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Defining Gerontechnology for R&D Purposes

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J.E.M.H. van Bronswijk, H. Bouma, J.L. Fozard, W.D. Kearns, G.C. Davison, P-C. Tuan. Defining gerontechnology for R&D purposes. Gerontechnology 2009; 8(1):3-10; doi: 10.4017/gt.2009.08.01.002.00. Gerontechnology is an interdisciplinary field that links existing and developing technologies to the aspirations and needs of aging and aged adults. It helps support 'successful aging', is organized according to the WHO definition of health, and is a response to the combination of the aging of society and rapidly emerging new technologies. Distinguishing it from other technology approaches is its focus on the total human life-span, its recognition of different technology generations, its cross-fertilization of specific technology and gerontology disciplines, its public health goals and the encompassing of all domains of human activity. An enhanced quality of life in older adults is the ultimate goal of gerontechnology.

Keywords: technology generation, gerontology, quality of life, inclusive design

Gerontechnology is a technology domain that links existing and developing technologies to the aspirations and needs of aging and aged adults. This makes gerontechnology a key factor in social sustainability as it is concerned with technologically-based products, services, and environments that improve the functioning and quality of life[1]. This approach addresses all technology that is useful for daily activities of all phases of the full human life span. However, we consider this technology to belong to gerontechnology only if it is targeted at a high quality of life of older persons. As to medical gerontology and geriatrics, the needs have been formulated recently[2].

One of the consequences of effective gerontechnology is a major reduction in morbidity from chronic conditions since gerontechnology interventions can remove the determinants of such conditions from cradle to grave, or can decrease their effects. Think of coaching-services for a suitable life style, or optimal indoor environmental control to prevent allergies and hypersensitivities. In this way the building, civil, sanitary, mechanical, electrical and agriculture engineer, as well as the designer of assistive technologies of the early 21st century, will inevitably become a gerontechnologist, a major morbidity fighter for the older segment of the population, to complement the successes of the early 20th century engineer, who protected the young against the ravaging effects of infant and child mortality due to infections. For the Dutch situation medical researchers calculated that medical care contributed at the most to only 20% of the decrease in mortality in the 20th century[3].

Gerontechnology's ultimate goal is the implementation of 'successful aging'[4,5], which includes (i) a sustained good subjective health assessment, (ii) continued good mental health, (iii) social support, (iv) self-rated life satisfaction in eight domains, including: income-related work, children, friendship and social contacts, hobbies, community service activities, religion and recreation as well as sports, and (v) preferably no physical restrictions as rated by a physician[6]. Since restrictions will eventually occur, Havighurst[5] postulates that old people have to adapt to physiological and psychological changes in order to experience satisfaction in life and to age successfully.

Aim & method

In this contribution we will further characterize the domain of gerontechnology and present its essential features. The analysis we offer is based mainly on the development of the domain as shown in the 'International Journal of Technology & Aging' (1988-1992), 'Gerontechnology' (2001-present), and the abstracts and proceedings of the international gerontechnology conferences in Eindhoven (1991), Helsinki (1996), Munich (1999), Miami (2002), Nagoya (2005) and Pisa (2008)[7-10].

History

Gerontechnology began in the 1990s as a response to two separate 20th century trends that are continuing into the 21st century. First is the relative and absolute increase in the older segment of society. Second is a man-made technological environment that is changing fast, especially in the communication domain. Significant engineered products since about 1990 include the internet, e-mail, search engines on the web, mobile phones, GPS (Global Positioning System) and navigation tools, digital cameras, e-games, robots, menu-driven washing machines, and other systems, services and products to make life easier and work more efficient, and to improve social, mental and physical well-being.

Gerontechnology does not pursue a completely new goal or approach. The 1946 International Health Conference of the United Nations approved the preamble of the Constitution of the World Health Organization of 1948 that stated: ''*Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity. The enjoyment of the highest attain-*

able standard of health is one of the fundamental rights of every human being without distinction of race, religion, political belief, economic or social condition"[11]. It is this high standard of social, mental and physical health of aged persons that gerontechnology tries to realize. In a later document WHO identified investment in people's health and their environment as a prerequisite for sustainable development[12]. To reach complete health an individual or a group must be able to (i) identify aspirations, (ii) realize aspirations, (iii) satisfy needs, and (iv) change or cope with their environment[13]. Gerontechnology is a major means to achieve sustainable development and social sustainability.

In the 1970s, engineers, industrial designers and gerontologists recognized the need for a conceptual framework targeting people of different ages and generations in order to (i) involve them in the planning, development, distribution and dispersion of technology, (ii) systematically evaluate technology's age-specific goals for health, housing, transportation, communication and work and leisure, (iii) study how to utilize the motivating properties of technology, and (iv) address policy issues related to technology applications, such as ethics and public financing[14]. Different professional groups have addressed age differences in the use of technology. The American Human Factors and Ergonomics Society created a technical interest group for aging in 1979[15]. Architectural groups and industrial designers developed the concept of Universal Design or Inclusive Design from the late 80s on[16-18]. Finally in the 1990s scientists of various disciplines established an interdisciplinary field called gerontechnology[19].

