Gerontechnology:

Technology to Improve Health, Functioning and Quality for Life of Aging and Aged Adults

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INTRODUCTION

The term, gerontechnology, is a composite of two words "gerontology", the scientific study of aging and "technology", research and development of various techniques and products.

The term gerontechnology was introduced in 1989 by Graafmans and Brouwers and is defined as the study of technology and aging for the benefit of a preferred living and working environment and medical care for the aging and the aged.

Development of gerontechnology is of personal interest to all of us who are aging and of scientific and professional interest to those doing research on aging or providing services to elderly persons.

The present report covers the following topics:

1. Current and projected changes in the age structure of the population and in the technological environment
2. The relationship between aging and the technological environment
3. Five ways that gerontechnology can improve health and quality of life
4. Pragmatics of implementing gerontechnology
5. Elements of a database for gerontechnology

CURRENT AND PROJECTED CHANGES IN THE AGE STRUCTURE OF THE POPULATION AND IN THE TECHNOLOGICAL ENVIRONMENT

The largest change ever to occur in the composition of the age structure of the world’s population is occurring now and it will continue well into the next century. In the European Community in 1990, "...nearly one third of the community’s population and one fifth of the labor force are over 50...by the year 2020 they will comprise more than two fifths and one quarter respectively of the EC’s population" (Walker et al, 1993). The change is the result of a declining birth rate and a lengthening of life expectancy. It is important to remember that women will make up an ever larger proportion of the elderly population inasmuch as they live on average 7 years longer than men.

Commenting on such population dynamics, Dr. Matilda Riley (1993) observed that current changes in social structures, role opportunities, and norms fail to keep up with the metamorphoses occurring in people’s lives. In particular the allocation of nearly all leisure time to older people in retirement, nearly all work and family care to the middle aged, and nearly all formal education to youngsters and young adults is no longer appropriate for our rapidly changing distribution of age. Riley cites the secular increases in the number of employed women. The good news is the increase; the bad news is that the developments are going in parallel with men’s current age structures--as it stands now the new development does little to help men or women redistribute the
three major roles of work, leisure and education over the lifespan. Political leaders and the taxpayers that support them see the erosion of the tax base required to maintain existing and projected social and medical care programs. Workers and industrial leaders are seeing their hard won social and economic infrastructure change more rapidly than ever before--changes in products, production methods and ownership of business are having an enormous impact on how and when in the lifespan one 'works'. Educators and their students see a revolution in scientific and practical knowledge that strains the traditional structures and approaches to education. Riley correctly points out that substantial changes must occur in the way society allocates resources and roles in response to the ongoing changes in the age structure of the population.

At the same time the evolution of technology--both in terms of speed of change and in complexity--is faster than ever before in human history. This trend is illustrated in Figure 1, a time trend line from 1900 to 2050. It contains projections for the world’s 65+ population, and for the average life expectancy for women. It also depicts some developments in technology of transportation and communication that have profoundly changed our lives. The figure suggests that current and projected developments in technology will provide new opportunities for improved lifestyle and health for old people of all ages. The developing technology will most likely also provide substantial challenges to many people of all ages who have difficulty controlling and effectively using the ever greater number of technology-driven products and services. These changes in the population structure and in technology provide us with an unprecedented opportunity and a mandate to use technology to improve the health and quality of life for aging and elderly adults including those that may become disabled.

SECULAR CHANGES IN ELDERLY POPULATION, FEMALE LIFE EXPECTANCY AND TRANSPORTATION AND COMMUNICATION TECHNOLOGY (1900-2050)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>1900</th>
<th>2000</th>
<th>2050</th>
</tr>
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<tbody>
<tr>
<td>POPULATION 65+ (millions)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;100</td>
<td></td>
<td></td>
<td>830</td>
</tr>
<tr>
<td>FEMALE LONGEVITY (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td>80</td>
<td>87</td>
<td></td>
</tr>
<tr>
<td>TRANSPORTATION/COMMUNICATIONS TECHNOLOGY</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>car/plane</td>
<td></td>
<td></td>
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<tr>
<td>spacetravel</td>
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<td>?</td>
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<tr>
<td>radio TV</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>interactive TV/computers</td>
<td></td>
<td></td>
<td>?</td>
</tr>
</tbody>
</table>

