ETSI

ETSI TECHNICAL REPORT

ETR 334

December 1996

Source: ETSI TC-HF

Reference: DTR/HF-02003

ICS: 33.020

Key words: Ageing, MMI, telephony, terminal

Human Factors (HF); The implications of human ageing for the design of telephone terminals

ETSI

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Foreword

This ETSI Technical Report (ETR) has been produced by the Human Factors (HF) Technical Committee of the European Telecommunications Standards Institute (ETSI).

ETRs are informative documents resulting from ETSI studies which are not appropriate for European Telecommunication Standard (ETS) or Interim European Telecommunication Standard (I-ETS) status. An ETR may be used to publish material which is either of an informative nature, relating to the use or the application of ETSs or I-ETSs, or which is immature and not yet suitable for formal adoption as an ETS or an I-ETS.

Introduction

The population of Europe is ageing rapidly; one in three individuals is over 50 years, one in five is over 60, and the most rapidly growing sector is the over 85s. This demographic shift is set to continue for the next few decades. As people grow older they tend to become more vulnerable to chronic illness and frailty. Technology can be used not simply to compensate for loss of ability, but also to prevent problems and actively to enhance the quality of life. However, this cannot be achieved effectively unless the technologists have information about the characteristics, abilities, needs and economic status of the target population.

Telecommunications technology is advancing particularly quickly. Given the indispensable role it plays in everyone's social and working lives there is a sense in which people have no choice but to involve themselves with these changes. Whereas for some of us telecommunication offers a partial solution to our communication needs, for many people it is a lifeline to the rest of the world, offering a wide variety of social and employment opportunities. An important consideration, then, shall be the extent to which new developments will encourage or hinder fruitful telecommunication use among these members of the population, along with the population at large.

One way of limiting technological exclusion or marginalization of potential users is to ensure that the design of new equipment and services takes into account the needs and characteristics of a broad range of users. Consideration of the needs and characteristics of older people is particularly fruitful, not only because of the above mentioned demographic projections, but also because good design for older people means increased flexibility in design; this in turn can mean improved design for the population at large. Age increases variability within a population along many dimensions, so equipment designed for use by people within a wide age range will tend to increase user-friendliness across a much wider range of abilities than that which is designed for use by a particular group of young people. The main requirement in telephone terminal design is flexibility - solutions that can be used in different ways by different individuals.

The content and recommendations in this ETR is intended for people engaged in the preparation of standards for telephone terminal equipment, as well as designers and manufacturers of telephone terminals.

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1 Scope

This ETSI Technical Report (ETR) highlights important issues in the design of telephone terminals for use by elderly and disabled people. The issues reviewed include:

- characteristics of older people, including demographic changes, attitudes to technology, economic resources and employment, housing and institutional living and social isolation;

- normal age-related changes, including changes in sight, hearing, spatial and temporal resolution, motor changes, cognitive changes and memory.

Each of these topics is considered in terms of implications for design, related particularly to tasks likely to be encountered in the use of the telephone and other forms of telecommunications, and design recommendations are given. Finally, consideration is given to the general issue of usability of telecommunications equipment for older persons.

2 References

For the purposes of this ETR, the following references apply:

[1] ETS 300 488: "Terminal Equipment (TE); Telephony for hearing impaired people; Characteristics of telephone sets that provide additional receiving amplification for the benefit of hearing impaired".

[2] ETS 300 381: "Telephony for hearing impaired people; Inductive coupling of telephone earphones to hearing aids".

[3] ETS 300 640: "Human Factors (HF); Assignment of alphabetic letters to digits on standard telephone keypad arrays".

[4] ETS 300 679: "Terminal Equipment (TE); Telephony for the hearing impaired; Electrical coupling of telephone sets to hearing aids".

[5] ETR 029: "Human Factors (HF); Access to telecommunications for people with special needs - Recommendations for improving and adapting telecommunication terminals and services for people with impairments".

[6] ITU-T Recommendation P.370: "Coupling hearing aids to telephone sets".

[7] Gleiss, N.: "The need of aids for hearing impaired telephone users"; TELE Engl. Ed. 2/1980.

[8] ETR 095: "Human Factors (HF): Guide for usability evaluations of telecommunications systems and services".

[9] ETR 051: "Human Factors (HF): Usability checklist for telephones Basic requirements".

[10] ETR 147: "Human Factors (HF): Usability checklist for Integrated Services Digital Network (ISDN) telephone terminal equipment".

[11] Eurostat, 1992, "Europe in figures" (3rd edition), Luxembourg, Office for Official Publications of the European Community.

[12] The Nordic Committee on Disability, 1995: "Telephones for all: Nordic design guidelines": NNH 3/95, ISBN 91-86954-26-1.

[13] US Congress, Office of Technology: "Hearing impairment and elderly people - A background paper": 1986.

[14] Glorig, Ward, Nixon: "Damage-risk-criteria and noise-induced hearing loss". NPL conference on Control of Noise, 1961.

3 Definitions and abbreviations

3.1 Definitions

For the purposes of this ETR, the following definitions apply:

accommodation: The automatic adjustment of the refractive power of the eye, i.e. how much the lens bends the light, to obtain sharp vision at different distances.

adaptation: The automatic adjustment of the eye to the intensity or quality of the light stimulation, e.g. to darkness or bright light.

ageing: The normal physiological and psychological changes associated with increasing age.

audiogram: A graphic representation of hearing loss (ordinate) at selected frequencies (abscissa) compared to average normal thresholds.

average hearing loss: The average value in decibels of hearing loss measured at 500, 1 000 and 2 000 Hz at the better ear.

cohort: A group of individuals having age, class membership or other statistical factors in common in a study of the population.

demographic: The statistical study of human populations, especially with reference to the sizes and distributions of vital statistical data.

glare: Reduction in the ability to see details or objects caused by unsuitable distribution or range of luminance, or by too extreme contrasts.

haptic: Relating to or based on the sense of touch.

hearing impairment: A reduction of hearing ability (unilateral or bilateral). The reduction may be mild (> 25 dB hearing loss), moderate (> 45 dB hearing loss), severe (> 65 dB hearing loss) or profound (> 80 dB hearing loss; deafness).

hearing level: The actual hearing threshold in decibels at specific frequencies relative to the normal average threshold for these specific frequencies.

hearing loss: The difference in decibels at a specific frequency between the normal threshold of hearing and the actual threshold for an individual.

hearing threshold: The minimum sound pressure level, at a specific frequency, that is audible; generally taken as the median value of a sample.

inductive coupling: The coupling of a hearing aid to a telephone through an electromagnetic field at voice frequencies, e.g. such as generated by a coil in the telephone hand-set.

median: The value of the exact mid-point of a statistical distribution of samples; = the 50th percentile.

older person: Someone aged 65 years or over.

presbycusis: The reduction of hearing level that occurs naturally with increasing age; affects the higher frequencies most.

spatial resolution: The ability to resolve differences between objects in space, by vision, hearing, or touch.

temporal resolution: The ability to resolve events in the time dimension, by vision, hearing, or touch.

text telephony: A telecommunication service offering two-way, real-time text conversation through telecommunication networks. Text telephony may be combined with voice telephony.

text relay service: A service that enables voice telephone users and text telephone users to communicate in real time by providing translation between the two modes of communication, normally by a human operator.

visual impairment: Reduction of visual acuity, or a reduction or distortion of the visual field.

3.2 Abbreviations

For the purposes of this ETR, the following abbreviations apply:

AHL	Average Hearing Loss
EU	European Union
ISDN	Integrated Services Digital Network
RACE	Research and Development in Advanced Communications technologies in Europe

4 Background characteristics of older people

The focus of this ETR is on "the older population", covering, in the main, those over 65 years. The reference group is extremely heterogeneous: one only has to consider an equivalent age range among "the young population", 0-35, to realize that it is not realistic to try to form an image of an "average" older person. There will be more shared characteristics between a pair of seven-year olds than a pair of seventy years olds. Nevertheless, a study of the characteristics of ageing can be extremely profitable since we are members of a greying population and need to attune ourselves to the problems we all face.

