

Gerontechnology : fitting task and environment to the elderly

Citation for published version (APA):

Graafmans, J. A. M., & Bouma, H. (1993). *Gerontechnology : fitting task and environment to the elderly*. (BMGT; Vol. 93.458). Technische Universiteit Eindhoven.

Document status and date:

Published: 01/01/1993

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

GERONTECHNOLOGY

**fitting task and environment
to the elderly**

J.A.M. Graafmans
H. Bouma

Paper presented at the 37th Annual Meeting of
the Human Factors and Ergonomics Society
11-16th November 1993 Seattle, USA

GERONTECHNOLOGY®, FITTING TASK AND ENVIRONMENT TO THE ELDERLY

Jan A.M. Graafmans#, Herman Bouma*
#Center for Biomedical and Health-care Technology
*Institute for Perception Research
Eindhoven University of Technology
P.O.Box 513, 5600 MB Eindhoven, the Netherlands
Tel: #31-40-472008, Fax: #31-40-443335

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. Physical and mental fitness are prerequisites to the satisfactory performance of daily tasks. Functionality decreases when perceptive motor abilities or skills diminish, when task demands are too high and/or when the product characteristics, the user-interface or the environmental conditions are in conflict with human skills. The introduction emphasizes the difference between approaching the elderly as patients or consumers. A concept of social interaction and active participation is described. It is discussed which support can be offered by technology and what the state of the art in gerontechnology is.

INTRODUCTION

The last chapter (126) of Principles of Geriatric Medicine and Gerontology is titled: Predicting Functional Outcome in Older People (Williams & Jones, 1990). In the first paragraph it is stated that the prediction of an older person's abilities is a primary goal of geriatric care, as the level of function may indicate an older person's ability to cope with a particular environment. Functional decrease forces a patient to adapt in one or more ways: accept the limitation; develop new strategies to overcome the disability; move to a less demanding environment; or increase reliance on support systems such as family, friends, health care workers, social agencies and nursing homes. Although this book is of a recent date, a few comments are in place. First, the statement is based on a medical or care patient model and not on the creation of a more functional or matched environment. It is a care push instead of a client pull. The latter approach is used more and more often in human factors research or ergonomics, where the focus is on the adaptation of the task and the environment rather than on the provision of protection and help. Second, the possible solutions that can be created by technological innovations are not mentioned. It is obvious that not all problems can be solved with technology, but it might be worthwhile to seek solutions where new combinations of technical products with adapted care provisions can create independence, autonomy and comfort for the individual. A higher quality of life may be within reach; possibly even at a lower price. Matching the technological environment with the faculties and needs of the elderly is the main objective of the Gerontechnology programme as described in Gerontechnology (Bouma & Graafmans, eds., 1992).

INTERACTION AND PARTICIPATION

In the interaction of a human with the environment, the options of perception, cognition and physical and motor action are determined by the abilities and skills of the individual person. The quality of the communication of the individual with the social and technical environment is also determined by the quality of the user-interface. Here, an increasing gap arises between the range of suitable products and services and the skills of the elderly. Bridging this gap is the main challenge for a fundamental and applied research programme in gerontechnology.

Independence as a quality of life in our society is desirable for every human. This requires the capability of effectively solving daily problems, which relies not on perception, cognition and locomotion alone. Most people supplement their skills or compensate for their disabilities and handicaps with products and tools that provide a larger range of possibilities in perception, information processing and/or mobility. Products are purchased to meet daily needs as effectively and efficiently as possible. Environmental conditions also determine whether or not the optimal interaction between man and product can be achieved. Performance depends upon the joint operation of four factors (Welford 1982):

- the demands made by the task
- the capacities, physical and mental, that the operator brings to the tasks
- strategies by which capacities are deployed to meet demands
- skill, i.e. the choice and use of efficient strategies.

Every human function - physiological, psychological or social - changes with age. For quite a few functions this means a decrease of performance. Needs for appropriate products arise when the performance of a specific human function declines below a certain threshold. At the level where people encounter problems with ease of everyday activities they will be encouraged to purchase better, or more convenient consumer goods or services if available at reasonable prices. When passing the independence threshold, needs will be expressed for special health care, social support, adapted housing, aids for disabled, etc.

