Design Implications of Ageing and Disability

The following chapter provides some background information on ageing and disability which may be useful for designers to consider. Detailed reference material is included at the end of this section in the form of design prescriptions

When considering the design of products for elderly and disabled people, two common questions emerge, namely;

- ☑ *What is the size of the population of interest?*
- ☑ *What is known about ageing and disability which may have implications for design?*

Unfortunately there are no simple answers to these questions, as it must be acknowledged that very little is known about many impairment groups and the numbers of disabled people. There is a lack of even basic information regarding the incidence of impairment in many countries, as historically such information has not been collected and common definitions or criteria have not been established to capture information. For this reason estimates of the populations of different countries of the total numbers with impairment vary considerably. Before we address some estimates of impairment and disability in the EC, we must first agree on some definitions.

The World Health Organisation defines **Impairment** as “Any loss or abnormality of psychological, physiological or abnormal structure or function.” They define **Disability** as “Any restriction or lack (resulting from an impairment) of ability to perform an activity in the manner or within the range considered normal for a human being”, and **Handicap** is defined as “ a disadvantage for a given individual, resulting from an impairment or a disability, that limits or prevents the fulfilment of a role that is normal (depending on age, sex and social cultural factors) for that individual.”

The point to be made from all of this is that handicap is a relative term which is dependent on the culture and environment that a person lives in and the aids that are available to them. For example a person who wears spectacles has a visual impairment, and also has a disability e.g. being able to read without their glasses, but as long as they have their glasses (or have no need to read) they are not handicapped.

From a practical point of view it is useful to understand what proportions of the population have a disability of some sort, and what the implications of these might be for design. Elderly people are also of particular interest as a design group for the developers of AT products, as it is common for the incidence of disability to increase with age.

The population of Geographic Europe has been estimated to be just over 800 million (Roe 1995) with the EC accounting for approximately 355 million (taking into account Austria, Finland and Sweden). It has also been estimated (EUROSTAT 1992) that there are about 77 million elderly people in the EC. The numbers of disabled people in the EC are harder to estimate as different countries have different ways of measuring disability. However 12% of the population is a reasonable estimate and therefore there may be as many as 43 million disabled people in the EC. Many of these will also be elderly (approximately 70% of disabled people are over 65) and so it is difficult to be precise regarding the whole potential market for AT technology.

Age Related Changes in Capabilities

It is estimated that the numbers of elderly people in most of Europe are growing, and that in addition there is a trend towards more frail or "elderly elderly" people. Currently the estimates are that there are about 77 million elderly people in the EC, which could represent a large potential market for AT products. However it should also be borne in mind that the majority of elderly people do not have significant disability. The majority of elderly can live independently, and that it is only in the "elderly elderly" (i.e. over 75) that high levels of disability is usually seen.

Literature is available regarding the effects of ageing on sensory and cognitive capacities, but it is also fair to say that the area has suffered through a lack of any long term longitudinal studies looking in detail at how capacity varies with age. However some trends are apparent and they do have clear implications for design. The following section summarises the most comprehensive report produced in this area, namely Age and Design (Rabbitt and Collins 1989). However it should be recognised that these trends are generalisations, and in addition focus on what elderly people cannot do rather than on their abilities. In addition it should also be recognised that although the effects of ageing can be detected throughout most of a persons life with a reduction in capabilities being for the large part of a gradual nature, the most severe problems tend to only occur with the frail or extreme elderly who are likely to be aged 75 years and over.

Age has many effects on human capacity, and is characterised by an increase in variability of capabilities, both within a population and also within individuals. Thus there is a greater variability in the capabilities of a group of seventy year olds compared to a group of twenty year olds, and perhaps more significantly individual variability in capacity also increases. This has been attributed in part to older people having greater problems in learning new skills, but rather relying more on established patterns of behaviour, which in some circumstances may assist them, whilst in others it may hinder. The clear implication from this is that where possible new products for elderly people should try and build on existing skills rather than demanding new ones.

Age related changes in sensory and cognitive capabilities also occur and these also have implications for design. Changes to the visual system due to ageing mean that elderly people need higher levels of illumination, greater degrees of contrast between objects and their backgrounds, and that they will find it harder to change their visual accommodation i.e. to rapidly focus on objects at different viewing distances. Changes in colour perception also occur due to a yellowing of the lens of the eye. The ageing eye is also much more sensitive to glare, and elderly people will take longer to recover from the effects of this.

Age related changes in hearing also occur, with losses in the upper frequency registers being common. Deafness in elderly people can be caused by a variety of factors which include simple sensory problems through to neural difficulties. Simple amplification may not assist the latter problem, where the elderly person may find it difficult to process complex sounds such as speech. One partial solution to the non linear loss of hearing with age is to have selective amplification of different frequencies, matched to the needs of specific individuals, but again this will have little effect on deafness due to neurological problems.

Other changes in sensory capability that occur with ageing include a reduced sense of balance, a reduced tactile sensitivity, reduced motor control and a decline in taste and smell. These changes also have design implications, as some elderly people can be at increased risk of accidents because of them. Thus equipment for elderly people to use should not demand that they stoop or have to operate equipment in an unusual posture, and that controls should not require fine motor movements or a high degree of tactile sensitivity. Elderly people may also be less likely to detect escapes of gas, and the smell of burning, and so such cues cannot be relied upon.

