MyUI: Mainstreaming Accessibility through Synergistic User Modelling and Adaptability

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Requirements for User Interface Adaptation

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Abstract	This deliverable defines the requirements for user interface adaptation for MyUI. The deliverable contains a literature review on the variability of elderly people, considering their abilities and limitations. It covers their physical/motor, sensory, cognitive and environmental degradations due to age and age-related conditions, and specifically including stroke. User requirements were derived based upon the literature review; empirical data from focus groups with the elderly in the UK and Spain; interviews with care professionals and subject matter expertise and technological expertise within the consortium. User requirements were defined for general, physical/motor, sensory, cognitive, and environmental aspects. From the user requirements corresponding functional, technical and non-functional requirements were derived.		

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1. Executive Summary

This document is a draft of the MyUI Deliverable D2.1 Requirements for User Interface Adaptation. The document reviews the existing approaches to adaptable and adaptive systems, and includes an overview of existing adaptive systems. It also reviews the literature on designing for human variability in old people and stroke survivors, and on the effects of the environment upon them.

User requirements were derived based upon a literature review of the variation in capability and disability of the elderly; empirical data from focus groups with the elderly in the UK and Spain; interviews with care professionals and subject matter expertise and technological expertise within the consortium.

User requirements were defined for general, physical/motor, sensory, cognitive, and environmental aspects. From the user requirements corresponding functional, technical and non-functional requirements were derived.

The user characteristics found to be of most relevance for adaptive user interfaces were: Physical/motor: personal mobility, hand strength, dexterity and finger movement, muscular control including semi-paralysis and speech impairment. Sensory: vision – diverse impairments, touch sensitivity and hearing impairments. Cognitive: memory impairments (long-term and working memory), reaction time, thinking speed, literacy (including computer literacy), learning ability, concentration, language comprehension and motivation. A number of environmental characteristics were found to be important also: Lighting (adequacy, quality, controllability, glare, flickering), ambient noise, physical layout of environment – devices – TV, remote, sensors, etc, and layout of controls – taking into account cognitive, physical/motor and sensory limitations.

The recommendation arising from the work is that experiments with simple interface prototypes should be designed to study user's reactions to interface adaptations in order to further refine the user requirements.

2. Introduction

This is deliverable D2.1 Requirements for User Interface Adaptation of WP2 of the MyUI project (ICT-248606). The results are specifically the outcome of Task 2.1 "Requirements for User Interface Adaptation" which is described as follows in the MyUI Description of Work (DoW).

> *"Specify the accessibility and usability requirements that arise from the specific end user characteristics and environmental factors covered by the modelling framework. Requirement collection will include end user requirements as well as functional requirements from the device and application providers' perspective and technical requirements.*
>
> *The requirements specification will be restricted to the application fields of the envisaged MyUI demonstrators (cf. WP 4). Therefore, the scenarios to be covered by the MyUI devices and services will be defined as a first step (see also T4.1)*
>
> *Requirements will cover different input devices and modalities, selection and presentation modes of displayed information, interaction sequences, available functionality and interaction options, etc. Moreover, the requirements for the design of dynamic user interface adaptation mechanisms are specified. Issues of acceptability, understandability and user interface stability/consistency are of special interest."*

2.1 Objectives & Scope

WP2 sets out to research and demonstrate interface adaptation for elderly people and stroke survivors. Interface adaptation is based on data derived from hardware or software sensors, which detect information about the user.

This document, based on research outlined in Chapter 4 below (Methods), sets out to define the dimensions of interface variability, which the adaptation engine should satisfy, while being acceptable and beneficial to the end user population. The scope will be limited to the end user characteristics and environmental characteristics of the three demonstration applications described in MyUI deliverable D4.1.

As a Requirements document rather than a Design specification, this document provides grounding in an understanding of what may be possible and affordable with current technologies, specifically sensor technologies. The main emphasis at this stage is on end-user accessibility and usability requirements, and functional requirements. There will also be specification of technical requirements in general terms, specifying the parameters within which technology should be selected but not pre-supposing what the technical solutions will be, or how they will be structured, at this stage.

2.2 Relationship to other work packages and tasks

This deliverable (D2.1, due month 6) is the result of Task 2.1 in work package 2, and depends on the following input deliverables:

- **WP1 User and context modelling**
  - *R1.1 Draft version of context ontology, user modelling concept and context management architecture (month 6).* As R1.1 is expected to be achieved in month 6 "tight coordination" between these tasks has taken place with regards to the development of the ontology and understanding the users.
- **WP4 Mainstreaming user-model-based adaptive accessibility into devices and services**
  - *D4.1 Demonstration scenarios (month 3).* This deliverable provided the application focus for the requirements and thus stakeholders and context of use as described in the

next sections. As such, early work towards D2.1 was carried out in conjunction with WP4.

