Design for Person-Environment Interaction in Older Age: a Gerontechnological Perspective

D.G. Bouwhuis PhD
Human-Technology Interaction Group, Department of Technology Management,
Technische Universiteit Eindhoven, P.O.Box 513, 5600 MB Eindhoven, Netherlands
e-mail: d.g.bouwhuis@tue.nl

D.G.Bouwhuis. Design for person-environment interaction in older age: a gerontechnological perspective. Gerontechnology 2003; 2(3):232-246. Gerontechnology is a new interdisciplinary field of research in which technology is directed towards aspirations and opportunities for older people. Consequently, gerontological and technological research are inherently connected. Demographically, the aged are an increasing section of our society with specific but not homogeneous characteristics. In principle they might benefit much from innovative technological research. This article tries to show that this is usually not the case, and quite likely, will not be the case in the future either. The most important reasons are the perceptual world of older people, and the nature of the technological design process. The design process, or rather the product creation process in its current form, is particularly refractory to changes that will benefit a Design for All strategy. This is not to say that the circumstances of older people in the future will not be any better than nowadays, from a technology point of view. Yet, a persistent backlog with respect to younger members of society will be unavoidable. Considerable changes in the design process will ensue when applications, based on situated and distributed control systems, will support activities of older people in their own environment. The behaviour of such systems, inasmuch as it emerges from continuous interaction with the inhabitants of the home, is essentially the product, and this is where gerontechnology can make important inroads. On the basis of recent research it is interesting to note that the existence of gerontechnology has led to renewed attention for motivation, decision, and choice, giving due credit to older people as the deciding agents of their own course of life.

Keywords: cognitive aging, design for all, agent technology, choice theory, development

THE WORLD OF THE OLDER ADULT

The social context of older people

Throughout the ages, and certainly from the Antique World onwards, the status of the elderly in society has always been a topic of lively debate. Naturally, this is due to the period of time they have been able to influence society, to their accumulated responsibilities, and to their range of expertise. They may be connected with traditional positions of dominance in society and be noted for singularity, but also considered as largely disengaged from society, bereft of relatives, stricken by poverty or afflicted by physical frailty[1]. They can be seen as valuable assets to the family, as counsellors for the social community, but also as demanding care and being unproductive, especially when times are hard. In this century, and in particular in the last decades, the issue of aging in society has gained in importance for a number of reasons.

An important factor is that by technological and behavioural factors, such as improved hygiene and food preparation, better sanitation and living accommodation, longevity has risen substantially,

while the dwindling birth rate has also made the relative size of the group increase. Both absolute and relative numbers of older people are rapidly increasing in the whole industrial world. Key figures for the Netherlands are an increase of the 65+ years old from 1 million (9%) in 1960, via 2 million (13.2%) in 1996, to 2.5 million (15.2%) in 2010. After 2010 the post WWII baby boom will create an even stronger increase to 3.3 million (19.2%) in 2020, while the percentages seem finally to stabilise at 25%. For the 80+ this was 0.16 million (1.4%) in 1960, rising to 0.48 million (3.1%) in 1996, and 0.61 million (3.7%) in 2010[2-6]. Also, greater longevity in women will result in about twice as many females than males in the 70+ group.

Next, improvements in the areas of income, pensions, and benefits for older people have resulted in a steady increase in the spending power of older people, many of whom can be considered affluent. These phenomena are representative for most countries in Western society. In human history it is only now that the social and economic situation allows for a few decades of good health, vitality, and comfort for a large category of older people. This period of comfortable old age, roughly stretching from 55-85, is now referred to as the third age, or `the crown of life'[7], and is followed by the fourth age (85+) when older people generally become more care dependent. In the Netherlands the age of 65 is still considered to be important in being the age of formal retirement[8]. But there are other changes beyond numbers and economics.

Lifestyle and culture

From a sociological point of view one of the most important developments in society throughout the centuries is the birth and rise of youth culture[9-12]. This was initiated by the remarkable increase in spending power of American youth in the post-war years, especially in the fifties. At first this was limited to clothing, audio equipment, and cars, but gradually expanded in many different directions. Many Western countries followed and in a matter of decades youth culture has not only come to determine fashion, products, and culture, but has also created a multifaceted economic industry that largely ignores other population groups. Logically, this neglect expresses itself most clearly in the aged population. From that perspective, age as a culture-determining factor is a relatively new phenomenon, leading to a position of older people way beyond the centre of developments in society, contrasting with age-old and established traditions. The concept of wisdom, a topic with wide ramifications (see[13] for a review) seems no longer a current one in policy concerning the aged. From the perspective of the dominant trends in current day society, older people are too often seen as characterised by insufficiency and deficits[14]. Rapid changes in society frequently lead to situations bordering on the issue of emancipation. The establishment of awareness, and especially self-awareness, in the parties concerned seems a point of necessity.

The role of technology

Another factor that has profoundly influenced the life of old and young differentially is technology. When intensive interaction with technology takes place in the phase of life that the maturing human is heavily involved in learning, the functional and the control models of the type of technology can be effectively internalised. During further periods of life the person can apply such knowledge effectively. To the extent that technology is introduced later in life, its use and control will be less well integrated in the existing representations that were established during maturation of the neural organisation.