Fig. 1 Changes in number of elderly, life expectancy and technology

THE RELATIONSHIP BETWEEN AGING AND THE TECHNOLOGICAL ENVIRONMENT

The ability and motivation of any person to function depends in large part on the supports and challenges presented by the environment. The environment has both a
social and a physical component. Successful in this group know well that successful functioning of an aging person depends on strong support from the social component of the environment—mostly the families and friends of the person. Government policy makers recognize the importance of the social component of the environment; substantial amounts of public money are spent to encourage and assist this type of support. The expenditure of the funds is rationalized in part on the basis of cost savings—assisted living and medical care provided in the home is relatively less costly than when provided in an institutional setting. It is further rationalized on the basis of surveys of older persons indicating most of them would prefer to remain in their homes as long as possible as they age.

The physical component of the environment also offers both challenges and supports to the successful functioning and quality of life of an aging individual. At present there is a substantial movement in Europe and the United States to reduce the environmental barriers to independent functioning of people with a variety of handicaps and disabilities. This movement is largely driven by pressure from special interest groups such as the physically handicapped, the developmentally disabled, the deaf, the blind, etc. The success of these efforts are partly reflected in structural changes in buildings and public transportation that improve access and mobility for physically handicapped.

The basic justification for spending public moneys for making the physical environment better support the independent living of the elderly is the same as the expenditure for social component of the environment—cost savings and accommodation to the preferences of elderly persons. However, the way that some public money is spent today on the physical environment is different from the social component of the environment. Support of the social component of the environment consists of subsidies to the elderly themselves or payments to those who assist them—caregivers, medical professionals, etc. In the case of the physical component of the environment, part of the money is invested in long term developments of environments, products and technological support services that are expected to favorably affect the quality of life and functioning of persons whose abilities, preferences and interests are themselves changing over a period of years. The key difference between planning of the physical component of the environment for the aging and persons with specific disabilities is that in the case of aging, there are a multitude of changes, most of which occur gradually that must be considered. In the case of specific disabilities such as deafness there is also much individual variability depending on the reasons for the deafness and when in life it occurred, but the goals of the particular interventions are relatively narrowly focussed.

Technology is part of the environment. If we are to use technology to improve the quality of life and independent functioning of the elderly, we must examine the relationship between the environment and the aging process itself. The major fact about aging for this discussion is that aging is a universal process but it is not a uniform one. The environment, like our genes, contributes to the uniqueness of the aging experience of each of us. Disabilities and diseases are not universal and may occur at any point in the aging of an individual further contributing to the uniqueness of the aging of a person.
Fig. 2 illustrates the relationships between the environment and aging. The uniqueness of aging starts with genetic variations in the biological processes of tissue composition, metabolism and repair. Genetic influences are reflected most obviously in the items shown on the left of the figure. Notice the differences between intrinsic and extrinsic influences on aging. Intrinsic aging includes measurable changes in a variety of physiological processes such as those indicated on the left of the figure.

Aging is Universal but not Uniform

<table>
<thead>
<tr>
<th>intrinsic aging processes</th>
<th>extrinsic environmental effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>cardiac</td>
<td>biomedical</td>
</tr>
<tr>
<td>pulmonary</td>
<td>infectious diseases</td>
</tr>
<tr>
<td>nerve conduction</td>
<td>carcinogenic agents</td>
</tr>
<tr>
<td>neuroendocrine</td>
<td>air pollutants</td>
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<td>auditory</td>
<td>lifestyle variables</td>
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<td>visual</td>
<td>built environment</td>
</tr>
<tr>
<td>proprioception</td>
<td>structural design</td>
</tr>
<tr>
<td>gastrointestinal</td>
<td>strength limitations</td>
</tr>
<tr>
<td>olfactory</td>
<td>dexterity limitations</td>
</tr>
<tr>
<td>gustatory</td>
<td>visual limitations</td>
</tr>
<tr>
<td>muscle strength</td>
<td>hearing limitations</td>
</tr>
<tr>
<td>immune</td>
<td>mobility limitations</td>
</tr>
<tr>
<td>renal</td>
<td>safety design</td>
</tr>
</tbody>
</table>