The reduced tactile capacity of many elderly people has design implications, which include providing large control knobs, good tactile feedback, and ensuring that fine motor control is not needed to operate equipment. Elderly people are also less likely to notice extremes of temperature, making them prone to hypothermia in cold environments, and at a higher risk of being burnt or scolded by hot water.

In addition to these kinds of changes, ageing also has some effect on a persons ability to learn and remember new information. It has been known for a long time that human beings have severe limitations on the amount of material that they can hold in their minds at any one time. Thus a persons ability to remember a number of random digits is limited to between 5 and 9 items (Miller 1956). However people can develop strategies to compensate for this i.e. by grouping information, by the use of mnemonics, and other ways of organising information so that it is no longer perceived as random or arbitrary. Ageing does appear to effect such short term memory, limiting the number of items that many elderly people can hold in this way, and making them more prone to distraction. Thus good design practice should be to ensure that where possible the elderly users does not have to rely on this form of memory in order to perform tasks.

In addition to age having an effect on short term memory there is also evidence that the ability to learn new material is also effected. Elderly people generally need longer to learn new knowledge, but fortunately there is no evidence that they forget such material more rapidly than when they were young. However elderly people do need more time to retrieve information than the young, and again are also more prone to distraction. There is also some evidence that many elderly people have more problems with "prospective memory" (Maylor 1990) which involves the holding of agenda for future actions. Thus many elderly people may have more problems planning and managing their everyday lives, the implication being that planning aids would therefore be particularly useful for them.

Ageing also has an effect on a persons ability to learn new frameworks or schemata's for organising their worlds. Thus many elderly people can very easily master information which fits into their existing view of the world, but have more problems than the young when required to learn a new schema or world view. The implication is that where possible systems should be designed to build on the existing knowledge and expectations held by their users.

5 Categorising and Understanding Disability

A further problem encountered when discussing impairment and disability is that historically such conditions have been described in medical terms i.e. diagnostic categories. This is understandable as one objective of medical intervention is to refine diagnostic procedures and to find effective ways of treating underlying disease processes. However such classifications are of little value when used to describe disability, as they do not describe functional implications well. For example two people with the same medical diagnosis may differ considerably in how the underlying disease effects their ability to deal with their environment.

Some attempts have been made to move way from using medical classifications to categorise impairments and disability in functional terms. Useful work in this area has been carried out by the TUDOR project which was funded by the RACE program, and which provided demographic information on European Member States, as well as a consideration of how telecommunication systems could be made more usable for different impairment groups (Sandu and Wood (1990)).

The report describes impairment according to the following categories:

- Visual
- Hearing
- Problems with Communication
- Use of Legs and Feet (lower limbs)
- Use of Arms and Hands (upper limbs)
- Co-ordination of Movement
- Mental Functioning (Cognitive impairment)

However estimates of the numbers of disabled people are only provided for a limited sample of these. See table 1.

A cautious estimate is that approximately 12% of the population of Europe have a significant disability due to their impairment, and as can be seen from Sandhu and Woods figures, physical disability is the most common (lower limb disorders), followed by hearing, mental and visual problems. An additional point worth making regarding these estimates is that multiple disabilities are also estimated to be common, and that this may be particularly the case with elderly people.

There are a variety of sources of information covering the design implications of different types of disability, but as has already been discussed a lack of a suitable framework to discus disability makes generalisations difficult. In addition it is important to try and consider individuals needs where possible, as in this area a high degree of diversity of abilities and attributes are seen. USERfit has collated a number of these design sources which can be dipped into or browsed as the designer sees fit, but it is also possible to make some generalisations which may be of value to developers wanting to create products for a population of users, or to create universal products that can be used by all. The following contains some of these general recommendations, and the reader should consult more detailed sources of information for further details.

Type of Disability	***% of Population***	***Incidence (millions)***	***% of Disabled Population***
Physical:			
- Lower limbs	5.8	18.7	**51**
- Upper limbs	1.9	6.1	**17**
Visual	2.0	6.5	**17.8**
Hearing	2.7	8.7	**23.9**
Mental	2.3	7.4	**20.3**
Verbal Communication	1.1	3.6	**10**

Table 1: The Disabled Population of European Member States (From Sandhu and Wood 1990)

2.1 Visual Impairment

Total blindness is reported to be uncommon in most European countries. For example in the UK only about 4% of people who are registered as blind have a total lack of sight. Partial vision is much more common however which can include lack of visual acuity reduced visual field and also visual distortion. Estimates are that something like 6.5 million people in the EC have visual impairment, and in wider geographic Europe it is estimated (Roe 1995) that approximately 11.5 million have low vision, and something like 1.1 million are blind.

People who are blind have little or no access to written or printed material and therefore the designer must rely on using other forms of information. These include the use of Braille writing to label controls on products and where necessary using alternative modes of output such as sounds or speech output from systems. It should also be noted that Braille readers are in a minority, with most blind people not using such forms of communication. This is especially true of those who have gone blind in later life. Elderly people may also have more problems learning Braille because of reduced tactile sensitivity, and this may also cause problems due to some medical conditions e.g. Diabetes.