The phenomenon that technology learned in early adulthood will largely determine the nature of, and habits in the interaction of the person with the environment in later

life has been called 'Technology generation'[15]. The concept of Technology generations has recently obtained considerable empirical support by the research of Docampo-Rama[16]. First it was established if, and how, generations of control surfaces of technical products could be identified. This appeared possible in a relatively unambiguous way, e.g. going from purely mechanical control, via electromechanical control, to 'soft key' control. An interesting dissociation could then be observed between two dependent variables by which usability can be measured. First, it appeared that the time it takes older people to learn a new and unfamiliar interface style is increasing monotonically with age. However, the error rate associated with a new interface increased stepwise, by itself unrelated to age. The increase in errors was found to be positively related with the unfamiliarity of the interface style. This phenomenon may be explained by assuming that the number of errors is a reflection of the degree of understanding, or experience, whereas increased slowing is only due to a general aging effect.

Technology itself, however, undergoes an ever faster change of generations, by which the critical age, at which new technology becomes less usable and transparent, is continually shifting downwards. This phenomenon is aggravated by the complexity that increases with functionality and, paradoxically, limits productive interaction with new technology. While older people benefit from increased functional specialisation, they lose neuronal plasticity at the same time[17], which reduces the flexibility to cope with new forms of interaction with technology. In this context it is important to notice that women tend to be even more wary of complex technology than men[18], which emphasises their precarious position in a technology-driven society.

Consequently, next to culture changes, technology-borne changes also affect the position of older people in society. Though aged people are certainly benefiting from specific technical products in their daily life, it is undeniable that the pace at which current technology is proceeding is outrunning the capability of ageing persons to successfully integrate its potential benefits in their daily existence. The accessibility and the perceived usability of new technology, to which no end can be discerned, is being reduced at the same measure as functionality and complexity expand. Paradoxically, the increased power that technology provides, or is intended to provide, runs counter to the possibilities that people see to control it, i.e. perceived control seems to fade in view of irrevocable technical progress.

No one can escape the profound effects of the prevailing technology. The human generation in which a successful diffusion of a specific technology has taken place may observe the difficulty of its older members to cope with it, but at the same time the seemingly successful interaction in its younger members. From this the completely unwarranted conclusion is often made that the technology gap will close up itself as the young generations have reached maturity. In effect, those holding such an opinion are victims of their own expertise built up in their formative years[19] inasmuch as it is assumed that technology will not change. Though the direction of technology development is uncertain in almost all of its aspects, except for the most global ones, the most certain thing about it is that it will change. Older people will always experience usability problems; now, and ever.

OPPORTUNITIES AND CONSTRAINTS; DEVELOPMENTAL CHANGES IN AGEING

Self-fulfilment and potentialities

Demographic and statistical evidence indicates that the majority of older people nowadays, and increasingly so in the future, do not fit the stereotype of people

with a loss of some sort. The larger part consists of mentally and physically healthy autonomous adults between 55 and 75 years of age. Also, for those over 75, autonomy and health are more often the case than dependency and limitation. A higher level of development, as a result of better education, is creating a generation of older people, with an increasing share of women, that has 'discovered' the possibility for opportunities. The second half of life is also one of liberation from older duties and obligations that can be employed for self-development and expansion[20]. Consequently, there are many reasons why the majority of older people do not feel a need for support and assistance for things that do not go so well, but predominantly for a meaningful deployment of their capabilities, on the basis of all available possibilities. It may be seen as questionable whether older people are indeed a group that is limited in their possibilities, and view their limitations in this way, or whether they aim at retaining their preferred activity pattern, and which issues in life they consider to be worth pursuing[21,22].

It seems, therefore, opportune to look for ways to reduce the gap between the ever-expanding realm of technology and the self-fulfilment of older people, a realm in which currently the young are the main beneficiaries. In this context it is relevant to note that developments in the working place head in the same direction, inasmuch as technical training for the older workers is discontinued, and retirement is severing further contacts with the infrastructure of society. Time and again it appears that this disjunction is an entirely artificial one, one that does not at all reflect the true potentialities and ambitions of older people.

Though old age then may be considered as the attainment of full maturity, as having acquired knowledge, life experience, expertise and skill, longevity also has a down side. On purely probabilistic grounds older people are more likely to have contracted diseases or to suffer functionality loss of various kinds. Basically this is expressed more as increased variability than as inherent limitation of functionality. But notwithstanding the high inherent variability among the aged, they show a higher incidence of functional losses than younger groups, and increasingly so after the age of 85.

Personal functionality

The view that older people are different from younger people is supported by the inherent course of development of the human organism. During the life span, the human body and the human mind are continuously subject to changes in practically all aspects of perceptual, cognitive, and motor functioning[23,24]. This multitude of changes as a function of age has been adequately documented, e.g. in the different topics that occur in three subsequent editions of the Handbook of the Psychology of Aging[25-27]. At the inception of human life these are growth and maturation, and structural changes in the anatomy and functioning of body parts and organs. On the perceptual level we may speak of 'body-scaled' perception, which indicates how the parameters of the perceptual system correlate with the anatomical and motor development of the body to realise effective functioning at a particular stage of development[24].