Fig. 2 Aging is universal but not uniform

Three points should be made about the intrinsic factors. First, the tempo of the age changes in the various processes listed is variable within and across individuals. Second, the aging of the processes listed is thought to be detrimental and to occur independently of disease processes. However, the distinctions between aging and disease are constantly changing as research continues. Third, intrinsic age changes reflect environmental as well as genetic influences. The environmental influences are typically in the form of stressors, which accelerate the aging process. Age associated hearing loss is more severe in industrialized societies than in non-industrialized ones (Rosen et al, 1962). The age loss in strength may be retarded by strength training, even in very old age (Fiatarone et al, 1990). The point of these observations for technology is that some of the intrinsic aging phenomena can be modified by long term technological aided interventions. There is sufficient evidence now that some, including age changes in hearing and strength merit such long term intervention.

The extrinsic age factors listed on the right of the figure are potent factors in the natural and the manmade environment that increase or ameliorate the susceptibility of a person to disease or impaired functioning at many points during the course of normal aging. Increases in susceptibility result directly from exposure to infectious diseases, carcinogenic agents, air pollutants, and indirectly from lifestyle choices related to patterns of activity, eating and use of recreational drugs including alcohol and tobacco.
Changing the susceptibility to risks to health and good functioning through environmental modification are possible and desirable. The potential for modification of the built or manmade environment offers the most obvious link between technology and aging. Age associated declines in vision and hearing, strength, cardiopulmonary function, etc., can be exacerbated or retarded by changes in building structures, lighting and acoustic environments, and indoor climate.

The major conclusion from this discussion so far is that aging is a very individual matter and that individual differences in response to the environment is a major cause of this variability. It is almost meaningless to discuss age or aging without reference to the environment(s) in which it occurs. Even though there is not a metric of aging that incorporates this idea, the notion of a person-environment matrix in which aging manifests itself is central to the development of gerontechnology or technology on behalf of aging and aged people.

In summary, five main points have been made so far about aging and the technological environment. First, the changes in the age distribution of the population that are occurring now will continue into the future; the aging of the population requires changes in the distribution over the lifespan of education, leisure and work as this demographic change progresses. Second, changes in the pace and density of technological evolution is occurring that contributes to differences in the way that successive generations of people experience aging. Third, aging is a very individual matter—any two persons are less likely to be alike at age 70 as they were at age 7, whether they started life as identical twins or unrelated persons. Fourth, environmental factors are so important in determining the pattern of a person’s aging, that it is no longer acceptable to attempt to understand aging without reference to the environmental context in which aging occurs. The fifth and concluding point was that the strong relationship between aging and the environment is the basis for gerontechnology, the development or adaptation of technology to the needs, interests, and preferences of aging and aged persons.

FIVE WAYS THAT GERONTECHNOLOGY CAN IMPROVE HEALTH AND QUALITY OF LIFE

The definition of gerontechnology may now be repeated: it refers to research and development of various techniques and products (technology) based on a scientific knowledge of the aging process. More formally it is the study of technology and aging for the benefit of a preferred living and working environment and adapted medical care for the aging and the aged (Bouma, 1993).

Applications of technology to aging requires a developmental view of the relationship between a person and his/her environment. At any point in time the interaction between a person and her or his environment may be characterized as an exchange of information and action as shown in Fig. 3. Information is received from the environment. Events within the person (upper panel) result in actions which may adjust or modify controls of a technical operating system which may be a vehicle, a device at work, or a housing system.
The figure also shows (inner central panel) that environmental considerations—both internal and external—must be taken into account in gerontechnology. Age associated differences in sensitivity to the visual, acoustic and thermal environment as well as individual differences in strength, cognitive abilities, etc., are the main things that determine whether it is necessary to age-adjust the optimal relationship between the human and technical environment. Whether the contrast characteristics of a visual display for a particular application is optimal for both a young and old adult may depend on differences in sensitivity to ambient light conditions and many other conditions.