In general terms its considered a good idea to provide keys that are well separated in order to assist in their tactile discrimination and careful grouping of keys according to function can also assist the visually impaired in using a keyboard. Where possible the use of tactile labelling such as raised dots or figures on keys will also assist the visual impaired person being able to locate items. Tactile marking should be at least 0.5 mm high if they are to be easily detected. The large raised keys found on standard keyboards may cause particular problems for visual impaired and blind operators as the number of keys and the actual frequency of key presses can lead to very high error rates. Alternative ways of using such technology have been explored, which include voice recognition technology and speech synthesis. There are also alternative keyboards and displays for visually impaired people which include Braille keyboards, keyboards with a reduced set of keys (chord keyboards) and keyboards which can be programmed or customised to give macro or power functions. However it has to be acknowledged that conventional computer applications are often not accessible to the visually impaired, and that this has been made more difficult by the move towards window style interfaces involving the use of icons.

There are some general principles which can be used to improve the usability of conventional computer technology with visually impaired users. This includes having the ability to change the size of visual displays, being able to change the contrast and colours of screen characters, and also where possible improving the intensity of on screen characters compared to the selected background. Other ways of improving the use of technology by visually impaired is to improve the size of operating keys to equipment and also any labelling which are used for keys as well. One recommendation is that labels should be 9 mm high, but a reasonable compromise might be to ensure that characters of at least 6 mm are used.

When designing products possible impairments in colour vision should also be considered. Impairment in the ability to discriminate between red and green is particularly common, and it is estimated that about 8% of all males have some deficiency in this area, though it is much rarer in females. Yellow and Blue confusion is much less of a common problem, but a good rule of thumb is not to design displays which solely rely on colour cues in order to discriminate between different items. One feature of the ageing eye is a yellowing of its lens. this in turn can distort colour perception i.e. making it harder to distinguish between shades of blue.

2.2 Hearing Impairment

It is estimated that something like 8.7 million of the EC population have hearing impairments. In wider Europe it is estimated (Roe 1995) that 1.1 million are profoundly deaf whilst 80 million are hard of hearing. Hearing impairment is particularly common with elderly people and estimates are that something like 60% of people over the age of 70 have a significant loss of hearing. Approximately 0.1% of children have a congenital hearing impairment the causes of which include such diseases such as Rubella and Meningitis. In addition deafness can be caused by chronic ear infections and this can produce problems in speech production and comprehension in children. In addition to such congenital defects there is a general reduction of hearing with ageing as previously mentioned but in addition the maximum frequency of the sound that can be heard also decreases. The effects of ageing are also compounded by any damage to hearing caused by exposure to high levels of noise during the person's life, and unfortunately many hearing losses occur in the frequencies used for listening to human speech (2-3.5 kHz)

However generally hearing loss may only affect one ear and the impairment may only be an inability to detect certain frequencies, which may have little effect on speech comprehension. However other forms of deafness can include a complete inability to detect any frequency however loud it is. Most people who are deaf do have some residual hearing and this can be effectively used if the sound signal is amplified. However, for many hearing impaired amplification just leads to further distortion, and it can be useful to be able to adjust the frequencies of audio messages e.g. boosting certain frequencies depending on the individuals needs. A particular form of hearing problem which creates difficulties is the hearing impairment due to tinnitus where sufferers also experience a range of unpleasant and disturbing noises.

One design solution it to try and substitute alternative ways of providing information to the hearing impaired person. So for example warning devices may also include visual and vibrating or tactile signals as well as more conventional auditory sounds. The design of products for people with hearing impairments might also take into account the requirement to ensure that auditory equipment has an inductive loop transmitter as well, the idea being that people with hearing aids can then switch their device to an inductive setting which would allow them to hear the sound or the message through their hearing aid.

Other general design implication is to try and ensure that low frequency sounds are used rather than high frequency ones for auditory tones because it is more common for hearing losses to occur in the higher frequencies. This is particularly true of those elderly people suffering from hearing loss as a result of the ageing process. In fact one recommendation is that the principle components of an auditory tone should be less than 900 hertz in frequency.

2.3 Problems with Communication

It is estimated that something like 3.6 million people in the EC have difficulties with verbal communication. It is estimated that in wider Europe (Roe 1995) something like 2.3 million people have a speech impairment, 5.6 million have some language impairment (often due to intellectual impairment) and something like 25 million people suffer from dyslexia. A variety of cerebral problems can create speech and language impairment. One example is Aphasia which is a language handicap which is caused by damage to specific parts of the brain. It is very common for these kind of problem to be seen after a cardiovascular accident or stroke, and can range from semantically normal speech which is grammatically faulty through to speech which may be highly fluent but have unintelligible sequences and errors in selected words. Other problems can be created due to apraxia where motor control of the vocal apparatus is impaired, leading to problems in articulating the control of sequences of sounds.

There can also be a variety of voice disorders or difficulties in communication some of which are caused by problems in the formation of the larynx and the mouth itself and others relating to difficulties of articulation of speech such as stuttering and fluency disorders. In addition to language production reading difficulties can be common as well. A number of forms of dyslexia exist which include difficulties in relating visual sounds to letters, making semantic errors in reading language because of the similarity of different words, and confusion's between different letters in reading.