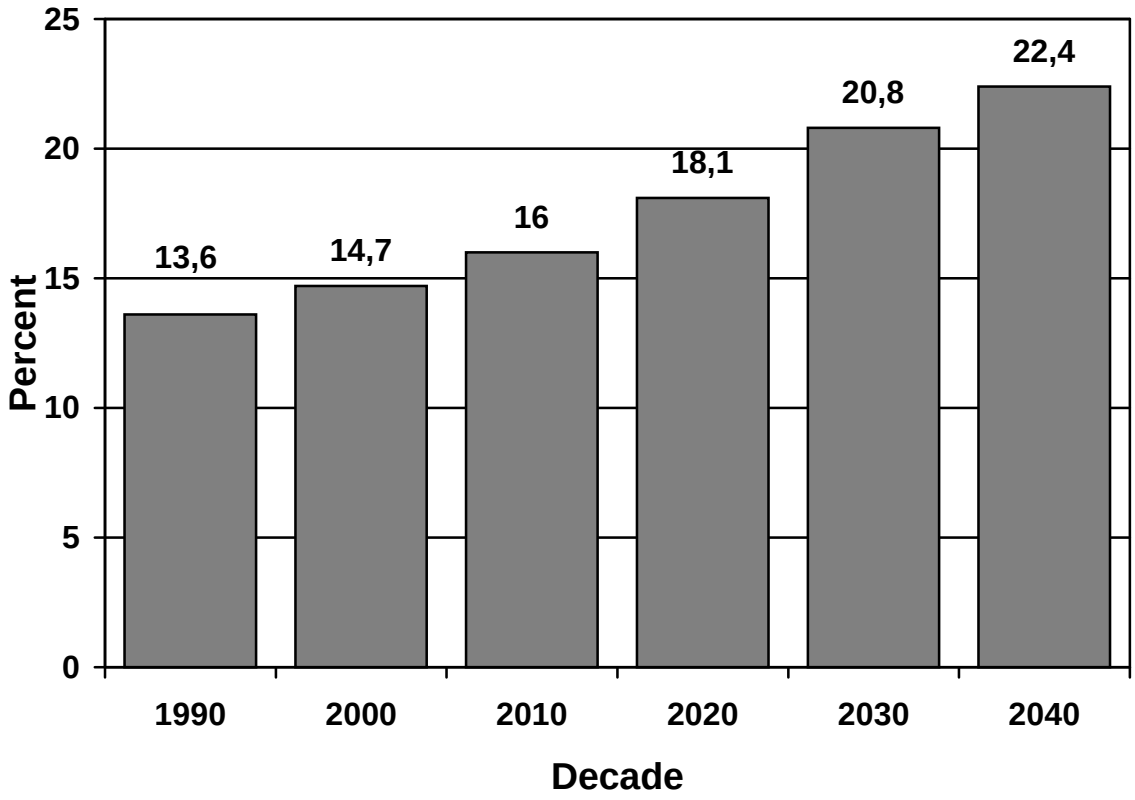
An interesting phenomenon with which all are familiar is that regardless of how old one is, "old people" are always at least 10 years older than oneself, so that it is rarely the case that people whom one considers to be older think of themselves as being old. Individuals all acknowledge their increasing age, but rarely think of themselves as old - indeed there is a tendency to think one's own generation or cohort as that "in the know" or up-to-date and forward thinking. When considering ways of adapting technological design for use by older people, therefore, it should be remembered when designing and planning that it is designing for one's future self.

There is no fixed age in life when people become old. Ageing is a gradual process, sometimes almost imperceptible. Because of this lack of a clearly defined time, different societies use different criteria for defining when a person has become older (e.g. among some groups in Kenya a man is considered old when the smell of food no longer awakens him, and a woman when she keeps dropping the cooking pot!; in other societies a person is considered old on the birth of his first grandchild). In Western society ageing is defined chronologically; a person is thought to be old when reaching 65. This has occurred essentially as a result of legislation on employment and social security payments. Thus, the boundary of old age is a purely arbitrary one and bears little relation to the point at which a person actually feels old.

4.1 Demographic change

One of the most significant changes occurring world-wide is that the number of older people is increasing very rapidly. Not only is the population growing older, but the old are growing older; one of the fastest growing age groups being the 85+ group. Three factors which reflect the ageing of the population are:

- an increase in the proportion of older people;
- an increase in the proportion of the old in relation to the young;
- a rise in the median age of the population.



Source: Eurostat, 1992 [11]

Figure 1: Proportion of the EU population aged 65 and over

Recent figures indicate that the proportion of people aged 65+ in member states of the European Union (EU) will increase from 13,6 % in 1990 to 16 % in 2010 and 22 % in 2040. By contrast the proportions of young people are declining, reversing the age balance experienced through the twentieth century. Finally, the median age refers to the age that divides the population into two equally sized parts, one younger than the median, the other older. When the median age rises the population is said to be ageing. In 1970 the median age of the Western population was about 28 years, it rose to nearly 33 in 1987 and is expected to reach 36 by 2000 and 42 by 2030.

4.1.1 Sex structure

There is a marked inequality of gender among the over 65s: over 60 % are female. This pattern is particularly marked among the very old where there are two and a half times as many women as men. This may reflect a cohort or historical effect. That is, those aged 85+ were born in the beginning of this century. The numbers of males surviving from these cohorts has been very much affected by the high mortality of the 1914–18 war. Some people argue that there is some kind of biological superiority for women, and this is supported by the life expectancy advantage for women at all ages across the life span (ranging for example between 4,8 years in Greece and 8,9 years in France). We cannot assume that this pattern will be reflected in future cohorts of older people. This balance of the sexes is interesting, since it is women who tend to be more frequent users of telecommunications for informal social networking, of which there is an increasing amount as people age.

4.2 Attitudes to technology

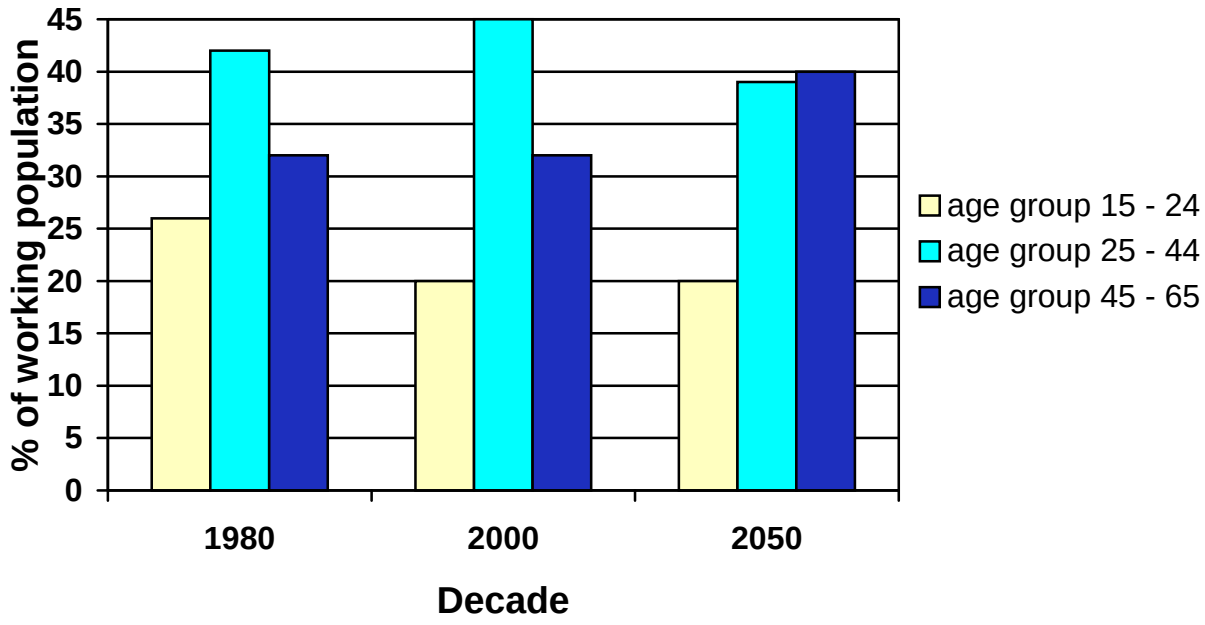
A popular myth perpetuated about older people is that it is not worth considering them as potential consumers of technology because they are indifferent, or even hostile, towards the opportunities afforded by technological development. In fact, recent research does show a tendency for older people to express less interest than younger people in owning a variety of equipment. However, it is not age which predicts interest in new technology, rather, it is current and past experience of technology.