The "time track" in the figure shows how the developmental view adds a dynamic aspect to the man/environment systems concept. As indicated earlier both technology and the environment change over time at the same time a person is aging, so personal aging and the time period during which a person ages are interdependent. Technology introduced at the present time may affect how young and old persons adapt to it and it may alter the course of aging itself over time.

Perhaps the most interesting implication of the developmental view of gerontechnology is that environmental interventions should emphasize adaptability of architecture and products as a design principle. In housing for example, the interface between equipment and appliances and their user may change over time even though the function and utilization of the equipment/appliance does not. Over time the requirements for space utilization may also change either because of age changes in the needs of the occupants or because of the desire to accommodate to newly introduced technology or products. The adaptability principle would now be reflected in changes in form, e.g., movable interior walls.

The developmental view of technology and aging outlined above suggest five ways in which gerontechnology can address aging. These are illustrated in the next five figures.
Fig. 4. Five uses of gerontechnology: prevention

At the center of Fig. 4 "prevention." Many "problems" of old age are modifiable through long-range, nonmedical interventions involving nutrition, physical activity, exposure to chronically dangerous environmental conditions such as auditory noise, changes in lifestyle regarding alcohol and tobacco consumption, etc. How can technology address prevention? Using physical activity as an example, technology’s applications would include monitoring ambulatory levels of activity in everyday situations, the design of exercise and recreational equipment that is fun to use, i.e., has a high positive motivational quality, and the design of ambulatory monitoring or warning equipment for improper posture for specific tasks such as lifting and general posture to prevent or slow the development of kyphosis. Recently Pendergast and colleagues (1993) proposed age associated criteria for several aspects of aerobic and strength abilities for adequate functioning in old age. Using as a reference the level of a 20 year old, they recommend as a minimum level: 10% of aerobic capacity; 40% of peak anaerobic metabolic power and sustained anaerobic effort; 40% for ability to sustain a muscular contraction and 40% for ability to generate a maximal force. These represent the first scientifically based effort to establish minimal goals for lifetime fitness and provide a basis for devising fitness programs. Notice that in this example, technology is not being used to compensate for strength limitations in older age but to help people maintain strength through exercise.

Another example comes from the study of age changes in hearing thresholds. In the Baltimore Longitudinal Study of Aging, ten year changes in hearing thresholds were obtained from very carefully screened men and women ranging in age from the 20s to the 80s at time of first testing (Pearson et al, in review). The average change in hearing level increased unevenly for frequencies ranging from 250-8000 hz. A dramatic difference between men and women is tentatively attributed to women's lower chronic exposure to environmental noise. Any person in a group who had any evidence of previous noise induced hearing loss based on audiogram evidence using Kryter's (1974) criteria was eliminated from the analysis. Comparison of the men who had evidence of noise induced hearing loss with those who did not indicated that in addition to higher initial thresholds, the rate of hearing loss associated with aging was relatively greater. The use of technology to monitor levels of noise in ordinary settings and to help reduce exposure to noise over the lifespan could reduce the prevalence of impaired hearing in old age. This use is in addition to the current use of technology in hearing aids and other systems to improve hearing.
The prevalence of chronic obstructive pulmonary disease (COPD) increases with age. It is attributed to chronic pulmonary hyperreactivity resulting from smoking or other airborne pollutants. It is usually considered by physicians as an individual medical problem. Scientists at the Eindhoven University of Technology view the disease and its antecedents as a public health problem, and are developing standards for indoor air quality designed to reduce the pulmonary hyperreactivity that is associated with the development of COPD. This is an extremely interesting application of technology inasmuch as well over half of our time is spent indoors. In contrast to existing engineering criteria for indoor air quality which uses "normal" outdoor air as the standard of quality, the approach at Eindhoven is to create an indoor air quality that is hygienic with respect to wet and dry bulb temperature, air velocity and particles.