Not only physiological aspects mature slowly (effectively till after adolescence), but perceptual and mental functions only attain full functionality in early adulthood. In contrast to maturation there is a variety of metabolic, biochemical, and physiological processes that lie at the source of continuous changes in the body, some of which only become noticeable at a later age. What is usually regarded as a typical ageing phenomenon is often the late identification of a feature of continuous change and development, that may be functional

in early youth, e.g. in body-scaled perception. Unfortunately, it appears that the gradual changes after adolescence do not have an equivalent ecological benefit as the changes in early youth: body-scaled perception is effective only during the first few years of life.

Perceptual developments

For practically all sensory modalities perceptual acuity diminishes slowly from about the mid-twenties, and takes on a more progressive character after about sixty on average, but with a large variability, both in time of onset and in extent. This also holds for more complex functions like speech comprehension, demonstrating again the developmental nature of the changes. The slow and mostly imperceptible changes over such a long time unavoidably lead to a different perception of the environment, and this age-related status of the senses leads to what is called a 'Perceptual world' specific to the perceiving person[24]. The perceptual world is not limited to what can be seen or heard, but also encompasses the experience of the flow of events. Whereas cognitive slowing is an unavoidable consequence of aging, it makes itself felt as a very gradual acceleration of external events. Time seems to flow faster, events seem to be shorter lived than they used to before. The frequent complaints about the fast changing subtitles on TV programs are a case in point. Inasmuch as the perceptual world is a purely subjective one, different forms caused by e.g. sensory deficits may make communication about the environment difficult. The effects of this show up frequently in designs that may cause substantial difficulty for the aged and/or perceptually handicapped, e.g. remote controls, automatic teller machines, and complex video and audio equipment.

Cognitive developments

On the cognitive level there are two, slightly contrasting, developmental trends. This may be exemplified by the distinction between 'crystallised intelligence' and 'fluid intelligence' [23,28-30]. Neither have much to do with the concept of intelligence, but refer to types of task and function. On the one hand people continue to acquire new knowledge, improve skills, and extend their vocabulary. Even at a high age people are quite able to use this store of knowledge, and may score higher than younger people on tasks requiring vast stores of information and establishing relations between pieces of information. This kind of operation is supposed to be mediated by crystallised intelligence. In tasks where speed of processing is necessary, however, younger people are both faster and more accurate than older ones[31,32], but it also transpires that when given more processing time, older people can attain the same level of accuracy. Speed of processing thus, seems to be the crucial difference between older and younger persons, which lends credence to the idea that the perceptual world is also typified by its own temporal course of events.

The frequent complaint of aging people about their forgetfulness essentially goes back on the same timing problem. While primary memory is hardly affected in old age, it must be realised that this involves retaining a few items with minimal processing. As soon as more processing is needed, and the number of items to be remembered increases, memory performance decreases rapidly[33]. It appears that when more encoding time is available, memory performance improves notably[34]: it appears that older persons tend to spend a longer time on encoding, but estimate that this period of time is sufficient for successful recall, which actually it is not. Yet, the encoding time taken corresponds to the time they took in earlier phases of life, which has largely become automated and is hard to change.

Norms and values

The totally different living situation of the

young and old also leads to a substantially different approach in formulating and applying goals in life, with the corresponding norms and values[20]. To the extent that these differ more, they will intensify the perceived distinction between younger and older people, as goals and values lie at the basis of many daily decisions and choices. Objects and events in the outside world have different values attached to them for older and younger people, which, again, extends the idea of the perceptual world, that is hard to know for a person who has a different one. It means that not infrequently there is a shrinking horizon of life, in terms of time as well as of space. The extent to which this is compatible with the aspirations of the individual raises the question as to how this compatibility can be optimised.

Choice and Motivation

Though increasingly older people are involved in usability studies, especially in the framework of 'Design for All' or 'Universal Design', the results of such studies are of an ergonomic nature, and actually shed little light of the motivation of older people. Yet, according to popular belief, such studies could be confounded by motivational factors that cannot be properly controlled. From this point of view, motivation of older people should have been studied more often than it actually has been. It has been frequently noted in decision theory that children badly tolerate delayed rewards. One basic example is the following. Children confronted with the question whether they prefer one candy bar now, or two tomorrow, almost uniformly choose for the immediate reward. Adults, encountering suitable rewards in the same temporal schedule have a greater tendency to choose the larger reward to be obtained later. Tentatively, it has been assumed that the older people get, the more patient they will become, sadder perhaps but also wiser, and usually choose the larger reward. There is strong evidence now that this is not the case; conversely, older people seem prepared to act in a more impatient way than children. There is an incontestable logic behind this, which is the limiting role of remaining lifetime. As people get older they have an increasing awareness of impending limitations, or even death. Delaying a reward would thus be counter-productive, as it would shift out of reach. Obtaining a small reward is at all times to be preferred over missing a large one. This time perspective is entirely different for children. Melenhorst[35] could establish that the value of future rewards decreases linearly with time, and that the slope at which it goes down, increases significantly with advanced age. Though frailty and health limitations could play an important role here, it appeared that the age effect was stronger than the health effect. Still it has to be borne in mind that health is strongly negatively correlated with age.