A systems approach

People and their environments are to be treated as a system to better predict the results of technological interventions. Changes

Table 1. Some aspirations as generally perceived in the lifespan, to be fulfilled by technology; - = hardly relevant; ± = probably relevant ; + = somewhat important; ++ = important; +++ = very important; Adapted after: Bouwhuis[16], Carstensen[30], Chong et al.[23], Graafmans et al.[34], Laslett[26], Leikas and Saariluoma[35], Melenhorst[30], Mollenkopf and Fozard[36]

Aspiration		The ages			
		1st Formative period	2nd Main working phase	3rd Active retirement	4th Frailty & dependence
Functional independence in	• housing and daily living	-	+	++	+++
	• transportation	+	++	+++	+
	• work	-	+++	++	-
Good health		±	+	++	+++
Happiness		+++	+++	+++	+++
Learning / education		+++	+	++	+
Leisure		+++	+	+++	+++
Maintain and enhance communication		+++	+	++	+++
Self-esteem		+++	+	++	+++
Social contacts (friends)		+++	+	++	+++
Sufficient financial resources for independence		-	++	++	+++
Temporal discount level of benefits of new products		++	+	++	+++
User interface quality		±	+	++	+++

in either the person or his/her environment will alter the end result (system output). A systems approach takes into account the changing dynamics of person-environment interactions over time during which both people and their technological environment change[20], with quality of life at advanced ages as the desired result of the interplay between two interdependent variables – changes in technology and people.

Designers and engineers have skills to create good products for people but must develop the additional skill to link products, environments, systems and services to the changing aspirations, needs and capabilities of end users of various age, gender, culture, health and wealth[21]. Note the continuity of needs across the life span that technology may fulfill by supporting activities and enhancing quality of life (*Table 1*). Maintenance of health, autonomy, and independent functioning are key needs in older adulthood[22,23]. Gerontechnology links human needs to the most appropriate products. Technologies that require extensive learning to utilize, e.g., altering and creating visual and auditory images, may be underutilized by older persons who may believe that the benefits of the technology are not worth the effort required to master it ('Temporal discounting', *Table 1*)

Gerontechnology concepts guiding R&D

Customizing technology to individual needs is within reach. Increasing cultural, economic and age diversities requires us to develop systematic and sustainable approaches linking technologies to individual and societal needs. Gerontechnology provides this approach. The value of gerontechnology for R&D purposes derives from three core ideas: (i) aging and developments in technology are considered together when creating a gerontechnological application; (ii) theoretically speaking gerontechnology is the result of cross-fertilization of core concepts of gerontology and technology in a life-span approach; and (iii) the deliberate provision of technological options for specific daily activities of people. In fact, the main approach of any gerontechnology research, design or engineering project will fill in one cell of each of the three matrices of Table 2.

Aging

For the industrialized world it is said that aging starts at about 10 or 12 years of age, or just before reaching puberty, since from that age on the probability of dying continually increases for the remaining life span and doubles every 7-10 years[24]. Some researchers see even earlier declines in functionality. Small & Stapells[25] report that normal hearing infants have much better 500-1000 Hz auditory steady-state response thresholds than adults have.

With aging, variability increases both between and within persons. Between-person variability increases because of the enormous variability of life experiences and age-associated increases in functional limitations among persons who have the same calendar age. Older people of the same calendar age display wide differences in their ability to cope with activities of daily living. Also the rate at which that ability to cope changes, varies for each individual. This rate of change is frequently overlooked in tasks that rely on a limited response time and accuracy, such as reacting in case of unexpected emergencies.

Technology generations

Gerontechnology's outlook on aging focuses on changes and diversity in needs and aspirations. Following earlier literature, it classifies the human life span into four functional phases not defined by calendar age: (i) the formative phase (1st age; in industrialized regions usually until about 25-30 years), (ii) the main working-for-income and family-formation phase (2nd age), (iii) the active retirement phase (3rd age), and (iv) the period of frailty, dependence and rapid senescence (4th age)[26,27]. Since technologies used in the formative period of a person remain his/her yardstick for technology-evaluation, different 'technology generations' emerge[28]. We consider 'technology generation' a more general phenomenon than pertaining to just

Table 2. A tool for focusing gerontechnology research; The main approach of each Gerontechnology research, design or engineering project can be summarized by one cell in each of the three matrices; Adapted after Bouma et al.[37], Bronswijk et al.[38], Docampo Rama et al.[28], Fozard[20,39], Fozard et al.[40], Graafmans et al.[34], Mollenkopf and Fozard[36], and Sackmann and Weymann[29]

a. Outlook: Age & Generation (2008, Industrialized world)