Fig. 5. Five uses of gerontechnology: compensation

At the top right of the diagram Fig. 5 is "compensation". The vast bulk of existing technical and human factors efforts in aging focusses on this issue. Examples include improved lighting for various visual tasks, mobility aids, devices to improve ability to carry out ADLs, etc. In the case of lighting, a unique demonstration project in the Netherlands includes the assessments of home lighting as part of the evaluation of the clients, most of whom are elderly, and the visual aids prescribed for them. (Neve, Jorritsma and Kinds, 1993). Because lighting requirements are relatively task specific and there are such substantial individual differences in the visual abilities of older persons, Fozard has recommended the increased use of flexible lighting systems in both work and home visual environments (Fozard and Popkin, 1978; Fozard, 1981). This recommendation has not been evaluated. The primacy of design over function of fixed lighting devices, e.g., floor, lamps, wall lamps and ceiling light systems is obvious to any visitor to a lighting shop, although recent developments of small intense light sources such as halogen lamps has been accompanied by more flexible lighting appliances.

Improved lighting of stairs, particularly in the home would also benefit the elderly inasmuch as most falls by them on stairs occur on the initial step of the flight of stairs, the step for which visual guidance is most important (Fozard, 1990). A simple design possibility would be to have a pressure activated switch on the floor near the top of the flight of stairs turn on a light that would illuminate the stairs for a short period of time while the person is traversing the steps. Lighting and step width and height requirements are probably not the same for ascending and descending stairs.
Fig. 6. Five uses of gerontechnology: enhancement

At the top left of the diagram, Fig. 6 is "enhancement". Aging brings with it challenges, which are addressed by compensation and prevention as described above. It also brings opportunities in the form of time for new social interactions and activities, time for new learning and leisure activities—self fulfillment. There has been virtually no attention paid to this aspect of aging in technology development. The exception is the design of adaptable housing to suit the differing needs of people during the life cycle of the family. The potential uses of technology for enhancement of activities is particularly intriguing.

What are some ways in technology can contribute to enhancement? One potential area is in user-friendly technology in communication to facilitate remote contacts with family and friends, to make new contacts and to participate in educational activities remotely. Another area is in the development of user-friendly computer systems for games, artistic and creative activities and learning through multimedia technology. The experiences as well as ages of potential users of technology vary with respect to the timing of introduction of technology and the user-friendliness of ergonomic design must include features that interest and motivate older as well as younger adults.

Fig. 7. Five uses of gerontechnology: aid to caregivers

Toward the bottom of the diagram, Fig. 7, is "aid to caregivers". Ergonomic analyses
and design of devices to lift and transfer people who cannot move themselves and
devices that assist caregivers in providing assistive and medical care are included in
this category. One of the most significant recent developments in home based medical
care is the widespread use of complicated medical equipment by family and other
nonprofessional caregivers, e.g., respirators, intravenous injection devices, monitoring
equipment, etc. The Human Factors and Ergonomics Society of the USA is involved in
the preparation of human factors guidelines for such equipment by the American
Institute for Medical Instrumentation.

Fig. 8. Five uses of gerontechnology: improve research on aging

On the very bottom of the diagram, Fig. 8, is "improve research on aging". As in the
case of "aid to caregivers" this contribution of technology to aging and the aged is
indirect. It is a truism that technology is revolutionizing the scientific study of
physiology, psychology and biology, and this is equally true for observational and
interventive research on aging. The impact is enormous both on data currently
collected and in the reanalysis of archival information. An example of the former in
the National Institute on Aging's Baltimore Longitudinal Study of Aging is the study of
differences in the dynamics of the strength training in young and old persons. An
example of the latter was the use of electronic scanning devices and custom made
computer software that allowed twenty-eight years of historical data on pulmonary
function to be digitalized and analyzed according to the same contemporary criteria for
research quality pulmonary function data (Tockman et al, in review).

