous system to nervous system”.

In this video, Warwick also describes the use of cybernetics to address issues related to cognition, memory and communication. These abilities were NOT communicated to interview participants beforehand as to not sway their opinion and therefore more accurately gauge their affinity or interest in this technology. Participants were asked to complete the questionnaire after viewing this video.

The second video was meant to emotionally counter-balance the first one. It is a 2009 Voice of America news segment that describes the application of deep brain stimulation with electrodes tied to an external regulator in order to slow or stop tremors caused by Parkinson’s disease. This video was chosen to show a practical application of cybernetics. Furthermore, the video speaks to the positive contribution provided by older adults in medical research.
This video was used to observe changes in affinity, if any, toward cybernetics.

Robotics Video

Participants were introduced to robotics through a 2011 ABC News segment demonstrating the use of Robots in long term care facilities to engage, stimulate and entertain Alzheimer residents.

At the time of broadcast, the robots were still at the experimental stage. The subjects featured in the video were all Older Adults.

[iii] It was designed to address the following "7 dimension of attitudes towards computers": comfort, efficacy, gender equality, control, dehumanization, interest, and utility. (Jay 252) .

[iv] Genetic Technology

This category covers any computerized technology that affects with or interfaces through the functioning of the human body. Genetic Technologies reviewed include cybernetics, EEG technology and Wearable Assistive Devices:

Cybernetics

Cybernetics is the fusion of technology with the human body. This field is still in its infancy. Kevin Warwick of the University of Reading has successfully grafted a one hundred electrode array to the median nerve fibers of his left arm. He was then able to control an electric wheelchair and a robotic hand. He was also able to communicate "nervous system to nervous system" with his wife Irene. He believes that cybernetics might reduce the need for pharmaceuticals, enhance communication, memory and other cognitive abilities.

Existing commercialized cybernetic tools are being used to address health issues. Examples include pace makers and deep brain stimulation devices used to stop body tremors caused by Parkinson's disease. Cybernetics prototypes are presently being used to address issues related to health and transportation.

EEG Technology

Electroencephalography (EEG) Technology uses electrical activity in the brain to interface with computers. Emotiv (www.emotiv.com) has released the first commercially available wireless headset that uses this technology. It replaces

the use of a mouse to interface with a laptop or desktop and therefore addresses issues related to mobility (transportation) and access to information.

Wearable Assistive Devices

A number of technologies are being developed to help users with sensorial disabilities. Presently, the Wearable Assistive Devices prototypes address issues related to blindness or loss of vision. For example, sonar technology embedded in glasses is being designed to help guide the blind. (Laurent, 2007) Another device sends optical images from a camera to the brain using a device on the tongue. This could eventually be a wireless system which sends signals to a device embedded in "a dental orthodontic retainer". Research indicates that over time "the user loses awareness of on-the-tongue sensations and perceives the stimulation as shapes and features in space." (Velazquez 9)

Robotic Technology

Robots are mechanized tools with some form of artificial intelligence that are able to complete various tasks. This can be as mundane as a vacuuming like

iRobot's Roomba or as complex as MIT Lab's Huggable, a robot in the shape of a teddy bear, which is able to monitor behaviour and respond accordingly.

The University of Toronto in partnership with the Baycrest Health-Sciences centre is developing Brian, the Robot Care Provider to assist Older Adults with cognitive impairment. Its anthropomorphic face displays emotions and complex artificial intelligent software enables it to interact with humans.

The Roomba is commercially available. Both Huggable and Brian are prototypes. These robots address issues related to care.

Also in this category are **Robotic Prosthetics -** computerized prosthetics that attach to the body in order to enhance or replace paralyzed or weak limbs giving the wearer strength, dexterity and mobility. Examples include EKSO Bionics' exoskeleton (www.eksobionics.com) and Toronto's Bionik Laboratories walking tools (www.bioniklabs.com) that help paraplegics walk again. These robotic prosthetics are commercially available and address issues related to transportation.

Information Technology

Emerging Information Technology includes rapid advancements in Artificial Intelligence, peripheral liberation created by Wearable Gestural Technology and the use of Web and Tablet Devices.