Lack of ability to communicate can be one of the most frustrating handicaps that people face and there are a variety of solutions which have been develop to try and assist in this process. Some of these include the use of advanced technology such as speech synthesisers whilst others may relate to very low technology aids i.e. communication boards where the person points to the alternatives they desire.

Reading difficulties can make the use of advanced technology particularly difficult and one solution is to use speech synthesis technology to support more conventional reading material. An additional technique which is often used is the labelling of keys or buttons with signs and non-verbal symbols as well as using text. Another technique used is to produce audio cassette versions of operating instructions and manuals. It should also be noted that those with congenital hearing problems may also have difficulty reading as well due to low educational attainments. It should also be noted that the reading abilities of some elderly people may by limited due to poor education, and it is therefore important to thoroughly test that any written material can be understood by the target population it is being designed for. It is very common for instructions and manuals for products to be designed as an after thought to product development, and insufficient resources given to this activity. It can be particularly useful for third parties not responsible for developing a product to write such material, as they will need to learn to use the product themselves in order to produce training aids.

2.4 Use of legs and feet - lower limbs

It can also be estimated that something like 18.7 million people in the EC have lower limb disorders. Gill (1994) estimates that there are 2.8 million wheelchair users in wider Europe, with a further 45 million who cannot walk withot aids. Impaired functioning of legs and feet obviously creates difficulties for people due to reduced mobility, and such problems are commonly caused by diseases such as arthritis, leg and spinal injuries and amputation. It is also certainly true that lower limb disorders are common in elderly people due to arthritic conditions, and this clearly has implications for the design of products and environments. The implications of lower limb disorders are clearly related to locomotion and mobility, and problems of gaining access and being able to reach and operate equipment. These issues have been discussed in detail in a variety of sources e.g. Goldsmith 1984, covering the need to provide access to buildings, ensuring that there are ramps to buildings, ensuring that doorways are wide enough and also ensuring that the design and layout of equipment is such that access to people with lower limb disorders (and in particular wheelchair users) is facilitated. Particular thought also need to be paid to the difficulties that such disabilities may cause to the reaching of controls for equipment, for example being able to change disks on a computer disk drive, and being able to reach the on off switch. One recommendation for this group is that all commonly used controls can be reached and operated from a sitting position. Another design implication of reduced mobility is that it will take longer to reach and operate equipment. Thus equipment which requires the person to respond rapidly may be difficult to use for such groups, and where possible this needs to be accounted for in product design.

2.5 Arms and hands -upper limbs

An estimated 6.1 million of the EC population have upper limb disorders. Gill (1994) provides more detailed esimates for wider Europe, estimating that there are 1.1 million who cannot use their fingers, 1.1 million who cannot use one arm and 22.5 million with reduced strength. Clearly these kinds of disability create problems for a wide range of activities such as holding objects, grasping and reaching. The degree and origins of disability experienced vary greatly, but commonly multiple sclerosis, arthritis and spinal injury are common causes of upper limb problems. It is common for interfaces to products to use keyboards or push buttons, and a good general design principle is to ensure that these can be operated with a minimum of force. Reduced strength can also be a problem with disabled people and tasks which involve strength such as lifting, pressing, pushing or pulling can be difficult for them. For example muscular dystrophy is a condition where strength is reduced in both upper and lower limbs with severe consequences for activities involving such limbs, but it can also be anticipated that there will be reduced strength to ageing and also common problems such as arthritis. One recommendation is that buttons can be operated with a force no greater than 0.6 N, and as well as facilitating use by those who are disabled this can also assist those who are young or elderly. Another good design principle is to ensure that products can be operated with one hand if necessary, and that simultaneous key presses are not required. Where possible it is recommended that controls can be operated by gross motor movements as well as fine ones e.g. it being possible to operate a switch with an elbow as well as a hand.

Also touch sensitive panels are a possible design solution for people with very reduced strength assuming they have good co-ordination. Problems are experienced for activities which require greater limb power such as opening and closing of doors and also the adjustment of equipment may be particularly difficult for those with reduced strength. Where there is very little motor control another solution is to allow customised input devices to be plugged into conventional units. For example a suck or blow switch can be used to operate a device rather than a button having to be pressed.

For those with severe upper limb disorders the use of alternative technology such as speech recognition can also be considered. For those people who have the use of their fingers but need support for hand and arms a keyguard allowing the limb to be supported or rested on the keyboard can also be a useful design option to avoid accidental key presses. Other options also include the use of 'sticky keys' functions on keyboards, and where muscle tremor is common to also build in software filters which ensure that accidental keypresses are not detected.

Interfaces with very simple menu driven systems can be of value for severely disabled people as it becomes possible to create a scanning interface where the user has the opportunity to select one of a number of menu options which are successively highlighted for selection. The menu automatically cycles through the items, allowing the user to select the item they want with a single keypress. Thus it becomes possible to produce a menu system which can be operated by a single input key e.g. a suck/ blow switch or some other simple input device. The ability to modify an interface to allow this kind of input can be valuable in ensuring that even those with a severe physical disability can use an interface. Another possibility is a stepping style interface, and it is argued that this is simpler to use for many disabled people (Cress and Goltz (1989)).