Individuals who are currently in their 70s have had relatively little and late access to new developments in technology. By contrast, people currently in their 50s have witnessed the explosion of new technologies in their working environments, and are more familiar with buying and using new equipment. A high proportion of individuals in their 50s express strong enthusiasm for technological developments and a keen interest in acquiring and using future facilities. As the population ages these people will be replaced by even more technologically aware and sophisticated people, so this pattern of interest will spread into the older population over time. The corollary of this is that given current demographic trends there will be a substantial and maintained increase in the size of the market for new systems and facilities among older people.

4.3 Economic resources

There are two very contrasting images of the standards of living of older people. One is an image with a long tradition of poverty–stricken old age. Indeed, a significant minority of older people fall into the lowest income bracket of each EU country. On average, 60 % of people aged 65+ fall into the lowest income brackets. Within the older population, it is women aged 80+, those living alone, those from manual occupations and those who are disabled who are most at risk of experiencing poverty in later life.

The second image, emerging more recently, emphasizes the relative affluence of later life. Older people who are not in employment rely on two sources of income: pensions, both state and employment-related, and savings. It is difficult to make comparisons of income for specific age-bands across different nations because of the very different levels of income support provided. Recent research has indicated that the spending power of older people is increasing, and may be even greater than that of younger people. Thus, the real incomes of retired people, and therefore their purchasing power, are higher than our negative images might suggest, but may be flattening out.



Source: Eurostat, 1992 [11]

Figure 2: Projected changes in the working-age population of the EU

4.4 Employment

While the size of the older population is increasing the numbers of younger people are decreasing. The net effect is that there will be proportionately fewer young people entering the work force, and the absolute size of the working population will decrease. One result of this is that the average age of the working population is expected to increase markedly over the coming decades. The average proportion of workers aged 15-24 is projected to decrease from 26 % in 1980 to 18 % in 2030. The proportion of workers aged 25-44 is expected to decrease from 42 % in 1980 to 39 % in 2040, but the proportion of older workers (aged 45-64) is projected to increase from 32 % in 1980 to 41 % in 2040.

Thus, in many European countries, it is expected that more than one fifth of the working population will be aged over 55 by 2020. Indeed, Germany is expected to have reached this situation by 2000. The mean increase in age of employees is significant, particularly with regard to design of working environments and support technology.

4.5 Institutional living

For many people there is a strong if erroneous belief that old age is particularly associated with residential and institutional care. In fact, the numbers of older people who live in such places are relatively small. Approximately 5 % of people aged over 65 live in some form of institution. This percentage increases to 19 % among the over 85s. Thus, the percentage of older people living in institutions increases with age but is always very much smaller than the percentage living in the community. The corollary of this is that 95 % of the older population live independently in the community.

4.6 Housing situation

As mentioned above, the vast majority of the older population is not in receipt of institutionalised care. Large numbers live independently and indeed substantial numbers live alone. Germany and Denmark have the largest proportions of older people living alone (16 % and 14 %, respectively) and Spain and Greece the fewest (about 5 %). Throughout Europe women are more likely to be living alone than men, because of their longer life expectancies.

Those who live in private accommodation, who are not on their own, usually live with their partners; very few live in households with two or more younger people. The large number of older people who live in their own households reflects a general trend for people of all ages to establish single households, rather than to live in larger groups.

4.7 Social isolation

A common image associated with ageing is that of isolation and loneliness. There is a substantial amount of evidence to suggest that there is extensive contact between older people and their families, friends and neighbours. Only a small minority of people aged 65+ report that their families do not visit them. Overall, the percentage of those aged 65+ being visited by family and/or friends is over 70 %. These sorts of numerical summaries do not, of course, tell us much about the quality of interactions, or individuals' subjective experiences, but they do endorse the point made above that there are large natural, social networks for the communications industries to capitalize upon.

4.8 Summary and conclusions

The population as a whole is greying, and its general characteristics increasingly resemble those of older people. Demographic projections into the next fifty years indicate a substantial increase in the proportions of older people in the population, in both domestic and work environments. These changes will have a marked impact on patterns of informal and formal social support and care, and indicate an increase in the complexity of people's personal communication networks.

The increasing market is there to be serviced by the telecommunications community. Additionally, a wider population of potential users can be reached by ensuring that the design of new equipment and services has taken into account the needs and characteristics of a broad range of people. Age increases variability within a population along many dimensions, so equipment designed for use by people within a wide age range will tend to increase user-friendliness across a much wider range of abilities than that designed for use by a particular group of young people.

5 Normal Age-related Changes

5.1 Introduction

Age-related physical and mental changes are usually much slighter than people expect, given common images of the health status of older people. However, they do interact, so the combination of several small changes can result in quite marked deterioration in performance. The principal characteristic of ageing is that it has a huge impact on variability of performance. Ageing does not affect sensory, motor and cognitive processes to the same extent or at the same rate, within or between individuals; some functions decline faster than others. Different individuals show unique patterns of ageing, maintaining certain levels

of competence and exhibiting differing degrees of loss. Thus, the main requirement in design is flexibility - solutions that can be used in different ways by different individuals.

5.2 Sensory change in vision

Visual impairment among older people is often mild to moderate but is quite common. Clear vision is not always possible for three principal reasons:

- **inadequate amounts of light reach the photoreceptors of the eye.** If there is not sufficient light or if light is occluded by opacities of the transparent media of the eye (e.g. due to cataracts), a proper image cannot be formed;

- **the eye is not able to focus light properly to form a sharp image.** Improper focusing of light may occur if the eye is improperly shaped (too long or too short), if the lens becomes too stiff, or if the focusing muscles do not function properly. This may result in farsightedness (hyperopia, most common in older people) or in nearsightedness (myopia);

- **light receptors and neurones in central visual pathways do not relay information properly.** The visual apparatus cannot process visual information properly if the light receptors in the retina are lacking or damaged (e.g. as a result of trauma, degenerative diseases, ischemia (reduced blood supply) or hereditary causes).

Although there is a lot of variation amongst individuals, research evidence suggests that about 40 years is the typical age at which age-related changes in visual function begin to appear (i.e. well before retirement. See also subclause 4.4). These changes occur as a function of both simple physical changes in the eye (e.g. decreases in the transparency of the optical media , decline in number and strength of muscle cells) and changes in the brain's information processing capacity.

The dimensions of vision which present most problems for older people, and are of most immediate relevance to the design and use of telephone terminals are:

- light sensitivity;
- colour perception;
- spatial and temporal resolution;
- visual search strategies.

5.2.1 Light sensitivity

As people age, brighter light is necessary if they are to see as much as they did when they were younger. Less light reaches the retina because of changes to the conjunctiva, cornea, lens and vitreous humour, which all become less transparent, and because of the decrease in size of the pupil. This means that, overall, less light is admitted, and the photoreceptors that respond therefore send fewer neural impulses to the brain, which in turn means that a less clear and accurate perception is formed.

As the eye ages, the number and strength of muscle cells in the iris and pupil decrease. The connecting fibres (collagen) thicken and stiffen. Thus, for any light intensity the pupil size decreases, producing a continuous decline in the amount of light available to form images. There is also a slowing of the rate at which the pupil dilates when changing from bright to dim light. This, in combination with age-related slowing of pupillary constriction, leads to a slowing of adaptation to changing light intensities.

5.2.1.1 Light adaptation

The light sensitivity of the eye changes as a function of the amount of light to which the eye is exposed. Young adults' vision adapts very rapidly with changes in illumination. However, adaptation to a decrease in illumination is much slower than to an increase. Adaptation to darkness may take several minutes. As people age, their low-light sensitivity is significantly reduced. Thresholds for dark adaptation increase between 60 and 88 years by about 0,09 log unit per decade in people with 6/6 acuity.