Communication

Communication is the glue of social networks. In it, many different functionalities of the human being come together, and they are of a perceptual, cognitive, linguistic, and motoric nature. Communication is further deemed so important that the greater part of technological development is directed at communication devices. The forms of communication stretch from bit exchange on the lowest level of abstraction to multimodal broadband interactive TV programs. Present-day society seems to ride on the beam that carries communication. Yet, these form only the necessary means by which communication can take place, whereas the goal of communication is of a rather more psychological and emotional nature. In other words, communication partners focus on content; not form. The physical and physiological limitations that confront the old are often a reason for the claim that modern communication devices would obviously be good for older people, much more so even than for

younger ones. The widely observed fact that older people rather shy away from these modern devices, is commonly attributed to the difficulty of use or the low social acceptance among peers. These are ergonomic and social concerns, and whereas the ergonomic usability issue might be tractable, the social issue is more refractory.

If, however, the content of communication is taken as central, then an immediate link may be made with the concept 'Optimisation by selection and compensation'[13,36]. Surveying the daily behaviour of older people, mostly of those who lead an active life, produces the observation that what they do is meet. Meet with friends, hobby groups, choirs, golf mates, hikers, relatives, friends in need, friends in hospital. Many of these activities are embedded in a fixed schedule, implying a degree of mutual dependency but also of obligation. Whenever the frequency of these contacts has to be reduced by mobility restrictions, distance, or sickness, older people are very selective and critical in what contacts to retain, and which ones to discontinue on a regular basis[35]. In this sense they optimise the emotional value of those contacts that are sustainable in their state of physical health. Often this may be a difficult and heart rending decision.

In this perspective the cost of communication would not seem to be so important; it is predominantly the benefit that has to be optimised. This is exactly what has been found[35]: older people choose that method of communication that yields the highest perceived benefit. Naturally, that is mostly the one they have grown accustomed to. Clearly this has little to do with ergonomic or usability issues, it is rather more a matter of visible and well-known benefit. Older people seem not to use advanced technology products because they are ergonomically complex, but because they fail to see what the use of that product is for their needs.

Finally there is the issue of what still can be enjoyed in certainty, considering the impending limitations of old age and ultimately the end of life. Does it pay to invest cognitive, perceptual, and learning effort in mastering a new product with an unknown benefit, which will prevent the old technology novice from carrying out the activities that have been carefully selected as preferred and sustainable ones? Such a question has profound implications for a gerontechnological approach that will effectively support people confronted with age-related limitations.

The nature of ageing

The various theoretical approaches in characterising the behaviour of aging people and the changes occurring during the lifetime of the human being enable now to draw up a framework for gerontechnological research.

(i). Behaviour in general is a continuous interaction of the person with the environment, enabled by psychological and physiological factors on the one hand and by social and physical factors on the other: -situated behaviour[37-38].

(ii). Inasmuch as there is a reduction in the personal area of functioning, it becomes necessary to select (more carefully) from among the available forms of interaction and behaviour: - the process of optimal selection[13,36].

(iii). Faced with a reduction of the interaction repertoire, compensation mechanisms can be employed, varying from vicarious use of the senses, or action patterns that make use of acquired knowledge and expertise: - the process of compensation[36].

(iv). Interaction of the person with the environment and the preparedness to learn new forms of interaction is an increasing function of the degree to which the result of actions matches goals and values of the person, and a decreasing function of the cognitive complexity and energy expenditure

connected with the actions to be executed: - the issue of action-preparedness, perceived behavioural control[39] and proactivity[40-41].

(v). Time is a scarce resource. There is an increasing mismatch between the time course of events and time needed for processing which is strongly compounded by event complexity and the demand level of processing: - the issue of situated time allocation[34].

(vi). In choosing their actions, older people go for the associated benefits, that should be known, meaningful, and certain. Benefits count heavier than costs. It is rather lack of benefit that keeps people from doing specific things, than the associated costs. Older people balance critically the obtainability of a benefit and the opportunity they have to enjoy it.

THE PRODUCT CREATION PROCESS AND KNOWLEDGE OF USERS

In the previous sections it has been argued that the changes that accompany the course of the life of the human being necessarily correspond to changes in the way the human being interacts with the environment. Objectively, as appearing from psychophysical and psychological measurement, these changes are always there: sometimes modest, sometimes striking and fundamental. Nevertheless, from the viewpoint of an individual, the surrounding world shows a dependable continuity. Even while the world may change, the basic outlook of life for an individual is that he or she is the same as before and that, except for accidents or sudden disabilities, changes are only slight or unimportant. In this way the subjective idea of continuity conflicts with the objective changes that take place in diverse fields of functioning.

The designer

In this respect it is interesting to consider who is actually designing products in current-day society; i.e. the designer. The designer also has a brief, or at least a design goal. This involves, next to the functionality of the product to be designed, an idea of what the typical users are for that type of product. But even the term 'functionality' already relates to behavioural possibilities of human users of the product. Thus, two types of knowledge can be distinguished: knowledge about the design and the operation of the product, and knowledge about the users of the product. For the first type of knowledge the designer is usually well equipped by training, expertise, and industrial support. For the second type, knowledge of the user, this is a very different matter. In the case of either relatively simple products, elementary tools, or highly specialized products, user knowledge needs only be minimal, but for products with some complexity user knowledge may well be essential.