		Target population			
		1st age Formative years	2nd age Main working phase	3rd age Active retirement	4th age Frailty & Dependence
Technology generation	Mechanical products, hierarchical organization				
	Electro-mechanical products, hierarchical organization				
	Menu driven products, layered software ('Microsoft generation')				
	Gaming software with proficiency levels, relational (non-hierarchical) organization at each level				

b. Science: Cross-fertilization of technology and gerontology disciplines

		Technology					
		(Bio)Physics (Bio)chemistry	Architecture Building	Information Communication	Mechatronics Robotics	Ergonomics Design	Business management
Gerontology	Physiology Nutrition						
	Psychology Social psychology						
	Sociology Demographics						
	Medicine Rehabilitation						

c. Engineering: Impact on application domains

		Application domain				
		Health Self-esteem	Housing Daily living	Mobility Transport	Communication Governance	Work Leisure
Main goal	Enrichment Satisfaction					
	Prevention Engagement					
	Compensation Substitution					
	Care support Care organization					

'user interfaces', for which its effects have been well demonstrated[29].

The whole environment is currently much more filled with ever-changing technological products and services within financial reach than has ever been the case in earlier times, wielding varying influences on the different generations. Since different age cohorts use different reference systems to evaluate new technologies, a person aged 20 in 2008 will never experience environmental change the way a person aged 60 in 2008 does. In addition, age affects the perceived value of time. As people become older they see less time ahead of them and they are consequently less interested in benefits that will appear in the future[30]. Therefore, as age advances the maximum time required to learn to use a new, valuable product is necessarily shorter[31].

The concept of the four ages combined with technology generations connects human aging to environmental and personal change over time and helps designers and engineers fit new technologies to the target population. Note that in the industrialized world of 2008 some combinations of age and generation do not exist, for instance, the mechanical generation for the current 2nd age or main working-for-income period (*Table 2a*). However, in other societies a different picture may arise. The Indian or African farmer employing an oxen-drawn plough may well use a cellular phone. Mechanical and software technology do exist side by side in many parts of the world, depending on culture and economic development.

Cross-fertilization

Gerontechnology has no scientific theory or methodology of its own. Its theoretical base is formed from the cross-fertilization of gerontology (scientific study of aging) and technology (engineering sciences) disciplines (*Table 2b*). It is the cross-fertilization that is essential here. Most researchers, designers or engineers were educated in a single discipline and will thus need to collaborate with the other disciplines. These disciplines may be much smaller than the broad ones listed in Table 2b: for instance, Human-Machine Interaction (HMI) is an aspect of ergonomics, but is also a major and distinct engineering discipline in its own right.

Although ethics and aesthetics are important issues in all (social) sciences mentioned, we have grouped them under social psychology (ethics) and ergonomics (aesthetics). Both could also be treated as independent disciplines because of their overwhelming impact on gerontechnology activities.

Engineers' assignments

Gerontechnology recognizes four goals of technological intervention in combination with five domains of human daily activities to support design and engineering (*Table 2c*). Most of these technologies are not limited to older adults. Again, it is clear that gerontechnology includes a large array of technologies, limited only by the striving towards successful aging and social sustainability.

The goals of gerontechnology fall within the domain of public health, which involves applying science in the context of politics so as to ensure the best health for the greatest numbers and to reduce inequalities[11]. This includes the prevention of the onset of disease by immunization, sanitation, nutrition and other broad scale interventions (primary prevention = prevention and engagement in gerontechnology), the management of disease, such as the delaying of chronic conditions (secondary prevention = compensation and substitution in gerontechnology), and the reduction in function decline (tertiary prevention = care support and care organization in gerontechnology), whose effectiveness was also demonstrated in a randomized study[32].

The four goals of intervention in gerontechnology may be further characterized as follows.

(i) Enrichment and satisfaction denote technologies for attaining the highest quality of life at all three levels under (ii) to (iv).

(ii) Prevention and engagement concern technology that delays or prevents development-associated physiological and behavioral changes that restrict human functioning, such as accidents, or lifestyle and environmental factors contributing to allergies, old-age depression, and other restrictions that may be modified with technological interventions.
(iii) Compensation and substitution pertain to technology that compensates for development-associated losses in strength, perceptual-motor functioning or cognition.
(iv) Care support and care organization encompass technology used by professional or volunteer caregivers to benefit persons with restrictions, such as devices that lift or move physically restricted persons, machines that administer and monitor the use of medication, or equipment that provides information about physiological or psychological functioning to a remote location.

Conclusion

In essence the gerontechnology domain encompasses all technology applied to the full human life span as far as it aims at increasing quality of life in older age categories. To do this gerontechnology takes into account environmental and personal changes over time and works interdisciplinarily with one or more professionals from both technology and gerontology[33].

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