Cress and Goltz (1989) also provide a number of recommendations for the control aspects of interfaces for use with severely disabled people. Some of their recommendations are also relevant for the design of systems for elderly people to use. Specific recommendations for designing interfaces for use with those who are severely disabled include;

- They argue that techniques which reduce the cognitive load on users should be used, these include using touch screens, light pens, and touch pads as input devices, and that designers should try and minimise the need for visual tracking of target items.

- Single switch activation is simplest if performing consistently the same action e.g. signalling yes or no, rather than for multiple actions.

- They also recommend building in motivational features into the tasks for such users i.e. incorporating game features, and the use of graphics and animation.

- They stress the importance of matching the medium of information presentation to the skills of particular users , i.e. the use of words, pictures, symbols, noise, voice or animation where appropriate.

- They also provide recommendations for the presentation of information and the informational content of dialogues. They recommend having very simple displays i.e. one idea per display, and using blank space to focus attention.

- They also suggest using voice output for task instructions and feedback.

- They suggest minimising the use of transitory signals i.e. auditory beeps. It is also recommended that these can also be turned off as necessary.

2.6 Co-ordination of movement

Another functional problem that disabled people may face is a difficulty in fine motor control and co-ordinating activities, and it is estimated that something like 11.5 million people in wider Europe suffer from problems in this area (Roe 1995). This can include a whole variety of problems related to controlling the movement of the hand or finger accurately, the ability to maintain a pressure with the limb once something has been activated and also the actual speed of operation. This has many implications for the design of interfaces to products. For example for such people it is important to ensure that very rapid response times are not needed and also that keys are not accidentally pressed. This can be assisted by putting a delay into a key operation and there are a variety of other ways in which a person with impaired co-ordination can be helped. For example increasing the size and spacing of keys and fitting guards over keyboards can help, and also filters can be built into software to provide compensation for unintended multiple keypresses, premature releases of switches or pressing for too long, etc. One design option is to allow these kinds of features to be configured to a individual users requirements under software control.

The robustness of products may be also be particularly important with such user groups, along with the ease with which products can be maintained and kept clean during use.

2.7 Cognitive Impairment

Another common area of impairment is mental functioning and it is estimated that something like 7.4 million people in the EC have problems in this area. Gill (1994) estimate that approximately 30 million in wider Europe have cognitive impairment, and this is commonly coupled with language (5.6 million) and speech (2.3 million) impairment as well. There is a wide range of diversity in the conditions which can lead to impaired cognitive functioning, and this is an area which is difficult to make convenient generalisations about. It is estimated that approximately 2-3% of the worlds population have an IQ of less than 70, with effects ranging from merely having delayed development through to a profound handicap and dependency on others. It is common for the mentally handicapped to do better on activities requiring physical performance rather than verbal skills, and even where these are well developed social skills may be lacking which make independent living impossible. The majority of mentally handicapped people are physically normal, but those suffering from some conditions e.g. Down's syndrome do have severe physical problems as well. Many mentally handicapped people may also have emotional problems and in particular may not be able to deal well with stresses in their environment i.e. by responding with withdrawal or conversely by extreme emotional reactions.

It is difficult to make many meaningful generalisations in this area, as there is a high variability in how individuals are influenced by having different medical conditions, and in addition the relationship between medical condition and functional ability is not a simple one. However some points can be made.

The most common genetic abnormality is Down's syndrome, which is estimated to occur in 1 to 600 or 700 of live births. Variation in ability is high and therefore each individual must be assessed independently. However there are some common features which may have deign implications. Sufferers may have reduced muscle tone (hypotonic), and it is reported that many are mimics and like rhythmic music. Disturbances in peripheral circulation may also be common, which means that their hands and feet need to be kept warm in cold weather, and in addition cardiac abnormalities may be present.

Environmental factors can also cause mental handicap, with maternal infections, poor nutrition and birth injury being a few of the possible causes. Childhood infections can also cause problems, with meningitis and encephalitis being the most important. A number of syndromes have been identified, which include Autism, Rhesus factor incompatibility and Toxoplasmosis.

Epilepsy is another condition which may be associated with severe mental handicap, but the converse is not true. It is estimated that about 1 in 200 of the population suffer from epilepsy in one form or another. Certain forms of epilepsy can be triggered by flashing lights, and for this reason it is recommended that displays do not use flashing lights in the 10- 50 Hz range. Children may be particularly sensitive to this form of epilepsy.

Cerebral Palsy is a generic name for a number of disorders of movement and posture which can vary considerably in terms of severity and how it effects the individuals ability to function independently. Its incidence is fairly low, and estimated to be approximately 1 in 40,000 births. This situation may also be improving, as it is estimated that about 80% of cases are associated with abnormal births or neonatal problems e.g. infections. Cerebral palsy results from brain damage or developmental failure, and is often associated with mental handicap i.e. it is estimated that 55% of cerebral palsy children have an IQ of less than 70. However there are many exceptions to this, and problems in co-ordinating muscles controlling speech, facial expression and the ability to focus, may give a misleading impression that intellectual impairment exists. Such communication difficulties may well also lead to emotional stress, which may not be recognised by carers, and also reduce the individuals opportunities for learning. Many different functional problems can be seen in Cerebral palsy sufferers, and so it is important to assess the individual rather than making too many generalisations. With some balance may be effected (Ataxia), whilst others may have spastic paralysis of any number of limbs. Cerebral palsy may also be associated with other impairments such as visual problems, hearing loss, feeding and speech difficulties and learning difficulties.