It has to be conceded that this user knowledge is mostly completely absent. First, designers are frequently young; for various reasons. They are cheaper to employ than older designers, which is one way to cope with the expensive development process, especially in the early stages of a design process, when actual scheduling is still infeasible. Also, at a young age designers are seen as being creative and less restricted by design conventions than older ones. But the young age also implies that there has normally been no time to become familiar with differences in human users.

Now, obviously, there is one important source of knowledge about the user: it is the designer him- or herself! Knowing your own perception, interaction, and knowledge is the most natural vantage point for considering those of other people. There can be no more intimate source that would give similar information. In this way personal psychological, perceptual, cognitive, and motor functioning of the designer provides that standard to which the users of the product should accommodate themselves.

This is not seen as accommodation, but as the normal, predictable way to use the product successfully. And this standard usually corresponds to an age at which most of the human faculties work in an optimal fashion. This is the worst possible example of what human performance is throughout the lifetime. Essentially, on average, behavioural efficiency is lower at all other ages. In fact, looking at the professional environment of the designer, an empirical law could be defended that 'designers design for their age peers'; it is the group with which they identify and that forms their subjective representation of the social environment at large.

The development process

One other reason for the limited contribution of user knowledge is the fact that in most cases the product development team is headed by a person with a technical background. When Donald Norman was a research fellow at Apple, he observed that when a new application or product had to be developed, preference was invariably given to a technician or engineer to head the development team, even when more suitable candidates were available. Though there are frequently no good arguments to support such a preference, it causes almost invariably a lack of user involvement in the design process.

An argument sometimes stated, that is related to user involvement, holds that systematic user involvement in the design process can lead to significant delays in development, as early user evaluation may indicate modifications that were not foreseen, and so cause unacceptable investment and time overruns. This position is not supported by empirical evidence. In actual practice user involvement seems rather to reduce development time, as well as development cost[42]. Nevertheless, from a technical point of view, in the planning of a product development cycle that contains non-technical components, not directly under control by the developers, those same components are usually considered as inherently uncertain and as a risk that cannot be taken. Whether this point of view is correct or not is immaterial as long as it appears to be remarkably stable over the years and shows no signs of improvement.

The economic constraint

One additional argument not to spend too much effort on what is considered to be extra development outlay for a wider and more variable consumer group, is the well-known economical rule to have the marginal yield covered by marginal cost. This means that the investment spent in improved features should be earned back by increased sales. The uncertainty inherent in this strategy, together with the unavoidable cost cutting that takes place during any product development cycle, means that extra features will always be cut. It should be realized, however, that this does not mean that the 'improved' version would indeed improve product handling, or would sell better as a result of easier handling. Ease of interaction usually does not depend on simple and single features but emerges rather from an architecture that is based on a product view focusing on the ease of human interaction.

A final problem is that market pull is generally coming from groups that experience no usage difficulties in the control and handling of new interactive products. For these groups the designer's self-image is well suited, and burgeoning sales, one example of which is the mobile phone, may strengthen the perceived correctness of this view considerably.

Fragmentary user knowledge

In this respect it has to be admitted that knowledge about behaviour and interaction of older people, despite much research and concomitant results[25-27], is still very fragmentary, and is mostly not directly suited to guide the design process. Despite early reservations about the cost

of the use of mobile phones by older people, it appeared that they were excellently suited for emergency calls, for which otherwise expensive provisions had to be taken. Seeing the obvious utility of mobile phones some older people purchased and used them with great abandon, only to find that the small size of those frequently made it hard to find them, exacerbated by a degree of forgetfulness of the owner. The obvious solution, to call the mobile phone via the wired network so it can be retrieved by the sound it makes, is not always productive as batteries may have gone flat. Scenarios like these do not feature prominently among mobile phone designers and additional features to solve this type of problems will normally be seen as unrealistic. Yet, if for safety reasons some extra features are integrated in the product, they need not be productive either. One example is the warning beeps that sound when a domestic appliance is overheating, or has reached its set temperature. In a survey conducted in Japan on these auditory warning signals it appeared that the majority of them had frequencies of 1000Hz, 2000Hz, and 4000Hz. For physical reasons the sound emitters for 4000Hz are smaller and cheaper to produce and install than those for 1000Hz and 2000Hz. However, 4000Hz may well lie outside the frequency band that is still audible for a sizeable proportion of older people, who will consequently not hear the signal at all[43]. Understandably this may pose a serious hazard risk.

Does ergonomics matter?

One other sobering thought is that many products enjoy enormous popularity despite their low ergonomic qualities. Examples can be found in widely used software applications that would fail any systematic ergonomic evaluation and be classified as totally unsuitable for professional or personal use. An imposed requirement, or social acceptance, can apparently overrule ergonomic limitations successfully. In this respect it is interesting to note that European consumer tests of mobile phones on average rate the usability of mobile phones as 'good' or 'reasonable', with practically no exceptions. In actual ergonomic evaluations, due to the cumulation of functionalities in ever smaller phones, the usability can only be rated as insufficient. This situation, sometimes gladly acknowledged by even adolescent users, has not diminished the mobile phone's popularity to any degree. Many concrete arguments have been adduced to explain the mobile phone's popularity, but on a more global level the finding[35] that choice and usage of an application depend largely on the perceived utility, or benefit for the user is one of the few experimentally supported explanations. Utility does not reside in ergonomic qualities, though they may play a role. Once the ergonomics of an application or product are taken for granted, bad or good, the perceived utility takes over. It is this state of affairs that makes designers all-powerful.