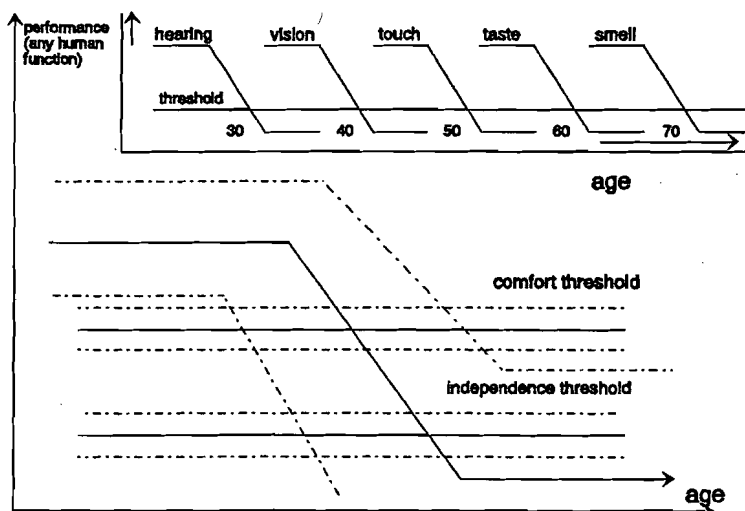


Fig.1: Normal aging processes

Therefore, it is necessary to carefully ascertain which faculties of elderly individuals are relevant and assess the distribution of these faculties in the population. Next we can try to define the critical values below which functioning in specific tasks becomes more difficult. This has to be done for as many faculties as seem relevant for normal daily life. Also, we need a better understanding of the normal physiological aging of perceptual, motor, cognitive and physical functions and we should gain a better view of which functions are responsive to training. In our discussions aimed at the establishment of the gerontechnology programme, a number of questions arose:

- Which important changes of capacities are related to age
- Can these changes be minimized, postponed or even reversed
- Are changes in strategy a solution for matching human capacities to task demands
- What are the possible effects of interventions
- What is the role of technology?

These discussions resulted in a model now serving as a framework for programme development. This model fits the concept of the development of behavior as described by Lawton (1982). This model is used as orientation into the scientific disciplines which have a possible relation to gerontechnology. Insights in the age-related changes should come from disciplines such as gerontology, psychology and physiology. The translation of these insights into task performance in complex activities is a challenge for human factors researchers. Task demands are often dictated by the technological shaping of the working and living environment. Such task demands then, have to be fitted to task performance. Moreover it becomes clear that the ergonomist can catalyse the interaction between life sciences and technological sciences and engineering.

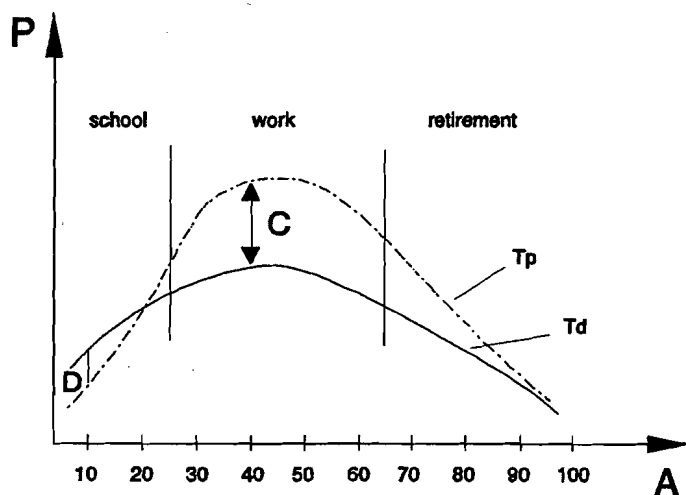


Fig. 2: Relation between task performance T_p , task demand T_d , comfort C and dependence D during human life.

The lines in figure 2 show a hypothetical relation between maximal task performance (T_p) and task demand (T_d) during human life. A positive outcome of T_p minus T_d is called comfort, a negative dependence. The scheme indicates that children are dependent during their learning period. The scheme also shows that the elderly are at a higher risk of becoming dependent with increasing age because their surplus of comfort is getting smaller. This means that, when suddenly confronted with a high task demand (like driving on a dark rainy night in an unknown area), an unexpected drop in maximum task performance and a temporary total or partial impairment might occur.

These situations can be prevented. One approach is avoidance of risk situations, probably leading to disengagement and lower levels of activity. Consequently, maximal task performance will decrease more rapidly. A positive approach might be to exercise in such a way that maximal task performance for most activities of daily life is kept at a sufficient level (mind and body "jogging"). For example, the physiological decrease of aerobic capacity can be postponed with ten years if a certain level of daily physical exercise is maintained. The intensity and duration of the exercises is not necessarily high. An additional approach is trying to prevent a sudden rise in task demands, e.g. better road signs, protection of the eyes against glare, prophylactic medication, etc.