There are no hard and fast rules for developing products for the mentally impaired to use, but some basic principles can be followed. One recommendation for example is that products are designed to be as visually appealing as possible, and that in addition for children they appear to be toys and games as well as having a purely functional value. This can be promoted by the use of bright colours for products, and having interfaces with a strong graphical component. As with design for many other user groups it is important not to rely on one sense to convey information, and auditory as well as visual feedback should be provided. As with the physically impaired it can be important to be able to tailor interfaces to the needs of specific individuals, and to some extend this can be achieved by having carer configurable features. The robustness of products may be particularly important with such user groups, and the ease with which products can be maintained and kept clean during use.

Ì General Design Recommendations

Some general principles follow for the design of products for elderly and disabled people taken from a variety of sources. More detailed information can be found later in this document in the section on design prescriptions.

3.1 Keeping Tasks Simple

It is particularly important to products that are simple to operate for elderly and disabled people. One trade off that needs to be explored is between providing more functions with the corresponding possibility of a complex control structure, and more simple systems with reduced functionality. The indications are that the latter strategy is likely to be more effective with elderly people, and systems should be developed which only provide simple functionality. Brown (1983) also reports that it is a good idea not to provide too many user programmable feature in interfaces.

Another general design principle, is that where possible dialogues should be designed to minimise the number of keystrokes required to operate them, as this will make them easier to use for people with arm and hand impairments. For this reason it is also recommended that in menu style interactions the most frequently used menu items are placed first on displayed lists, and that where possible selection can be with a single key. The objective should be to try and minimise the memory load on users, and the use of simple interfaces worded in a plain language will facilitate this. Where information is displayed for users to read it is a good idea to use short words which are positively phrased, as there is evidence that it is harder to understand material phrased in a passive or negative form.

An attempt should also be made to minimise what the elderly person has to remember in order to use a system, and as recognition is much easier than recall, where possible the interface should give the user cues as to what actions are permissible at any given point in the interaction.

3.2 Providing Consistency of Operation

Consistency is often regarded as a key design objective of user interface design, as consistency makes it easier for users to build up their own internal models of how a system will operate. It makes a system easier to learn and once something has been learned, the next time the same situation occurs it is already familiar. Consistency covers a variety of interface attributes, and includes consistency of controls and display layouts as well as operation. Thus it is important to try and ensure that menu items or keys which have the same labels perform the same functions at different points in a dialogue and that the same actions always have the same consequences.

Consistency can also be manifest in the application of style guides for development, where interfaces to applications are produced with the same look and feel as different applications. In mainstream IT development such style guides are now common, and are used for the development of the majority of Macintosh and Windows based applications. Such style guides are not common in the domestic control environment, with the possible exception of the work of the FACE project carried out under ESPRIT. One simple recommendation for the design of displays is that menus, warnings and messages to users should always appear on the same part of a screen.

3.3 Providing Cues for Operation

Where possible products should be designed to be as obvious or apparent in operation as possible. This is not a simple problem, and requires a combination of good labelling, structured tasks and where necessary cues for operation to be explicitly given. Thus if a user must press a key at a particular point in an interaction it can be useful for the system to explicitly remind the user that this action is needed. In addition it can also be useful in this context to build on users expectations or understanding of how a system may operate. Error correction routines may also be of value in this context, i.e. guiding the user to appropriate actions when mistakes have been made. Another aspect of this is to try and ensure that interfaces are self descriptive i.e. contain all the information that a user needs in order to learn to use them. Interfaces which do not provide these features will be difficult to learn to use, and may also need to rely on external sources of information e.g. instruction manuals.

3.4 Providing Feedback of Operation

Another good design principle is that all actions should provide feedback to the user that they have occurred and that this should take place as soon as possible after the users action. At the simplest level users should therefore be aware when a control has been activated and it is also recommended that users are informed through redundant sensory cues e.g. tactile feedback provided by any keys when operated. Direct task related feedback should be presented to users, and system responses are best used for indicating errors in learning tasks rather than for providing positive and negative feedback regarding performance.

Another reasonable design principle relating to providing feedback is the recommendation that equipment provides some feedback to the user that it has been switched on, and is working. Often this can be obvious from the way in which the equipment operates, but in some cases it can be useful to have some form of display e.g. an LED showing that the equipment has been powered up. Feedback regarding the consequences of user actions also needs to be given. In some systems this may be immediately apparent by the nature of the control task itself e.g. the telephone being rung, whilst in other cases more explicit feedback will need to be designed into the interface. Where a control action can be delayed e.g. commanding a window to be opened, the user needs to be given immediate feedback that the task has started.

A related principle is that interfaces should be perceived by users as being controllable i.e. that they understand where they are in an interaction, and the range of actions that are available to them. If users can easily build a mental model or internal representation of a system they are using then this will facilitate their acceptance of that system, and comfort in its operation.