THE CHALLENGE OF GERONTECHNOLOGY

While gerontology provides an important step forwards in the systematic description and explanation of ageing processes, it does not take into account a number of driving forces that determine tomorrow's society, in which older people will form an ever increasing part. Many disciplines touch upon the challenge of an ageing society, but show as yet but little integrative force. To the extent that technology has a large impact on the shaping of future society, it seems particularly opportune to integrate technological research with behavioural-, health-, and economic sciences in an attempt to provide more broadly based solutions for the older population[45]. Gerontechnology captures the essence by aiming at technological developments that might improve the daily living environment of older people. Gerontechnology is a double-edged approach[45-47] in that it supports the current

Product Creation Process to optimise design for older users, but also creates new forms of technology motivated by the specific nature of the life situation of the old. The latter includes the professional working life and the private life situation.

Currently hardly any attention is paid to the various groups of older people when markets are segmented, and beyond that, there is the stigma in many companies not wanting to be associated with the older consumer. Even if that ever was a realistic image, it certainly is not valid these days. Soon industry will recognise the assertive and powerful older consumer. The travel business already exploits this market and banks and insurance companies are soon to follow. It is worth noting that in these cases product development is practically absent, as mostly the products exist already and can easily be adapted to suit different consumer groups.

The role of information and communication technology

Though the central position of information technology in current-day society is incontestable, the actual and practical use of particular applications for specific groups is much more doubtful. Some applications are only accessible for a very limited group of users, while the full potential of the technology ought to be of benefit for many groups in society at large[48]. Yet, various forms of information technology seem to be of inestimable value, sometimes especially for the older people. The foremost example is the telephone, which is often seen as the most reliable lifeline to relatives, friends, and service providers. Other devices that have an indispensable place in the home of older people are radio and television.

It is, however, unmistakable that the accessibility of present-day information technology for the older people in particular is so low that it prevents significant extensions to their communicative behaviour[49]. An even more important issue is that of the perceived lack of benefit that minimizes motivation to employ new forms of communication to their full extent[35].

Gerontechnological research objectives

Research should concentrate on aging issues of a social, interactional, and physiological nature. The first aim is to improve the quality and frequency of communication and to increase, or at least to maintain, the size of the effective social network of the ageing person to improve the integration in society and to support self-fulfilment. This should counter the effects of the gradually but ever decreasing social network that increases isolation and puts limits on fulfilling needs and ambitions.

There is also the aim to provide effective support in case of the loss of behavioural functionality. Loss of functionality reduces the interaction bandwidth of the person with the environment, which, in turn, leads to loss of independence and increases the constraints of the environment on the person.

Finally, an important aim is to optimise the health state, coping with the slowly increasing likelihood that physical discomfort will occur. A poor health status directly leads to diminished well being but can also severely reduce the person's actions and mobility.

Consequently, from a social, an interaction, and a health perspective, independence and well being are targeted as the main objectives for optimisation, both of which may express themselves on different levels of the person's existence in interaction with the environment.

Adaptive information and communication technology

On a global level a main research question is how personal independence and well being can be durably improved by making use of adaptive information and communi-

cation technology specifically tailored to the life situation of older people. Three research areas are involved here.

On a first level there is the need to develop and evaluate monitoring tools and methodology. Self-thinking monitoring tools should provide an assessment of the person's state in terms of health, communication, and expertise, as well as of the state of the environment wherever relevant, related to the type of monitors.

On a second level the information, the recommendations, and the support actions need to be adapted to the person by means of an adaptive information and communication tool. Such a tool should conceivably be based on an interactive information system[50-51] with domain modelling capabilities and with an adaptive instructional tool, that operates from an autonomous situated agent architecture. A desirable property of such a system would be the ability to take the initiative in a dialogue, not only when need arises, but also when such is recommendable in view of a person's momentary or general action potential.

On the third level attention should be given to the design and evaluation of persuasive communication and effectiveness of support provided by the tools. Essentially, this area involves measuring the impact of interventions, recommendations, and information in terms of durable behavioural change in the direction of heightened independence and improved well being.

Meshing design and gerontechnology

Seen from a functional perspective we can speak of situated technology, where any action, operation, or change is the joint result of the person's behaviour in direct interaction with the environment. In principle, of course, the monitoring tools are (quasi-) continuously assessing environmental variables and as such are expressing part of the person's context. In general, parts of the relevant person's environment, or the health state are represented in a domain. Autonomous situated agents that compose the basic architecture would then be operative in a configuration that is directly tied to the actions of the person and the state of the context, mediated in turn by the monitoring tools[51]. Inasmuch as the level of personal control by the user can be manipulated flexibly, it is a challenging research question how well autonomous systems of this type can adapt themselves to the needs and desires of their users, and how helpful they can be in attaining a level of functioning that otherwise would be infeasible.