Once the eye is light adapted, its response to lights of different intensities and wavelengths depend on the level of light adaptation. With adaptation to a high level of light, longer wavelengths appear brighter, whereas with adaptation to low light levels, sensitivity shifts down to shorter wavelengths. A practical result is that the relative brightness of reds and blues changes in going from bright to dim light. In a bright light red may appear brighter than blue, but in dim light blue may appear brighter than red.

5.2.1.2 Glare

As the eye ages, more of the light that enters is scattered. For example, the conjunctiva, a smooth thin layer covering the part of the eye exposed to the air, becomes less smooth with age; this means the light that enters the eye is scattered. Scattering is also brought about through a decrease in the transparency of the cornea and the development of opaque spots in the lens (cataracts).

A common effect of the scattering of light is that much of it hits the retina in the wrong places, creating the phenomenon of glare. This can vary from being a relatively minor problem through to obscuring objects completely. External conditions that exacerbate glare include:

- having brightly lit objects against dark backgrounds;
- having bright light strike the eye at an angle;
- viewing light with shorter wavelengths, such as blue light.

Sunlight generates a lot of glare since it contains a predominance of short wavelength light, while longer wavelength yellow light causes less glare. Age differences exist in response to temporary high levels of illumination, or glare. Older people are more adversely affected by glare than younger people, both in terms of reduced image contrast caused by the glare and recovery time.

5.2.2 Colour perception

Age-related differences in colour perception relate to two aspects:

- changes in the selective absorption of the lens (which filters out light of shorter wavelengths);
- changes in colour discrimination associated with changes in the central nervous system.

In addition, there is a gradual deposit of yellow pigment in the optical media of the eye, which selectively affects perception of colour. Thus, older people tend to suffer a mild loss of colour discrimination, and are especially prone to confuse green with blue, beige with white, and light grey shades in general.

5.2.2.1 Change in the lens and cornea

The gradual decrease in transparency of the cornea and lens with age has the effect of blocking a considerable amount of light. Light at the blue end of the spectrum is blocked more than light towards the red end of spectrum. The perception of blue objects, or objects lit with blue light, is thus reduced more than the perception of red objects.

5.2.2.2 Change in the cones

Cones in the retina are sensitive to light of different wavelengths. The central part of the field of vision is focused on the central fovea (the most sensitive part of the retina). Since the fovea has a very high concentration of cones, it allows the person to see the object in the centre of the scene in full colour and with maximum acuity. From the age of about 40 many cones degenerate, which leads to a gradual drop in visual acuity and a diminishing ability to distinguish colours. Since age-related decreases in transparency preferentially affect short wavelengths, the perception of violet, blue and green is affected most. Problems are particularly salient when the field of view is dimly lit.

There are also age differences in colour matching in 60 to 88 year olds; small but significant declines of about 0,01 log unit in sensitivity can occur per decade.

5.2.3 Spatial and temporal resolution

5.2.3.1 Visual acuity

Even when light is bright and glare is minimized, there is a decrease in visual acuity because of a stiffening of the lens, the flattening of the cornea and a decrease in the ability of the muscles within the eyes to move. Visual acuity decreases with increasing speed. Much decrease in acuity goes unnoticed until the age of about 40, but then does not change much after the age of 60, though some people may show a continuous change. In some individuals, a thickening of the lens may restore some near vision.

Distance vision also decreases from the age of about 45 though, in fact, more than 50 % of 80+ years old have good distance vision. Some of these losses may be compensated for by corrective optics.

5.2.3.2 Perception of movement

The external muscles attached to each eye, which allow it to be turned in any direction, become less flexible with age. This, in combination with changes in the neural pathways controlling the muscles, means the ability of the eye muscles to turn the eye smoothly, declines. This decreases visual acuity when:

- watching moving objects;
- watching stationary objects while moving.

A slowing of neural transmission with increasing age enhances perception of moving objects, e.g. after-images persist longer, which in turn can have the following effects:

- flicker may be perceived as steady light;
- fast-moving objects may appear blurred;
- there is a decrease in the ability to perceive small movement in stationary objects.

All of these effects may impact on the design of visual displays used in telecommunications.

5.2.3.3 Visual search

Between the ages of 55 and 75 there is a particularly marked narrowing of the visual field. Older people tend to be slower at visual search than younger people, because they process information more slowly and because of the decrease in discriminability of symbols so that large displays can no longer be processed in large chunks.

Such age differences depend on the visibility of the target, as defined by its size and contrast, and on its context. Poorer performance among older people arises as a function of reduced visibility of peripheral stimuli. In addition, when looking for information, older people are more distracted by increasing complexity of the visual scene, and show a higher error rate than younger individuals. This reflects a slower rate of scanning as well as the constriction in the size of the visual field.

5.2.4 Requirements for optimizing vision

The following requirements are important for optimizing vision in older people:

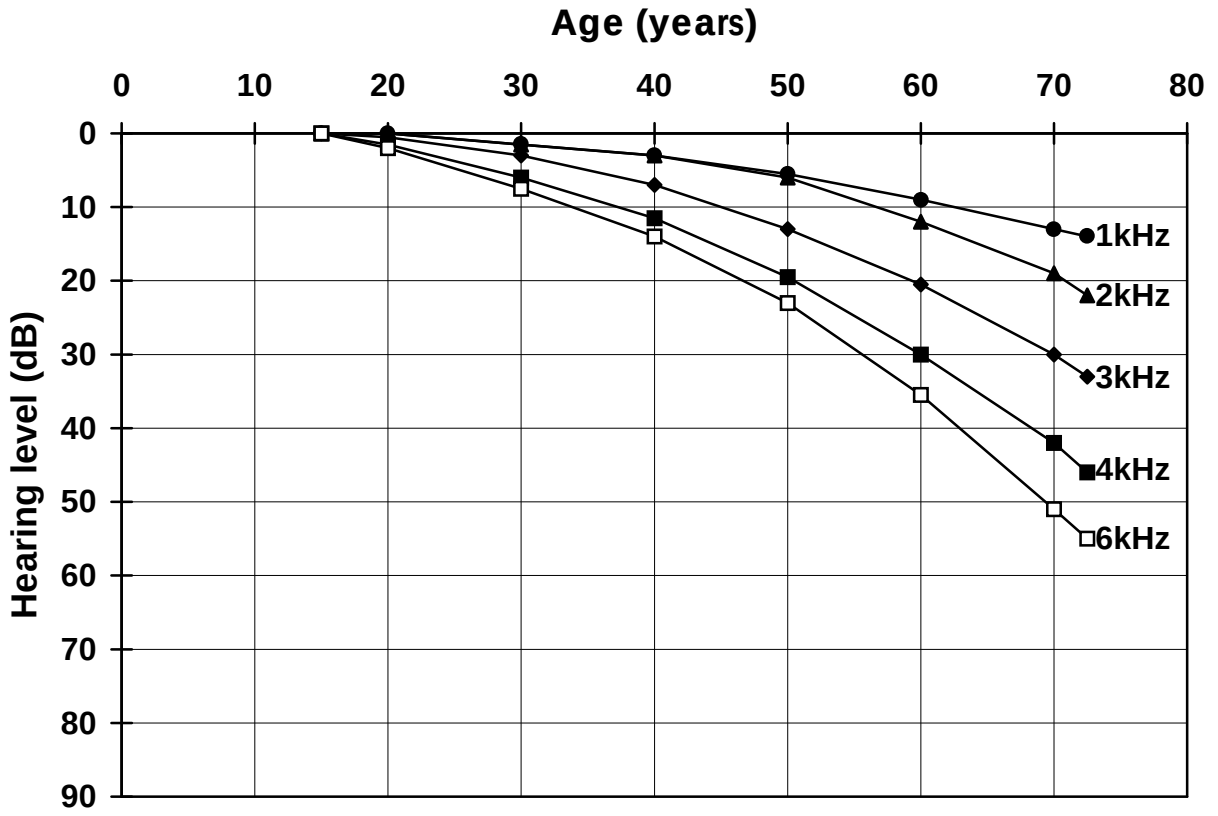
- provide adequate levels of illumination, particularly of target relative to its surround;
- reduce sources of glare;
- enlarge objects, especially target items;
- increase colour and brightness contrast;
- reduce the speed of moving objects, e.g. moving displays;
- position targets so that they may be inspected at close quarters according to need;
- use corrective aids;
- allow adequate time to read changing information.