3.5 Providing Error Correction

Where possible emphasis should be placed on reducing the potential for errors to be made. Error correction is important in most application areas, and it can be anticipated that many elderly and disabled people will make many mistakes when learning to use a new system. It is therefore important that the user can recover from errors made, and also know that the consequences of any mistakes will not be serious. Thus it is important to try and produce error tolerant systems. One way to achieve this is to demand confirmation of actions that cause irreversible changes to the system, but where possible to ensure that actions are reversible or can be cancelled. It is also considered important that error messages do not implicitly or explicitly blame the user for mistakes made, but rather should be positive and guide the user towards recovering from errors.

In order to improve the chances of an elderly or disabled person being able to detect output messages it can be useful to give the same message through different senses. On a fire alarm, for example, the letters in the word fire would illuminate on a panel while a "buzzer" would sound. Where possible devices should give visual, auditory and tactile feedback in order to improve redundancy and improve the chance of operation with a variety of disabilities. This is particularly important as multiple impairment is common.

3.7 Reducing the Complexity of all Operations,

A key design criteria for many elderly and disabled users is to make products simple to operate, and systems with a simple functionality are likely to be more acceptable than systems with a large number of features. For control purposes there is some indication that it is better to have a simple or shallow menu system for elderly users i.e. that it is better to have larger numbers of dedicated keys compared to a complex menu structure.

3.8 Providing Adjustable User Interfaces,

Many of the problems facing elderly and disabled people in using interfaces can be solved by developing interfaces with an underlying philosophy that they be adjustable to individual users needs. It is recommended that the maximum degree of adjustability be built into interfaces, and where possible this should also include the capability of connecting specialised control switches so that a standard product can be easily adapted for a severely disabled person to use.

3.9 Designing for Slow User Response

Elderly and disabled people may also have difficulty responding quickly to systems and for this reason it is important not to force such users to respond quickly. Where possible it is recommended that it should be possible to slow down or turn off timed responses. It should also be possible to switch off any automatic key repeat, and to adjust its delay characteristics. It is recommended that systems requiring responses in less than 5 seconds or the release of a key in less than 1.5 seconds should have such adjustments as an option. Users should be given flexible amounts of time to complete tasks, with the user being prompted when delays are excessive.

3.10 Avoiding Cluttered Displays

Another general recommendation is that attention is paid to the amount of information presented on any displays a product uses, as it is common for designers to try and put too much information on single screens. For the severely disabled user it can be effective to ensure that each display only contains one key idea, and in all cases the use of blank space can help to focus attention. Good layout is important and it is a good idea to ensure that only the information that the person needs to use is displayed, and that irrelevant or redundant information is kept to a minimum. Another good principle is to ensure that displays are kept consistent, with the same types of information always being displayed in the same areas of display screens.

Introduction to design Prescriptions

General

When you are designing a new device for people that are elderly or disabled it is useful to know if there is advice available that could help you in providing a good product specification. Indeed, there are many such sources of information and they may provide a significant contribution to your design. Some of them are general rules of thumb, others are specific statements about the actual design of a product or user interface. Some are merely suggestions, others have the status of standards. Some are based on experts opinions whilst others are based on empirical testing.

The term prescription is used in this document to refer to all of these different sources of advice which are in the form of recommendations. The advice provided may have been obtained from a general guidelines listing good practice, or may be derived from more formal sources such as design standards .

A total of 276 recommendations is cited here. However, since several of these recommendations (123) contains more than one statement, the total number of statements are actually much larger, and this collection contains a total of 780. The largest contribution (258 statements) comes from the work of the TRACE centre (Scadden and Vanderheiden, 1988, Vanderheiden and Vanderheiden, 1991, Vanderheiden, 1992, Vanderheiden, Mendenhall & Anderson 1992). However the work of Brandt (1995) has provided an additional 167 statements, and an analysis of Thorén (1993) has revealed a further 74. In addition to these main sources, an additional 15 papers by various authors are included in the collection.

The most optimal way of using the material in this section of the handbook, is to list all the statements that seem relevant to your design problem, and then to decide if you need more information on the rationale and background to that particular item. If so, you should look up the original source, which is referenced for each single statement. It is also important to remember that the guidelines listed in this section have been taken out of a larger document, and for this reason may be lacking the original context in which they were written.

There has not been any attempt to validate the different statements. They are cited directly as they are in the source literature. However, there can be problems when a statement is taken out of its original context and listed with other statements from different sources. One of the difficulties can be cross referencing in the original material; a statement may for example start like this: “As pointed out in section 2.3.4, people with a mental disability ...... “. Since such additional material is not reproduced in this document, such cross referencing in the source material is omitted. Many statements are the result of specific empirical investigation, and may seem difficult to apply when they are taken out of their original context. Where the meaning of a statement is not obvious it is strongly recommended that the reader consult the original source text.

The format of the prescriptions

When putting the different prescriptions together in one list and presenting them using a common format, there are several issues to be resolved. First of all, in the source they all have different structures. One prescription may contain a problem description, a rationale, some illustrations, references to other documents and so on. Another may only contain one single statement. In this document only the prescriptions themselves are cited, and not any of this additional material. This can lead to the material appearing more uniform than was originally the case, but this approach has been adopted in order to make it easier to search through the reference materials.