In conclusion, one might state that a good understanding of the interplay between task demand and task performance can nourish engineers and designers with the type of information that is needed to create a functional environment, which is comfortable for the elderly. These actions can also have a trickle down effect for other age groups.

The concepts of task performance and task demand are well-known in human factors research. However, if the challenge is to fit the task and the environment to the needs and capacities of the elderly, the already multidisciplinary approach of human factors is still lacking input from social sciences.

A useful concept to include social sciences is suggested by Arber (1991) called the resource triangle. When getting older it is essential that three key types of resources remain available i.e. material, health and caring resources, which have a strong interrelationship. The absence of any of these resources acts as a constraint on the well-being of the individual and increases the likelihood of dependency. Realistic solutions can only be based upon insight in the preferences of the elderly, the way they want to arrange their present and future life and their willingness to invest in their independence, well-being and personal space.

THE ROLE OF TECHNOLOGY

What support can technology offer? Both the physical and mental (perceptual, motor and cognitive) functions of the elderly could profit from exercise. There is of course considerable cognitive training already in practice. If we could gain a better view of which mental and physical functions are responsive to training and which are less so, then we might better direct our efforts in finding the technology to aid this training.

For instance, interactive education is at present feasible. Employing systems (not to be called computer systems) which can offer individual help in training might help. The problem is not construction, but how to create a proper user-interface and to determine what functions these systems should offer the elderly. It has been shown that memory can be served by environmental and schematic support, which is of importance to technologists and designers (Craik, 1992).

Standardisation must also be stressed: it is far more important than was previously realised. This is still not recognised enough throughout industry and therefore governmental legislation regarding standardisation and normalisation would be advantageous.

From past experience, it has been found that the required information is often not present or in the form it should be. For example, designers are unaware of the visual functions of the elderly, and the elderly are uninformed as to what is available. Therefore information streams warrant consideration; needing to be organized so that they are really useful.

As a means of rapid feedback, test beds are necessary. If it is left to the market, things can only improve by timeconsuming trial and error. Test beds are required to give early feedback of what is right and what is wrong so the improvements can be swiftly instigated.

As stated before, design for the elderly can be design for everyone. It is a logical conclusion that if we take into account the characteristics of our elderly citizens, a great many younger people will also benefit.

The central question of the workshop on future actions during the Eindhoven conference on Gerontechnology in 1991 was: 'What should we do next?' In the centre of figure 3 are the products and services for a wide range of elderly users and the appropriate environment.

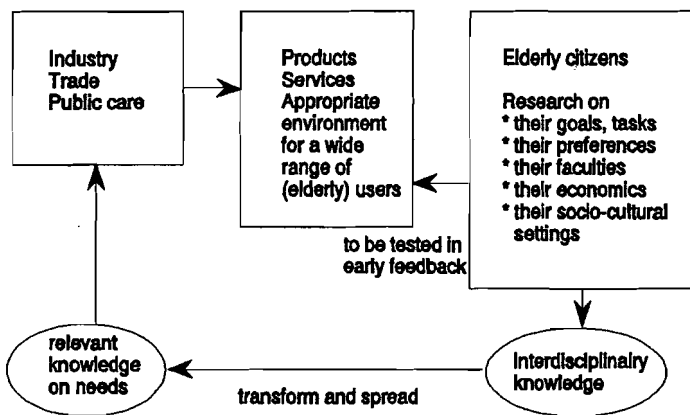


Fig. 3: Scheme of the way in which technology can be directed towards fulfilling the needs of the elderly. Arrows indicate the main direction of the stream of information. The networks necessary for the proper integration and dissemination of results are not shown. Obviously, the exchange and transfer of information is a two way or even multiway process (Scheme from Bouma and Brouwers in Bouma, 1992).

The elderly consumers are our fundamental concern: we need more information about this age group. Research projects should be undertaken regarding their goals and tasks.