5.3 Sensory change in hearing

A US Congress report [13] on hearing and older people provides a good summary of the situation with respect to hearing:

> *"Most hearing research has been focused on very severe impairments. Hearing impairment in the elderly is often mild or moderate, but it is widespread. A significant, but as yet undefined, number of elderly people have decreased ability to tune out background noise and thus have more difficulty hearing in noisy settings than younger people with comparable hearing ability".*

In general, loss of hearing acuity follows a similar pattern to loss of visual acuity, though the changes begin much earlier. Sensitivity to high frequency sounds falls off before the age of twenty; this form of hearing loss (presbycusis) can be so gradual that the person is not even aware that something is wrong, other than that people do not appear to speak as clearly as they used to. About 12 % of those aged between 45-65 are affected by presbycusis (24 % of 65-74 year olds; 39 % of 75+).



Source: Glorig [14]

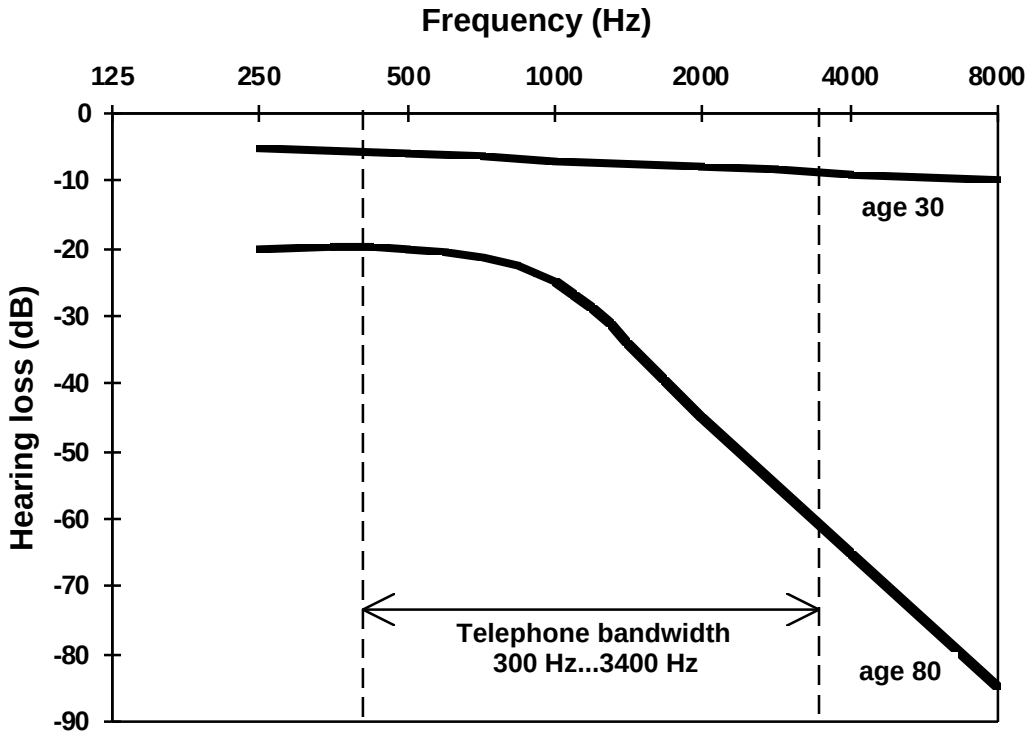
Figure 3: Presbycusis, loss of hearing with age. Reduction in hearing level in decibels (ordinate) is plotted for five frequencies as a function of age (abscissa) for noise unexposed subjects

5.3.1 Hearing thresholds for tones and speech

It is clear from longitudinal studies (i.e. studies where individuals are followed over several years) that people aged between 20 and 80 experience changes in hearing thresholds continuously throughout adulthood, with an average change per year of 1 dB at 8 kHz. The rate of change is lower for speech frequencies (0,5 to 2 kHz), at about 0,3 dB per year. However, the rate accelerates after age 60, reaching levels of 1,2 to 1,4 dB per year in the age range 80 to 95.

Although increasing age affects the high frequencies more than the low, there is a disproportionate spread of hearing loss to lower frequencies in old age. In addition, the rate of change in thresholds for the speech frequencies rises at an accelerating rate between the age of 50-90 years.

Individuals who have been exposed to excessive noise levels for a long time, e.g. some types of factory workers or others working in noisy environments often exhibit a higher than average hearing loss at frequencies above 3 kHz.



NOTE: Reduction of hearing levels in decibels (ordinate) is plotted as a function of frequency for age 30 (upper curve) and age 80 (lower curve). The typical frequency range for telephone speech is indicated by the two vertical broken lines.

Figure 4: Combined presbycusis and noise-induced hearing loss as demonstrated by typical audiogram curves for two age groups

5.3.1.1 Speech perception and comprehension

Presbycusis does not usually affect the frequencies occurring most in speech until around age 80, so speech perception is usually not seriously impaired until late in life (see figures 3 and 4). However, a few sounds such as /s/, /ch/ and /sh/ involve frequency bands that are affected earlier. Consequently middle-aged and young-old adults (60-75) may have problems hearing these sounds.

By about the age of 50 years there is sufficient hearing loss, on average, to bring about impairment in some of the more demanding listening situations - faint sounds, background noise, multiple sources and so on. The signal to noise ratios required for satisfactory intelligibility are higher for normal and hearing impaired older listeners than for younger ones This occurs primarily because of changes in the sensory and central nervous system; age changes here affect the ability of the hearer to process and interpret signals from the cochlea. These effects are noticed as an increased difficulty in understanding the following:

- sounds that contain echoes or background noise;
- sounds that change quickly;
- speech that is broken up, or has syllables or words missing.

Both hearing-impaired and non-impaired older people experience more difficulty than those who are younger in understanding speech presented against a background of babble or noise. This cannot be aided by simple amplification but may be alleviated through the selective enhancement of particular consonants which can be achieved in modern hearing aids by signal processing (e.g. in English, p, b, t, g). A practical problem is that by bringing up the overall intensity of the consonants to an acceptable level, the loudness may become uncomfortable.

5.3.2 Localizing sound

Ageing generally affects one ear more than the other. Since sound localization depends on the brain comparing small differences in the signals from the two ears, a greater hearing loss from one ear causes errors in localization that can lead to disorientation.

Furthermore, the ability to pick up the direct sound from a source in a reverberant or noisy environment is very much dependant on binaural hearing. The same is true for separating a particular voice from other voices nearby (the cocktail party effect). This may be compensated for by the use of stereophonic hearing aids.

5.3.3 Requirements for optimizing hearing

When installing telephone equipment the following precautions should be observed:

- avoid situations with high levels of background noise;
- avoid multiple sourcing and reverberation;
- allow the listener to control amplification;
- provide means for listener selectively to enhance frequencies.

5.4 Motor changes

Ageing has an effect on a number of motor functions which are important to telecommunications tasks.

5.4.1 Motor changes: strength

There are many changes at the cellular level in the muscle system that have the effect of reducing the total amount of muscle mass that tends to decline faster as people age. The rate of loss is particularly fast after the age of 50. Most of is due to the loss of muscle cells rather than thinning of the cells.

In general, strength in all muscles in all individuals decrease with age. However, the amount of loss may vary considerably from person to person. Muscles used for quick, strong contractions show a greater decline than muscles used to maintain posture or to perform other actions requiring long-lasting mild contractions.