Each prescription is given a heading to identify its area of application, and each prescription may contain a number of design statements. There will always be a reference to the original source document for each prescription and the nature of the prescription is also indicated. If the original document classified the prescription as a “guideline”, “recommendation”, “standard” etc. then that term is used to classify the type of material presented. If the prescription is the result of an empirical investigation, but the authors have not classified the prescription themselves, it has been termed “Empirical based recommendation”. In all other cases this field is left blank.

Selection of prescriptions

The first criterion for inclusion in this collection, is that the prescription is aimed towards the general TIDE area i.e. the design of technology to support the elderly and disabled people. This means that it should be relevant for the design of information and communication products. However, we have considered it reasonable also to include recommend-ations for “universal design” and “design for all”. Design guidelines that are aimed at the general population, without addressing the requirements of elderly and disabled people, are however not included.

The next criteria for inclusion has simply been the availability of the material at the time of reporting. Although there has been an extensive literature review as a basis for this collection it is almost impossible to collate all design material which may be relevant in this field. In addition it should be noted that the collection provides a representative set of design prescriptions, and it is often difficult to attribute one source to recommendations which have become well established in the design community. The USER project makes no apologies for not being able to produce a comprehensive source list, as the resources for this activity have not been available, and the collation of prescriptive material was judged to be of a lower priority than other aspects of USERfit.

Overlaps and contradictions

Since the recommendations are cited in their original form, it may happened that two statements give conflicting recommendations. This may reflect a genuine disagreement between the authors concerned, or it may be the result of taking the statements out of context. There has been no attempt to resolve such conflicts in this collection.

The fact that several statements may express the same principle, should not be surprising since many source texts are concerned with the same issues. The repetition of a principle should not be directly taken as an indication that it is better proven, or rests on a firmer ground than other principles. It is very often the case that a new set of guidelines build on old ones, in this way similar statements in two different collections may build on the same, “older” source material.

Classifications

The prescriptions have been classified on the two dimensions: “Application area” and “User group”. There has been no attempt to construct an ideal classification system, or to use an existing one like ISO 9999. The rationale for this has been purely pragmatic, in order to classify the material in a such a way that makes it easy to find. For this reason common terms such as “elderly”, “vision impairment” etc. have been used to characterise the user groups. The recommendations for the blind and visually impaired have been classified together under “Vision impairment”, and recommendations for the deaf and hard of hearing is classified under “Hearing impairment”. Other groups covered include those with motor impairment, cognitive impairment and those who are elderly.

When a recommendation is aimed at more than one user group, or when it is aimed at “Universal design”, it has been given the label “More than one group” on the “User Group” dimension. Many of the recommendations that are relevant for the elderly user and for people with multiple handicaps may be found here.

The application areas have been classified simply based on the focus of the original recommendations. This has resulted in two broad categories, Computers and Telecommunication terminals, which covers about 70% of all the recommendations, with a smaller category to also cover consumer products. The possibility to further subdivide these areas has

Table 2: Classification system with page references and number of recommendations.

	User Group					
Application Area	***More than one group (113)***	***Vision impairment (59)***	***Hearing impairment (51)***	***Motor impairment (31)***	***Cognitive impairment (11)***	***Elderly (11)***
General recommendations (58)	p. 31 (29)	p. 43 (15)	p. 49 (2)	p. 50 (8)		p. 53 (4)
Computers (101)	p. 55 (39)	p. 69 (33)	p. 80 (7)	p. 83 (9)	p. 87 (6)	p. 92 (7)
Telecommunication terminals (96)	p. 95 (38)	p. 106 (7)	p. 110 (39)	p. 121 (10)	p. 125 (2)	
Consumer products (22)	p. 127 (8)	p. 132 (5)	p. 137 (2)	p. 139 (4)	p. 143 (3)	

not been implemented, since it would result in many categories containing no information. However, the material has been sorted within each Application area x User Group combination. The categories used are: General, Input device, Screen/Display, Sound output, Dialogue, Printer, Documentation.

Where recommendations have been aimed at more than one application area, they have been classified as “General recommendations” on the “Application Area” dimension.

Using prescriptions

The design prescriptions can assist in the definition of a products specification, and are of particular value in the translation of design objectives to detailed operational features. These detailed design activities are documented within the Product Analysis phase of USERfit.

However, it is important to be aware that prescriptions are a limited source of design information, and may not give you the accurate information you need for your specification. One would usually find that the statements are too general to give a good input to technical specification. However, there are good chances that general statements may be sufficient to assist in the process of developing a functional specification.

It is possible that your problem does not belong to any of the categories used for classification in table 1. One should then be aware that recommendations within one area may be relevant to other areas. For example many of the recommendations on how to design telephone keys, be appropriate to the design of keyboards in general.

A reasonable procedure for getting a list of relevant prescriptions would be to identify the most relevant cell(s) in table 2. The page number in the cell shows where that section starts in the prescription section. Look at all the pages which have been identified as being relevant in this way and mark those that might be of interest. One should then browse through the “More than one user group “for the relevant application, and the “General recommendations” for the relevant user group. If there is still a need for more material, one should look at related headings. Some requirements for the elderly user might very well be similar to some of the requirements for the visually impaired, and so on. The same holds for the application areas. Designing the user interface for a consumer product could very well use principles from the design of computer software.