Artificial Intelligence

Artificial Intelligence (AI) refers to the computer's ability to process data and make decisions accordingly. Presently, research is being conducted with AI in the homes of Older Adults with cognitive impairment. In these Smart Homes, Older Adults are being monitored using motion sensors, GPS, RFID, contact switches, load sensors, light sensors, thermometers, water sensors, video cameras and bio sensors. The system then processes the data and provides alarms and status reports. Alternatively, systems could be developed to intervene or compensate. (Pollack 14)

One smart home device already commercially produced in the Greater Toronto Area is Tertec Enterprises Mon Ami (www.mymonami.com) a plug and play system that allows caregivers to monitor and assist loved ones remotely. This

device addresses issues related to care.

AI is not limited to the home. As per Li-Mei Hoang on the globeandmail.com, it is now being integrated in cars to help Older Adults to continue to drive. These cars include "tracking systems, eye-motion detectors and bio-monitors to help researchers understand the challenges faced by older drivers as well as night vision systems and intelligent speed technology." Dana Kerr on cnet.com reports that Google has prototyped a fleet of cars that drive themselves. Smart cars address Older Adult issues related to transportation.

Wearable Gestural Technology

Instead of a being limited to a keyboard and mouse to interact with computerized technology, a Gestural Interface allows users to communicate using body movement. Still in its infancy, this technology is commercially available in gaming consoles like Nintendo's WII and Microsoft's XBOX Kinect. Pranav Mistry at MIT's Media Lab has innovated this technology by creating a wearable device that combines sensors and video projectors. It projects digital information on any surface and allows users to manipulate it using hand

movement. Users are now liberated from the confines of traditional peripherals and heavy cumbersome devices (tablets, laptops, consoles, and computers) and are now truly able to interact with data anytime and anywhere. (www.pranavmistry.com/projects/sixthsense/) These tools address issues related to access to information.

Web Technology

Baycrest in partnership with MaRS are converging emerging cognitive science research findings with Internet Web technology to create Cogniciti (www.cogniciti.com) a cognitive decline self-assessment, coping and maintenance tool. This technology is commercially available and addresses issues related to information, care and health.

Tablet Technology

The University of Toronto's Aging Gracefully (TAG) Lab (taglab.utoronto.ca) is currently creating tablet applications that address Older Adult Needs. The Accessible Large-print Listening and Talking (ALLT) eBook is an iPad app which

helps people with vision loss read or listen to books. Users can increase the font size or have a family member read and record the book.

Another iPad app developed by TAG Lab combats social isolation by transforming a picture frame into a communication device. Pictures display on the iPad screen. Users touch the photograph on the screen and a preprogrammed email message is sent to a family member. This family member replies by recording a video message and sending it back to the picture frame.

These two prototypes address issues related to health, care and neglect.

Nano Technology

Nano Technology or nanotechnology is the development of objects or tools that are 1 to 100 nanometers in size. The term is also used to refer to technology that builds things (objects, foods, lotion) at the molecular level. It is presently being used to create sunscreen which better penetrates the body as well as wrinkle-free clothes. It is also used in the miniaturization of electronics. (Hornig Priest 242-243) Kevin Bullis of technologyreview.com reports that MIT is

developing Nanohealing, a liquid made of “nanoscale protein fragments” which instantly stops bleeding and could “accelerate healing of damaged brain and spinal tissue.”

When converged with other sciences or technologies, nanotechnology provides incredible scientific advances. For example, BioPrinting uses inkjet printer technology to create living tissue which can repair organs or replace cartilage like an ear. (Binder 1)

These nanotechnologies are all prototypes. They address issues related to health.

[v] Ethnographic methods are currently being used by Dr. Richard Lum and Michel Bowman of Vision Foresight Strategy LLC for scenario building. VERGE, an ethnographic futures framework, invites futurists or foresighters to conduct ethnographic studies on populations living in possible future worlds using as guidelines the following 5 categories:

1. **Define** refers to how our participants define this future world.
2. **Relate** refers to the social organization and inter-relationships in this future world.
3. **Connect** refers to the communication technologies used in this future world.
4. **Create** refers to the methods used to create goods and services in this future world.
5. **Consume** refers to the goods and services consumed in this future world.

Just as ethnographic methods are used to created scenarios in VERGE, they can also be used to trend multi-generational shifts in social behaviour and attitudes! In light of this study, our existing research would guide foresighters in the categories: Connect, Create and Consume when using the VERGE framework in a scenario dealing with gerontology and technology in the year 2032.