5.4.2 Motor changes: skills

Motor performance, that is, the execution of tasks that require co-ordinated muscle activity, is of central importance because it the basis for all the activities of daily living, including walking, eating, typing, writing, lifting, reaching, and so on. Most people tend to associate increasing age with decrease in physical ability and efficiency. However, the variability in motor performance increases with age. Therefore discussions of "average" behaviour for different age groups will grow less accurate as the age of the group increases. Nevertheless, it is the case that physiological changes occur with age which will eventually limit motor performance. The kinds of motor deterioration which are relevant for present purposes are:

- speech production;
- handgrip strength;
- fine motor co-ordination;
- sensitivity to small movements.

5.4.2.1 Speech production

Most of the sound that people make is produced when air passing through the larynx causes the vibration of the vocal cords. The sound gets louder when more air flows through the larynx. All the actions that produce and modify sounds from the respiratory system are controlled by the nervous system.

Sound production depends on the co-ordinated action of many muscles. Age changes that alter the breathing will also affect sound production. The ability to control voice volume and the precision of word pronunciation diminishes. Age changes in the larynx lead to voice changes in pitch and strength. In addition, hearing impairments may affect speech since hearing provides the necessary feedback for an individual's sound production.

Vocal changes with age are brought about in part by the hardening and decreased elasticity of the laryngeal cartilage. Later in life the laryngeal muscles atrophy and the vocal folds slacken, so that the voice becomes more high pitched as the person moves from middle to old age. In older adults the voice tends to grow less powerful and increasingly restricted in range, becoming quite high pitched in some people.

5.4.2.2 Handgrip strength

For the most part, decline of handgrip is accounted for by the deterioration in muscle mass that occurs with ageing. The extent of decline in handgrip strength with age is not fixed; changes from 0 to 20 % have been reported. Any loss of strength will, of course, be exacerbated in situations which require the manipulation and holding of objects for any length of time.

5.4.2.3 Fine motor co-ordination

Motor behaviour involving the rapid movement of one or more limbs or digits slows down in older people. This effect is emphasized when individuals are involved in quite complex perceptual or judgmental tasks. This is thought to be in part a result of slower information processing. However, the effect is mitigated by practice, in particular by the overpractice which occurs in activities of daily living. Thus, for example, it has been found that experienced older typists performed as fast as younger individuals. Overpracticed movement, then, is more resistant to the deleterious effects of age.

5.4.2.4 Sensitivity to small movements

In addition to changes in motor control there is also a steady depletion in the number of sensory receptors in our skin. Gradually this has an effect on the precision of the sense of touch. In conjunction with changes in fine motor control this means that any manipulation which requires very fine adjustment is compromised. This becomes a problem whenever people need to use instruments with small controls and keys. In addition, decreases in haptic sensitivity mean that it may be difficult sense when keys have been depressed or not.

5.4.3 Requirements for optimizing motor skills

- avoid the necessity for any rapid motor activity/response during tasks;
- provide sufficient size and spacing of keys;
- avoid control knobs that require small angles of rotation;
- ensure that there is distinct haptic feedback on key-pressing;
- ensure that handsets are balanced and designed without sharp edges.

5.5 Cognitive change

Some individuals may lose their ability to solve problems or learn new information rapidly. Nevertheless, they retain considerable ability in skills which they have developed to a high degree (e.g. crossword ability, social skills, skills of everyday living).

5.5.1 Information-processing

The rate of processing of information slows down with increasing age, affecting cognition, as well as sensory and motor processes. This means that older people can absorb less information in a given time, take longer to react to signals, and take longer to search and interpret their environment. This slowing is compounded by task difficulty, so that the more complex the situation the more time an older person will need, compared with a younger person. The time required for an older person to perform a given task is 1,3 - 1,7 times longer than that for a younger person. This slowing down refers to all mental functions. Such a change impacts on several other functions related to telecommunications, such as: short-term memory span (e.g. for telephone numbers), retrieval of recently acquired information (e.g. people's names), retention of long sequences of actions (e.g. all the steps for logging in to Internet), etc.

5.5.2 Attention

The ability to select relevant information from the environment depends on an individual's rate of information-processing. Older people experience a slowing of their rates of information-processing and find it increasingly difficult to attend to more than one thing at once. In communication situations it can be difficult to know which source of information to attend to until the meaning of the information has been understood. This can take time, and when the presentation of information is rapid older listeners may find it very difficult to follow fast enough to extract the relevant information. To allow older persons to perform complex tasks information should be presented sequentially.

5.5.3 Psychomotor speed

Psychomotor speed is a measure of motor movement in response to information that has been processed. People slow down as they get older; older persons are at a particular disadvantage in reaction time tasks when they are not given specific advance information about the oncoming response. When the response situation is complicated, the elderly are disadvantaged further. Although practice can improve performance, age difference will not be altogether eliminated. However, experience allows older persons to compensate for loss of speed by enabling them to anticipate what is likely to happen.

5.5.4 Memory

The basic memory processes encompass the receipt of information from the senses into a sensory store. From here information moves into "working memory". This is a small capacity store that deals with items currently being processed. Information is kept active through rehearsal. This process ensures that the information can move to longer term secondary and tertiary stores.

To be remembered deliberately (e.g. a telephone number), the information has to undergo three steps:

- encoding;
- storage;
- retrieval.

Changes in memory with age are due both to storage and retrieval problems. Older persons tend not to organize incoming information as well as younger persons and this can cause decrement in storage. Additionally, since older persons process different types of material less efficiently, they may experience significantly greater difficulty in retrieving information.

This decrement in memory performance can impact on older peoples' understanding of discourse (e.g. text, story lines, instructions, dialogue, etc.), particularly if the speed of presentation of information is high. However, when text is clearly organized, with emphasis on structure and the main ideas, older persons are just as good at grasping and remembering the main points as younger persons.

5.5.4.1 Factors that hinder memory

When recall from memory demands speed, older people tend to perform poorly. They tend to trade speed for accuracy.

Older people perform better when the memory task is relevant as possible to their experience. When exploring differences in everyday memory between young and old people, it has been demonstrated that young persons out-performed older people on memory for trivial information (e.g. what things did the subject see on the dining room table?). When tested for relevant and important information (e.g. at what times is the dining room open?) the memory of older people was just as good as that of the young.

5.5.4.2 Memory efficiency

Older people do experience loss of memory efficiency, particularly in working memory. Although research suggests that the absolute deterioration is slight, it has an effect on more complex cognitive processing such as reading and comprehending complex text. In order to make sense of information people need to be able to hold relevant information in working memory. It is also important to know what has just happened in order to be able to plan what happens next. Older people can be aided in this regard by the provision of sequence cues, simple help manuals and instructions, and presenting information in small, digestible chunks.

5.5.5 Requirements for optimizing cognitive performance

Patterns of decline in cognitive functioning vary across individuals, so different people will benefit from different interventions - some tackling internal characteristics (e.g. through memory exercises) and others external aids (e.g. variable presentation speeds of information). It is unlikely that everyone will benefit from exactly the same intervention or aid. Individuals need to be able to exert control over information-processing situations. What can be a reassuringly slow pace for one user can be extremely frustrating for another, more confident, user who can make good use of short-cuts. Design should be flexible enough to answer individual requirements. Considerations should include the following:

- allow variable speed of presentation of information;
- provide sequence cues;
- provide warnings of response times and actions;
- avoid the need for users to perform complex multiple tasks;
- avoid presenting irrelevant information;
- provide simple, well-written and well-designed help manuals.

5.6 Pathological change associated with older people

When trying to understand the needs of older people, it is natural to focus on limits and impairments, but it is important not to equate old age with disability. There is a high proportion of disabled people among the elderly. However, it should not be assumed that an older person will be disabled. Disability is not an inevitable consequence of ageing, and there are many older people who would not be considered disabled under any definition of the word.

Normal ageing involves changes - biological, mental and social - that are inevitable and occur as a natural function of maturing. Such patterns of change were presented in clause 5. Pathological ageing results from trauma or disease, and is not an inevitable part of the ageing process: a mild hearing loss is part of the normal ageing process; diabetes, heart attacks and strokes are not.