The nature of the drawing board

Considerations like the above are not seen as guidelines for concrete product design, and to be beyond the concern of functional requirement specification. There appears to be a distinction between a behavioural scenario and the functional significance of an interactive product. Scenario builders and product designers usually claim to complement and support each other; in actual practice there is rarely a productive interaction at all, largely due to the different levels of abstraction on which they are operating. What seems to be clear is that future provisions as sketched above cannot be implemented as a single, but perhaps multifunctional product. On the contrary, they will be composed as a collection of tightly integrated, networked nodes, each of which may be a product with a specific functionality bandwidth. Its operation will not always be predictable inasmuch as it will depend on the interaction between the user and the control tool that resides in the environment as a distributed system. In current parlance, systems like these are said to provide 'ambient intelligence'[52].

The important difference between provisions like ambient intelligence or situated control systems and traditional products is

that the latter do not change their operation as a result of the owner's usage. In the former, it is the result of the provision emerging in close interaction with the user that is essentially the product; not the technical components. This property modifies the role of the product designer in a substantial way: no longer the responsible person for one specific product and its functionality, but for one of many contributions of a composite system that will evolve a behaviour in conjunction with, and in support of the person living with it.

Will this solve the designer problem in its consistent withdrawal from or rejection of Design for All? The basic question is then who will be the designer of the composite system, and what will be the nature of the constituent components? Gerontechnology has an important role to fulfil in filling exactly this gap.

Research that would effectively support such 'design' activities should combine measurement and evaluation of behavioural change, personal control, and the establishment of the durable and consistent aspirations in the life of the aged[20,22,39,53]. Central issues here are:

(i). The analysis of perceived costs and benefits[35],

(ii) The related expectancy-value systems[54],

(iii) The size and nature of the social network[55,56].

Summarising, the specific technological tools will have to allow for information provision, selection, compensation, and active support, while on the behavioural level these in turn will have to lead to improved personal behavioural control of the older person of her or his environment in daily life situations and in the professional working place. In practice this implies that the older person will be able to run her or his daily environment independently for a longer time than would be possible otherwise and in a state of improved well being, and also be able to lead a life in harmony with personal ambitions and needs.

Acknowledgement

Valuable comments on the draft of this manuscript were provided by H. Bouma, J. Fozard, and C. Vermeulen and three anonymous referees, while the final text benefited much from discussions with A.-S. Melenhorst.

References

1. Knipscheer CPM. Zelfstandigheid en ouder worden, een inleiding. In: Baars J, Knipscheer CPM, Schuyt ThNM, editors, Zelfstandigheid en Ouder Worden. Utrecht: Lemma; 1994. p1-11
2. Eurostat. Demographic Statistics. Luxemburg: Eurostat; 1994
3. Eurostat. Demographic Statistics. Luxemburg: Eurostat; 1996
4. CBS. Statistical Yearbook of the Netherlands 1994. The Hague:SDU; 1994
5. CBS. Statistisch Jaarboek 1996. Voorburg: Centraal Bureau voor de Statistiek; 1996
6. CBS. Statistisch Jaarboek 1997. Voorburg: Centraal Bureau voor de Statistiek; 1997
7. Laslett P. A fresh map of life: the emergence of the Third Age. London: Weidenfeld & Nicolson; 1989
8. Vermeulen CA, Bosma AMM. De Gezondheid van Ouderen; Epidemiologie en Beleid. PhD Thesis University of Amsterdam; 1992
9. Fiske J. Television Culture. London: Methuen; 1987
10. McQuail D. Mass Communication Theory. London: Sage Publications; 1994
11. Lull J, editor, Popular Music and Communication. London: Sage Publications; 1992
12. Garssen J. Demographics of youth. (in Dutch) Bevolkingstrends 52. The Hague: CBS; 2003; p11- 20 www.cbs.nl/nl/publicaties/publicaties/maatschappij/bevolking/b-15/b-15-0301.pdf
13. Baltes PB. The many faces of human aging: toward a psychological culture of old age. Psychological Medicine 1991;21:837-854