Already, we have learned much about their vision, hearing etc. but, as mentioned before, we have more to learn about their objectives, tasks and preferences, what they want to do and wish to be helped with. Some of their communication needs are known, and we also have our own ideas and assumptions concerning this, although these often lack the support of real evidence. At present, information exists about their faculties and backgrounds; we know less about their economics and sociocultural settings and how this affects their views on technology and the type of technology they need. However, the available knowledge is not always relevant to industry. Take again visual acuity: it has been known for a long time what the distribution is for the visual acuity of the elderly, but if you present this information to designers, it has no meaning to them. The available knowledge has to be transformed into a usable form. For this to be accomplished, close ties are of paramount importance. We must work together in order to understand where problems exist for designers and product managers. The difficulty is that this is an interdisciplinary venture. Designers and engineers are unused to dealing with such data and therefore it must be transformed and distributed in a form that is meaningful to them. It should be stressed that products and services have to be tested in an appropriate environment to gain early feedback.

STATE OF THE ART IN GERONTECHNOLOGY

What is known and what should be done? We can adopt the statement that social interaction and active participation depend on the balance between human characteristics, task demands and environmental conditions. Then, activities of daily life, work, study and leisure can be seen as a continuous cycle in the presented model (fig. 4).

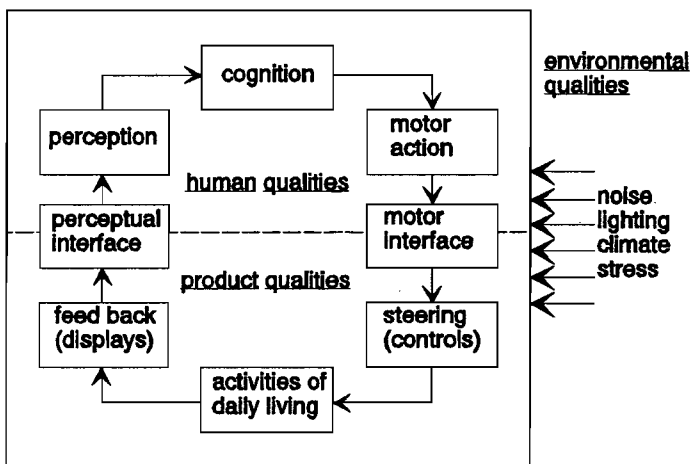


Fig. 4. Man-product environment interaction.

The quality of the interaction will be determined by the weakest link in this cycle. The contribution of gerontechnology is threefold. One obvious role for technology is in the types of research we can do to understand the aging process and how this affects the qualities of the human links in this cycle.

An even more important role for technology is to optimize the technical and interface links in this cycle by matching them to the characteristics of the aging user. A third role for technology is to create the optimal environmental conditions for the interaction.

Human qualities

Physical interaction.

At least five systems can be distinguished that are important in physical interactions with the environment, e.g. the visual, auditive, proprioceptive, musculoskeletal and central nervous system. Performance of other systems, such as the cardiorespiratory system, changes too but this has less direct influence on the design of the technical environment. Without going into a detailed description of age-related changes in these systems - these are well-documented in overview articles - a few statements should draw attention of ergonomists and engineers (Fozard, 1992):

- The average older individual is non-existent
- The more complicated the recruited human function or the task, the greater the impact of age (e.g. Fitt's law with regard to the sensory motor system and the speed-accuracy trade-off)
- Minimize the need for stooping, kneeling, pushing and pulling heavy objects or lifting them from above
- The design of physical activity systems should be motivational, challenging and fun for adults of all ages
- No combinations of training and task redesign possibilities have yet been devised for maintaining the effective functioning of older persons at work or leisure
- Requirements of aerobic fitness for particular tasks are not available in usable forms to design engineers.

Cognitive interaction.

Interaction with the environment also requires cognitive skills. Memory is considered to be very important. Memory efficiency declines are real but their effects are strongly related to the task under consideration (Craik, 1992). The decrements are slight in primary and procedural memory and in memory for frequently used facts. Episodic memory for events is relatively good if environmental or schematic support is good and there is little need for self-initiated activities. Heavy memory losses are observed in working memory, poorly supported episodic retrieval, recollection of source, and semantic memory for infrequently used facts and names.

In summary, Craik suggests three major sets of applications:

- Reduce demands on working memory by providing external displays or 'notebooks'
- Provide good schematic and environmental support whenever possible
- Encourage the use of memory aids.

Continuous training and education.