Nonetheless, many of the issues that need to be considered when designing facilities for use by older people are the same as those that need to be considered when designing for people with disabilities. This arises partly because of the higher incidence of disabling conditions among older people, and in part because there is a relatively high probability that at some time in the future non-disabled older people will experience a disabling condition. Discussion of specific disabilities and their implications for design may be seen in ETR 029 [5].

6 Design issues

In this clause, points to address when designing for the elderly have been organized by considering how the different characteristics of older users impact on different aspects of telephone usage. For further design issues see "Telephones for all: Nordic design guidelines" [12]. Note that it is important to consider these issues from the outset of the design process, rather than as cosmetic enhancements to be addressed towards the end of the process. The primary user characteristics that have been considered are changes in:

- vision;
- hearing;
- motor control;
- cognitive functioning.

The different aspects of telephone usage considered are:

- access to the telephone (see subclause 6.1.1, 6.3.1);
- finding the telephone number (see subclauses 6.1.2, 6.3.2, 6.4.1);
- using the handset (see subclause 6.3.3);
- dialling (see subclauses 6.1.3, 6.3.4, 6.4.3);
- hearing the dialling tone and line signals (see subclauses 6.1.4, 6.2.2, 6.4.2);
- communication over the telephone (see subclause 6.2.3);
- accessing help and information (see subclauses 6.1.2, 6.4.4).

For further design details, see "Telephones for all: Nordic design guidelines [12].

6.1 Design considerations relating to visual change

6.1.1 Finding the telephone

Finding the telephone is not usually a problem for older people unless they are in an unfamiliar environment. When using the telephone, issues to do with illumination become important. Changes in light sensitivity, adaptation and glare have implications for the levels of illumination and contrast that older people require in order to be able to function well. The response of older people to glare also has implications for the luminance of an object relative to its background, the level of ambient illumination and the rate at which levels of illumination change. Designs which are helpful to older people will ensure that the environment is well-lit, and that the users can adapt contrast to their own requirements.

6.1.2 Finding the number or seeking other information

People with reduced vision have problems reading small, tightly-packed, and low-contrast print. A practical implication of reduced acuity and sensitivity associated with old age is that older people have greater difficulty in detecting and discriminating details, particularly when they are presented under low contrast. Design which allows for adjustable contrast and illumination can alleviate many of the problems engendered by loss of acuity. Signs and symbols should be highly discriminable.

Many people might find it helpful to have on-line help available to give verbal information about numbers and procedures. When information is presented visually or auditorally it should not be presented too fast. The quantity and organization of information on a display at any one time should be optimized to allow people with reduced vision quickly to identify which items of information they need.

In general older people have problems identifying targets in cluttered visual environments and will be aided if the target information is highly discriminable, if the search area is relatively small, and the amount of information presented at any one time is low. Where older people are confronted with rich and complex scenarios, rates of information presentation should be kept down.

6.1.3 Dialling

It is important that characters on keys are printed in an easy-to-read typeface. Preferably a sans serif font should be used, and characters should be large and have high contrast. Because of changes in resolution with age, it is best to have keys for supplementary functions positioned and presented in such a way that they are clearly distinct from the dialling keys. The keys should have a shape and surface that will not cause specular reflections. Such reflections may make it difficult for older people to discern the characters on the keys (see also work being conducted under ETSI Work Item DTR/HF-02009 "Characteristics of telephone keypads, requirements of elderly and disabled people").

The practical outcome of changes in colour vision is that shorter wavelengths, as perceived by older people, are selectively dimmed. To maintain good visual performance, colour contrast should be maximized and combinations of the colour blue should be avoided.

Additionally, it is useful for people who cannot see very well to receive auditory and/or haptic feedback when the keys are activated.

6.1.4 Telephone information signals (tones)

When visual analogues of auditory information are displayed for the hearing impaired, the presentation of signals should mimic the cadence of auditory tones as far as possible. Although elderly people become less sensitive to flicker, telephone line signal cadences are usually well below any reduction of flicker fusion threshold.

6.2 Design considerations relating to changes in hearing

6.2.1 Hearing and locating the ringing telephone

Even moderate hearing loss can make it difficult to hear a ringing telephone, particularly in a noisy environment. Frequency components below 1 000 Hz will help people hear it more easily. Additional ringers and/or extra amplification can be useful, and/or the addition of alerting signals in other modalities, e.g. flashing lights or vibrators. Ambient noise levels should be reduced as far as possible, which will

assist localization in an unfamiliar or cluttered environment. Ideally, users should be able to make appropriate adjustments to amplification to suit their own needs.

This should not be a problem for people in a familiar environment. However, since ability to localize auditory information becomes less acute with age, consideration needs to be paid to the discriminability of location cues in tonal signalling.

6.2.2 Dialling and line signalling

Different signals (e.g. dial tone, ringing, busy, etc.) are more readily interpreted by people when such signals fall in a sensitive part of the auditory range, and when the patterns of tones are quite distinct (see also work being done under ETSI Work Item DTR/HF-01026 "Human Factors (HF); European harmonization of network generated tones. A review and recommendations").

Ageing particularly affects sensitivity to higher frequencies, so the use of high frequency signalling (i.e. > 1200 Hz) should be avoided unless frequency contours are highly discriminable. Most countries use signals in the region of 400-600 Hz - this is a useful frequency range for older people.

6.2.3 Communication

Background / external noise should be kept to a minimum for elderly people. The earpiece of the handset should fit well against the ear, so that it is at once comfortable and protects against extraneous sounds.

To the benefit of hearing impaired users, the telephone system itself has an inherent amplification, compared to face-to-face communication. Therefore, many people can actually understand speech better over the telephone than directly.

Further improvement may be obtained by simply adding a second earpiece on the telephone for listening with both ears. The loudness gain achieved by this is comparable to increasing the listening level for one ear by the order of 10 dB.

The majority of older people have a relatively mild hearing loss and can communicate without using hearing aids. For this group, and even for some hearing aid users, telephones with receiving amplifiers are of great help, provided that the gain is in the order of 10-20 dB. Further details are given in table 1 (adapted from Gleiss [7]).

Table 1: The effect of individual Average Hearing Loss (AHL) on speech communication

AHL	Problems with direct communication	Problems with telephone communication
$\leq$ 23 dB	Not appreciably.	None.
24-34 dB	Have difficulty in understanding speech in auditoria and in group conversation, but can hear speech at close range.	Not appreciably.
35-54 dB	Have difficulty hearing direct conversation at close range but can hear loud spoken speech.	Can hear satisfactorily at normal speech levels.
55-89 dB	Can hear amplified speech by means of hearing aids or similar devices.	Have difficulties at normal levels without additional aid.
$\geq$ 90 dB	Cannot hear speech under any circumstances.	Cannot use telephone with any acoustical aid.

People with severe hearing loss, who are dependent on hearing aids, should have the possibility of coupling the aid inductively to the telephone rather then using the microphone of the hearing aid, because the sound quality is much better than with acoustic coupling. In most European countries telephone terminals equipped with a coil for inductive coupling to the receiver are available to subscribers, and modern public telephones generally have this facility. However, inductive coupling can easily pick up electrical noise from the environment, and it is often difficult for the user to find the optimum position of the magnetic coil of the hearing aid in relation to the telephone receiver. Furthermore the frequency response of the coupling may not be very good.

Requirements exist on the provision of additional amplification as well as on the magnetic field strength and frequency response for inductive coupling are given in references [1] to [6].

Recently also terminals with a direct electric output adapted to a standardized input on hearing aids have been introduced [6]. The absence of electromagnetic interference in this coupling mode ensures that sound quality is high and stable.

Finally, people with such severe hearing loss that they cannot communicate by speech at all have to use visual sign language or text communication. Therefore, for communication over the telephone network they need access to a text telephone service.

Ideally, individuals should be able to make amplification adjustments and connections appropriate to their hearing needs.

6.3 Design considerations relating to changes in motor strength and skills

6.3.1 Getting to and handling the telephone

Overall, strength and motor co-ordination decrease with age. This can impact on the speed with which older people can move to a ringing phone. Many people may benefit from an automatic answering device that asks the caller to wait, or from a remote controlled telephone with handsfree facility (e.g. infra-red or voice activated).