14. Perlmutter M, Hall E. Adult Development and Aging. New York: Wiley; 1992
15. Sackmann R, Weymann A. Generations, Social Time and 'Conjunctive' Experience. In: Becker HA, editor, Life Histories and Generations. Utrecht: ISOR, Faculty of Social Sciences;1991. p 247-274
16. Docampo-Rama M. Technology Generations; handling complex user interfaces. PhD Thesis Technische Universiteit Eindhoven; 2001
17. Korteling JE. Multiple-task Performance and Aging. PhD Thesis University of Groningen; 1994
18. Baars J., Knipscheer CPM, Schuyt TNM, editors, Zelfstandigheid en ouder worden. Utrecht: Lemma; 1995; p 79-98
19. Goor AG van de, Becker H. Technology Generations in the Netherlands, A Sociological Analysis. Maastricht: Shaker; 2000
20. Dittman-Kohli F. Das Personliche Sinnsystem: Ein Vergleich zwischen frühem und spätem Erwachsenenalter. Göttingen: Hogrefe; 1995
21. Little, BR. Personal projects: a rationale and method for investigation. Environment and Behavior 1983;15:273-337
22. Austin, JT, Vancouver JB. Goal constructs in psychology: Structure, process and content. Psychological Bulletin 1996;120:338-375
23. Schaie KW, Willis SL. Adult development and aging. New York: Harper Collins; 1991
24. Bouwhuis DG. Aging, perceptual and cognitive functioning and interactive equipment. In: Bouma H, Graafmans JAM, editors, Gerontechnology. Amsterdam: IOS Press; 1992. p93-112
25. Birren JE, Schaie KW, editors, Handbook of the Psychology of Aging. San Diego: Academic Press; 1977
26. Birren JE, Schaie KW, editors, Handbook of the Psychology of Aging. Third Edition. San Diego: Academic Press; 1990
27. Birren JE, Schaie, KW, editors, Handbook of the Psychology of Aging. Fifth edition. San Diego: Academic Press; 2001
28. Cattell RB. Theory of fluid and crystallized intelligence. Journal of Educational Psychology 1963;105:105-111
29. Horn J. Theory of fluid and crystallized intelligence. In Sternberg RJ, editor, Encyclopedia of human intelligence Volume 1. New York: Macmillan; 1994. p 443-456
30 Belsky JK. The psychology of aging theory, research, and interventions. Pacific Grove: Brooks; 1990
31. Salthouse TA. Theoretical Perspectives on Cognitive Aging. Hillsdale: Erlbaum; 1991
32. Freudenthal D. Learning to use Interactive Devices; Age differences in the Reasoning Process. PhD Thesis Technische Universiteit Eindhoven; 1998
33. Craik FIM, Bosman E. Age-related changes in memory and learning. In: Bouma H, Graafmans JAM, editors, Gerontechnology. Amsterdam: IOS Press; 1992. p 79-92
34. Kausler DH. Learning and memory in normal aging. San Diego: Academic Press; 1994
35. Melenhorst A-S. Adopting communication technology in later life; the decisive role of benefits. PhD Thesis Technische Universiteit Eindhoven; 2002
36 Baltes PB, Baltes MM. Successful Aging: Perspectives from the Behavioural Sciences. Cambridge: Cambridge University Press; 1988
37. Lewin K. Field Theory in Social Science. New York: Harper & Row; 1951
38. Suchman LA. Plans and Situated Action. The Problem of Human-Machine Communication. Cambridge: Cambridge University Press; 1987
39. Ajzen I, Madden TJ. Prediction of Goal-Directed Behaviour: Attitudes, Intentions, and Perceived Behavioral Control. Journal of Experimental Social Psychology 1986;22:453-474
40. Lawton MP. The impact of the environment on aging and behavior. In: Birren JE, Schaie KW, editors, Handbook of the Psychology of Aging. San Diego: Academic Press; 1977. p 276-301
41. Lawton MP. Residential Environment and Self-Directedness Among Older People. American Psychologist 1990; 45:638-640
42. Rauterberg M, Strohm O, Kirsch M.

Benefits of User-Oriented Software Development Based on an Iterative Cyclic Process for Simultaneous Engineering. International Journal of Industrial Ergonomics 1995:16; 391-410
43. Bouma H, Graafmans JAM, editors, Gerontechnology. Amsterdam: IOS Press; 1992
44. JIS Japan Industrial Standards Centre. Tsukuba, Japan; 2000. Personal communication
45. Bouma H. The conceptual basis of gerontechnology. In: Kivelä S-L, Koski K, Rietsema J, editors, Normal and Pathological Ageing and the Impact of Technology. Course Book on Gerontechnology European Union: Cost A5; 1994. p 15-23
46. Bouma H. Gerontechnology: emerging technologies and their impact on ageing in society. In: Graafmans J, Taipale V, Charness N. Gerontechnology, a sustainable investment in the future. Amsterdam: IOS Press; 1998. p 93-104
47. Sixsmith A, Sixsmith J. 'Gerontechnology': New Technology and the Older Person. Generations Review 1995;5:11-12
48. Freudenthal A. The design of Home Appliances for young and old consumers. PhD thesis Delft University of Technology; 1999
49. Bouwhuis DG. Parts of Life: configuring equipment to individual lifestyle. Ergonomics 2000; 43:908-919
50. Ahn, RMC, Beun RJ, Borghuis T, Bunt HC, Overveld CWAvan. The DENK Architecture: a Fundamental Approach to User-Interfaces. Artificial Intelligence Review Journal 1994;8:431-445
51. Masthoff J. An Agent-Based Interactive Instruction System. PhD Thesis Eindhoven University of Technology;1997
52. Aarts E. Technology Issues in Ambient Intelligence. In: Marzano S, Aarts E, editors, The New Everyday; News and Views on Ambient Intelligence. Rotterdam: 010 Publishers; 2003. p 12-17
53. Brandtstädter J, Renner G. Tenacious Goal Pursuit and Flexible Goal Adjustment: Explication and age-related analysis of assimilation and accommodation strategies of coping. Psychology and Aging 1990;5:58-67
54. Eagly AH. & Chaiken S. The Psychology of Attitudes. San Diego: Harcourt Brace Jovanovitch; 1993
55. Knipscheer CPM, Jong-Gierveld, J de, Tilburg TG van, Dijkstra PA, editors, Living Arrangements and Social Networks of Older Adults. Amsterdam: VU University Press; 1995
56. Tilburg TG van. Delineation of the Social Network and differences in Network Size. In: Knipscheer CPM, Jong-Gierveld J de, Tilburg TG van, Dijkstra PA, editors, Living Arrangements and Social Networks of Older Adults. Amsterdam: VU University Press; 1995. p 84-96