THE PRAGMATICS OF FULLY UTILIZING TECHNOLOGY FOR THE
AGING AND THE DISABLED

Gerontechnology stands for a consumer oriented approach to the development,
evaluation and dispersal of technology. It's successful implementation requires changes
in conventional thinking about technology. Four aspects of the required changes are
outlined below.
Developmental approach to design. To fully realize the uses of technology for the aging and disabled, industrial designers, architects, and planners need to adopt a developmental view of product design. For example, the uses of homes change over the life cycle of a family—from a home for newlyweds to a home for a family, to an empty nest for parents with grown children, to a shelter for elderly persons with limitations in mobility, perception and memory. Needed are adaptability in form, e.g., movable partitions, and function, e.g., adaptable person-product interfaces in appliances to fit changes in strength and mobility. There is considerable knowledge about such approaches presented in architectural schools, but applications are very limited. Adopting a developmental approach entails small additional initial costs which will be offset by savings in renovating or retrofitting existing products or housing stock.

Consumer involvement. Involve the consumer in the design process of new technology and in the evaluation of the usefulness and usability of existing technology. Consideration of the preferences, needs and abilities of elderly and disabled consumers becomes relatively more important as the complexity and variety of technology increases. Today’s technology is full of examples of products and services that are very difficult to use, e.g., the VCR and its control and many automatic bank teller devices. Often, the time required to adapt to such devices discourages their use and limits their intended usefulness.

Development of scientific knowledge base for technology. Scientific information about peoples needs, abilities, desires, and economic status are needed to make the most effective use of technology for the aging, elderly and the handicapped. In the past quarter of a century a substantial knowledge base about aging and disability has been established. The knowledge needs translation to be effectively used by designers and manufacturers of technology, but a substantial start has been made.

Change technology infrastructure. The pragmatics of technology utilization call for changes in the infrastructure for technology development and dispersal. Let me illustrate this with the concept of market-pull vs. technology push, a concept developed by Bouma and colleagues (Bouma, 1991). Figure 9 illustrates technology push.

![Technology Push Diagram](image)

*Fig. 9 Technology push*

Industry and trade generate products, techniques, and services that are offered to potential consumers who have little to do except to accept the products offered or to reject them.
Fig. 10 Technology push and market pull

Fig. 10 illustrates market pull as applied to the aging and aged consumer. The development of technology is influenced by the consumer in two ways—feedback about technology offered on the market, and scientifically based information about the consumers and their needs and preferences provided to the designer and manufacturer. The implications of market pull are many. For example a salon or studio approach to presenting lighting fixtures as opposed to a store with hundreds of fixtures on the ceiling, tables and floor, would allow the visually impaired customer to better identify the products available for his lighting needs. Training in the possible uses of technology would supplement or replace the current use of salespeople to explain their products.

ELEMENTS OF A DATABASE FOR GERONTECHNOLOGY

To date, most information in gerontology is oriented toward age associated limitations in functioning, and the following paragraphs reflect this fact. Disability, whether or not it is related to aging, is not just a characteristic of a person carrying the disability label; it is a gap between personal capability and environmental demand (Verbrugge and Jette, 1994). Expectations and adaptation of an individual to a disability are profoundly affected by the degree to which the environment is supportive or challenging. The most effective long range use of technology are in primary prevention of the disability and secondary prevention (compensation) of its sequelae.

The impact of a particular disability depends in part on the age of the person experiencing it; indeed, the relationships between aging and disability can be quite complicated. For example, many persons who have suffered from coronary heart disease have subsequently modified their lifestyle with respect to exercise, nutrition and use of recreational drugs such as tobacco and alcohol so much that their overall health is improved above the level prior to the coronary event. A person who ceases smoking may expect to regain pulmonary function, but only to the level of non-smoking persons similar in age to a person sometime after the age he ceases smoking rather than the age that he started (See Fozard, et al 1992 for a summary). In old age, a positive association has been observed between the number of chronic medical problems and degree of limitations in functional ability; however the cause and effect relationships are unknown, and many of the chronic medical problems are preventable (Guralnik, et al, 1989).
Most information on the abilities of old persons is the prevalence and incidence of age limitations in functioning. The view of aging and technology presented above suggests a need for a different approach to the epidemiology of aging and disability than presently exists. Knowing the prevalence of limitations in functioning in various groupings of people will not by itself help us to use technology most effectively on behalf of the aged, the aging or the disabled. Without knowing how people adapt to limitations in functioning, or what correctable difficulties exist in particular environments we cannot take full advantage of technology to prevent disabling or handicapping processes or to compensate for limitations in abilities, whatever the cause.