6.3.2 Looking up numbers

When trying to find numbers in a printed directory older people may have problems; the directory may be too heavy to hold at a height at which they can easily read it. Directory enquiry services can offer a solution if the enquirer is able and prepared to take down details with pen and paper. An even better solution is that the operator of the enquiry service has the option of connecting through to the number requested.

An electronic directory providing telephone and facsimile numbers is another improved solution. By using a screen based terminal (such as that provided by France Télécom: the Minitel terminal and the Télétel service) the enquirer may consult the directory and receive one or more numbers (depending on the preciseness of the enquiry) on the screen. In general, numbers should remain on the screen until the chosen number has been dialled.

A quick-dial (see subclause 6.4.3) and repeat-last-number-dialled facility should be available to simplify dialling of important or frequently dialled numbers.

6.3.3 Using the handset

Older people's handgrip strength may diminish by up to 20 %. This may affect a person's ability to hold the handset over extended periods of time. The design of the handset should be of a shape and size that it is balanced and may be gripped in comfort. It is also important to avoid making handsets too heavy, or too light, since the lack of apparent substance may cause people to drop it on first contact, and more generally, they may find it uncomfortable.

The weight of the handset should be balanced across its length because it feels particularly uncomfortable for people when the earpiece is heavier than the mouthpiece.

With regard to shape, it is difficult for people with reduced strength to hold handsets that are very wide and/or have sharp edges.

Guidelines on the optimal design of handsets can be found in handbooks and ETRs (see bibliography).

6.3.4 Dialling

The accuracy of very fine movement is compromised in old age, along with reduced sensitivity to touch. This has implications for the design of key pads, which should conform to good ergonomics practice, particularly with respect to key size, shape, spacing, resistance and feedback.

Because of older people's reduced touch sensitivity, it is important that:

- keys shall be large enough to be easily to located by touch;
- keys should be well-spaced to avoid users pressing more than one key at a time;
- key groups with different functions should be easily discriminable by touch;
- the pressure required to activate a key should not be too light (to avoid accidental activation);
- the pressure required to activate a key should not be too high (making it too uncomfortable or difficult to activate);
- there should never be a requirement for pressing two (or more) keys simultaneously, as in some computer keyboard commands (e.g. *control-c*, *alt-shift-del*);
- keys should give a clear haptic feedback on pressing (to confirm that the key has been activated).

Designers should also note that among older people there is a large accumulated experience of keypad / keyboard usage, that is, older people are over-practised, or extremely efficient, in many key-pressing related activities, such as dialling numbers on telephones. This makes it very important that the arrangement of keys on different terminals follows existing standards, such as ETS 300 640 [3].

There should be no perceptible delay between key-press and reaction (i.e. acoustic tone or display update feedback) since this will be detrimental to all users, but especially to older people. Without fast response, there is a tendency to repeat the key press in the mistaken belief that the first press did not register.

6.4 Design considerations relating to cognitive change

6.4.1 Finding the number

For many older people there is some slowing down of all mental functions. It becomes increasingly difficult to attend to more than one thing at a time, so that absorbing the right information can take time. This needs to be taken into consideration for directory enquiry operations. Information should be presented slowly in "bite-size" chunks, e.g. digits should be read at about two digits per second. Written numbers should be printed in groups of two or three and directory pages should not be cluttered with irrelevant information.

6.4.2 Line signalling

As mentioned above (see subclause 6.2.2) it is important that the different tones are clearly discriminable. If they are too similar, older people may have problems recognizing which sound signifies which message. In help functions it would be useful to display a visual analogue or icon of the sound, beside the description of the signal.

6.4.3 Dialling

Once a process has become automated it is quite difficult to unlearn; this is particularly the case for older people. Thus, as mentioned above (see subclause 6.3.4) it is important to standardize dialling procedures and keypad layout, to avoid older people making errors as they apply their over-learned behaviours to new systems. For example, confusion may arise when older users proceed to use overlap dialling on a system that uses en-bloc dialling.

"Quick dialling" (use of abbreviated numbers) is a useful feature for people experiencing memory problems. It can be achieved by storing frequently used telephone numbers in an electronic memory in the telephone or in a machine-readable card. Each number is associated with a short number (one or two digits) and is activated by a function key or a code symbol. It may also be possible to obtain a similar service under the name of "Abbreviated numbers" from a service provider. It is important that the facility is easy to use - the programming and use of the feature should not involve multiple-tasking. Again, it would be useful if the procedure were standardized, so that people did not become confused when using different terminals / systems. Instruction manuals should be written in an accessible style.

6.4.4 Information and instructions

Older people tend to trade off speed for accuracy, and find it increasingly difficult to follow rapid streams of information to extract what they need; it is important that information is presented in small chunks.

When older people are in dialogue with a help system they need to be given sufficient time after presentation of information to decide on their appropriate response. It may help if simple cues or prompts for action are provided.

As older people are increasingly less able to attend to more than one thing at a time, it is important not to provide much information in different modalities simultaneously. It is also important to avoid providing unnecessary information.

7 Usability issues

It is commonly accepted that issues of usability should cover all types of user and older users should not be an exception. A fundamental usability issue is that real end-users' characteristics and requirements should be understood. A "user-needs analysis" has the function of identifying the key factors that should be considered when designing a system (guidelines can be found in ETR 051 [9] and ETR 147 [10]). The stages involved in such an analysis usually comprise:

- user description - who the users are, and their characteristics;
- task and scenario analyses - what the users' activities and goals are; and what usually arises as a function of the users' normal activities;
- acceptance criteria - the users' requirements and preferences;
- usability testing - analyses of objective user behaviour and of subjective attitudes.

7.1 User description

Most of the information in this ETR has focused on addressing user characteristics, specifically as it relates to older users. Consideration of these, along with other information, such as the users' back-ground, the users' goals, and their personal preferences comprise a checklist for user characteristics. Once such characteristics have been identified it is possible to draw up a user profile to aid design of tele-communications products and services.

7.2 Task and scenario analyses

Many users of telecommunications systems share the needs which are uncovered through the analysis of tasks and scenarios. This involves an examination of the different stages of the user's task (e.g. where the decision points are, dependency on other tasks, performance criteria, etc.) and a consideration of the different situations that can arise in the usage context, and how these might affect the user's performance and needs. By analysing situations that might render the product or system less usable, it is possible to gain insight for improvements.

7.3 Acceptance criteria

The analysis of the user characteristics and task should give an indication of what the user wants to achieve and how well the system matches these needs. However, it is often the users' own perceptions of their needs, and how they think the system matches them , that determine whether or not the system will be used. These requirement and preferences form part of the users' acceptance criteria.

7.4 Usability testing

While user needs analysis may help to identify many of the issues and concerns that should be considered when specifying and designing a system, usability problems may still remain. Consequently, it is very important that manufacturers regularly carry out usability testing of their products from the outset of the design process. Usability testing in the telecommunications environment is fully described in ETR 095 [8]).

It is important that testing should involve representative groups of older persons, covering the range of activities where some reduction in performance may be expected, i.e. impairments of vision, hearing, dexterity and memory. In addition, labelling, instructions and user guides should be included in the testing process. Older persons tend to enjoy being involved in user testing scenarios, and they tend to be very good at identifying ranges of performance and acceptability.

Measures of usability are commonly of two kinds:

- performance measures, which are *objective* measures or observations of user behaviour and are focused on task performance, i.e. how well the user can achieve a specific task;
- attitude measures, which are *subjective* measures or observations of the users opinion of working with the product or system, i.e. how well they like to use the system.

In addition to measurements of performance and satisfaction, usability testing will identify usability defects and ideas about how the product or system may be improved, and designers will benefit from involvement in the testing process.

Ultimately, the most rigorous test of usability takes place in the field, where the situation may be very much more difficult to control, but measures of acceptability will be possible and in particular, problems of use of a product are likely to emerge.

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History

Document history	
December 1996	First Edition

ISBN 2-7437-1170-1
Dépôt légal : Décembre 1996