The workforce today needs a solid base of skills and education, that is constantly adapted to the rapidly changing job market and workplace environment. Older workers often fear education and training programs, especially those elderly who expected to work in the same plant and in the same production process until their retirement. Effective training and education programs should (Teegarden, 1988)

- combine remedial education with vocational training; relevant remedial education will shorten the training period
- be intensive to keep the training periods short
- make use of and add to existing skills
- include peer support and make use of older persons as instructors (Brickfield, 1984)
- not place an extra financial burden or risk on the worker
- connect with available jobs with comparable wages to previous employment.

Qualities of product and environment

The interactive quality of technical products is poor when compared to the interactive skills of human beings. There are some ergonomic rules of thumb for the design of interactive systems, but it seems that they are difficult to apply in for example the design of a cash dispenser. Instead of summing up all the design rules we know, a case is presented here to show how easy it is to violate those rules (Bouwhuis, 1992).

Cash dispensers are of great and often emotional importance for elderly people. When a system like this is equipped with an active display, like a CRT tube, direct sunlight can make the entire text unreadable. In general, high illumination levels will decrease subjective image contrast and so make text on displays hard to read, especially when observers, contrast sensitivity is reduced. The same holds for the numerical keys with brushed metal tops that do not show contrast in all conditions. During the transaction most messages are displayed on the top half of the display. Sometimes a final question (do you want a receipt?) is displayed at the bottom. The question is not directly relevant for the transaction, the user does not expect or search for it so it remains unnoticed because it falls outside the functional visual field. No answer means no money and after a little pause a not satisfactorily ended transaction. With some creativity we can come up with many more product or environmental hostilities. A good example of this was presented by Rabbitt (1988). Random crackle on telephones affected slightly deaf elderly in two ways: sometimes it causes them to mishear what is said and it makes listening more effortful and therefore harder to remember the information.

In general, environmental noise hinders elderly even to a point where peripheral sensory losses mimic cognitive disabilities.

This example confirms the necessity of a test bed. Only through direct evaluation of product usability in real life environments, coupled to a thorough understanding of the cognitive and perceptual capabilities of the users, a successful and acceptable interactive system can be devised.

ACKNOWLEDGEMENT

The authors wish to acknowledge Mariëlle Snijders, Pauline Evers, Cor Vermeulen, Ad van Berlo, Jan Rietsema and Teddy McCalley for their critical reading and valuable comments on the manuscript. Special thanks are due to Tonny Brouwers who restricted the schemes to essentials. Jeanine Waterreus created the document in its final form.

REFERENCES

- Arber S., Ginn J.: *Gender and later life. A sociological analysis of resources and constraints.* Sage Publ Ltd London, 1991.
- Bouma H., Graafmans J.A.M. (eds): *Gerontechnology. Studies in health technology and informatics.* Vol 3. IOS Press Amsterdam, 1992.
- Bouwhuis D.G.: Aging, perceptual and cognitive functioning and interactive equipment, in: Bouma H. Graafmans J.A.M. (eds): *Gerontechnology.* 1992.
- Brickfield C.F.: Attitudes and perceptions of older people toward technology, in: Robinson P.K., Livingston J., Birren J.E. (eds): *Aging and technological advances.* Plenum Press New York, 1984.
- Craik F.I.M., Bosman E.A.: Age-related changes in memory and learning, in: Bouma H., Graafmans J.A.M. (eds): *Gerontechnology.* 1992.
- Fozard J.L., Metter J.F., Brant L.J., Pearson J.D., Baker III G.T.: Psychology of aging, in: Bouma H., Graafmans J.A.M. (eds): *Gerontechnology.* 1992.
- Lawton M.P., Windley P.G., Byerts T.O. (eds): *Aging and the environment: Theoretical approaches.* New York Springer Publ Co, 1982.
- Rabbitt P.M.A.: Social psychology, neurosciences and cognitive psychology need each other; (and gerontology needs all three of them). *The psychologist; Bull of the Brit Psych Soc*, 12, 500 - 506, 1988.
- Teegarden S.: The mature worker within the mature industry, in: Lesnoff-Caravaglia G. (ed): *Aging in a technological society.* Vol VI. Frontiers in aging series. Human Sciences Press Inc New York, 1988.
- Welford A.T.: Motor skills and aging, in: Mortimer J.A., Pirozzolo F.J., Maletta, G.J. (eds): *The Aging Motor System.* Praeger New York, 1982.
- Williams M.E., Jones T.V.: Predicting functional outcome in older people, in: Williams W.R., Andres R., Bierman E.L., Blass J.P. (eds): *Principles of Geriatric Medicine and Gerontology.* 2nd ed. McGraw-Hill Inc New York, 1990.