One approach to the epidemiology of aging and disability that includes a consideration of the environment that we favor was described by Verbrugge and Jette (1994). Their model, called the disablement process, deals with both personal and environmental factors that contribute to disability.

A second is based on the needs assessment approach developed by Cullen and Moran (1992). Cullen and Moran described uses of technology for four classes of needs--social, medical, activities and security. They classified needs as met, not met, or inappropriately met.

A third approach is based on task analyses of many everyday situations originated by Faletti (1984) and elaborated by Czaja and her colleagues, e.g., Czaja, et al (1992). They analyzed video recordings of elderly persons doing a variety of tasks ranging from bathing to meal preparation and shopping. As shown in Fig. 11, they identified several postures, movements, and forces required in these activities that were difficult. An important finding was that many of the difficult actions observed were common to several different situations, e.g., bending, crouching, lifting. An example of their results is shown in the table. The authors are using the findings to recommend ergonomic design principles for furnishings and utensils.

<table>
<thead>
<tr>
<th>Performance Demands for Select ADL Activities</th>
<th>(Percentages)</th>
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<tbody>
<tr>
<td>Actions</td>
<td>Meal Preparation</td>
</tr>
<tr>
<td>Lift, lower</td>
<td>37%</td>
</tr>
<tr>
<td>Push, pull</td>
<td>23</td>
</tr>
<tr>
<td>Hold, carry</td>
<td>11</td>
</tr>
<tr>
<td>Rotate</td>
<td>13</td>
</tr>
<tr>
<td>Side to side, hand to hand</td>
<td>8</td>
</tr>
<tr>
<td>Other</td>
<td>8</td>
</tr>
</tbody>
</table>

| Postures | Meal Preparation | Grocery | Bathing |
| Stand | 64 | 58 | 44 |
| Lean reach | 26 | 16 | 14 |
| Bend | 7 | 9 | 14 |
| Sit | - | 9 | 9 |
| High reach | 3 | 5 | 15 |
| Stoop | - | 2 | 2 |

| Grips | Meal Preparation | Grocery | Bathing |
| No hand grip | 40 | 45 | 29 |
| Precision | 49 | 28 | 44 |
| Power | 6 | 8 | 8 |
| Palm | 4 | 6 | 12 |
| Cradle | 1 | 2 | 5 |

Fig. 11 Table from Clark et al, 1990
Finally scientists at the National Institute on Aging, Baltimore Longitudinal Study of Aging developed a physical functioning inventory that provides specific information on how people adapt to limitations in functioning (Whetstone et al, in preparation). Twenty two questions covering activities from strenuous exercise to showering and bathing are included, e.g. "do you have difficulty climbing 10 stairs". Answers of "yes" are followed with queries about assistive devices used, help from another person, modification made in how task is done, its frequency and health problem if any responsible for the difficulty. Responses of "no" also query about modifications much in the way the task is performed. The result is more specific information about what adaptations are made and how technology can help.

While none of the four approaches are fully satisfactory by themselves, they provide approaches to two uses of gerontechnology, compensation and prevention, that can be utilized in developing a data base for gerontechnology.

CONCLUSIONS

This brief report presented a view of aging that emphasizes the importance of the environment, including technology, for optimal human functioning. It was argued that a new approach to epidemiology of aging and disability is necessary to fully take advantage of technology. It was further argued that the truly effective use of technology requires a change in the infrastructure of development and distribution of technology. The conclusion we may be optimistic about the value of technology for improving the health and quality of life of all people who are aging or aged.

REFERENCES


Riley, M.S. (1993), The coming revolution in age structure. First Annual Pepper Lecture on Aging and Public Policy, Pepper Institute on Aging, Florida State University, Tallahassee, FL 32306.


Tockman, M.S., Pearson, J.D., Fleg, J.L., Metter, E.J., Cruise, L.J., Rampal, K.G.,