The output of this deliverable will be relevant for the next task in WP2: task 2.2 Concepts for Self-Adaptive Multimodal UIs. It will also inform the design of the virtual user lab (WP3).

2.3 Stakeholders and Roles

The following is a list of all the relevant stakeholders and their roles in this deliverable.

- End-users of the MyUI demonstrators, particularly *elderly people and stroke survivors* involved in the focus groups to elicit needs that the adaptation features are intended to meet.
- Industrial users such as *caring professionals and physiotherapists* involved in interviews to provide understanding as potential facilitators of the MyUI demonstrators.
- Consortium partners, such as the *human factors experts* who have elicited needs to produce user and functional requirements; and *software developers* who have considered the user and functional requirements to understand the end users and thus produce the initial technical requirements for the adaptation system.

2.4 Contexts of use

Based on the outcomes of MyUI deliverable D4.1, the specific environments in which it is envisaged that the system will be used are as follows:

- *Domestic homes* - Elderly users may have access to MyUI technologies within their own homes, in cases where people still wish to live independently but are not very mobile and therefore limited in their ability to get out and about. This means that they would be able to use the various technologies from the comfort of their own armchair.
- *Clinical premises such as physiotherapy clinics* - Following a stroke and after discharge from medical care, a physiotherapist may carry out a formal assessment of a stroke survivor in a professional clinic. It would then be possible for the physiotherapist to create an initial user model for the MyUI system in order to run a customised exercise regime for the patient, taking into account their motor, sensory and cognitive abilities.
- *Day centres for older people* - These are points of community contact for the elderly, where various groups meet up to provide social interaction and support. There is an opportunity for the MyUI technologies to also be used in this environment, perhaps with the possibility of assistance from Day Centre staff where required.
- *Care homes for older people* - Care homes offer an increased level of support for elderly people who may no longer be able to live independently in their own homes. People here live within a community of elderly residents in a fairly confined environment and will suffer from varying degrees of age-related disability. Professional staff provide a high level of support within the care home.

3. Definitions and Terminology

3.1 User Interface

The user interface of interactive computer systems includes (Preece, 1993, p. 58):-

- the methods of input used,
- the style of the output and screen displays,
- the overall 'look and feel' of the interaction

The user interface of a system or device is defined by the controls and displays used to input to, and receive information from, the system.
Successful interaction will be affected by how well the user understands how the system works, how to use the controls and how to interpret information from the display (Norman, 1998).

Information presented to users should be accessible and comprehensible; when the input language and output language match the user's understanding, they are more likely to have an accurate understanding, or 'mental model' of how the system operates (see Figure 1; Abowd and Beale, 1991).

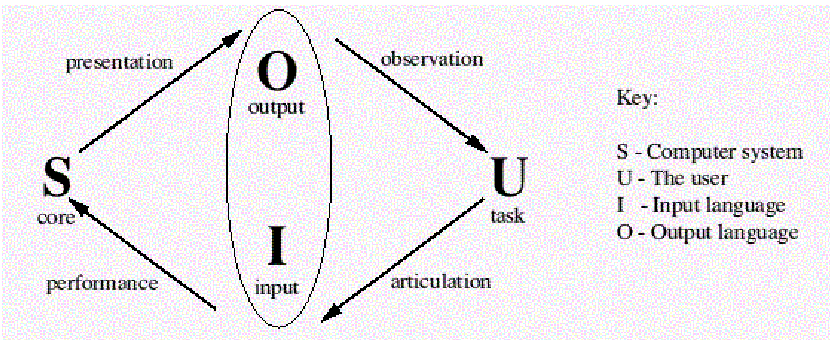

Figure 1: Interaction model (Abowd & Beale, 1991)

3.2 Usability

Lin, Choong & Salvendy (1997) present three definitions of usability:-

Shackel (1991):

> *"... the capability in human functional terms to be used easily and effectively by the specified range of users, given specified training and user support, to fulfil the specified range of tasks, within the specified range of environmental scenarios."*

Preece (1993):

> *"The goals of HCI are to develop and improve systems that include computers so that users can carry out their tasks: safely, effectively, efficiently and enjoyably. These aspects are collectively known as usability".*

ISO (1993):

> *"... the quality of use: the effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments."*

3.3 Accessibility

ISO 22411 (2008) Annex A defines “Accessibility” by quoting the “Principles of Universal Design”, generated by the Centre for Universal Design (1997):-

> *“Universal design can be defined as the design of products and environments to be usable to the greatest extent possible by people of all ages and abilities. Universal design respects human diversity and promotes inclusion of all people in all activities of life. It is unlikely that any product or environment could ever be used by everyone under all conditions. Because of this, it may be more appropriate to consider universal design a process, rather than an achievement.”* (Story, Mueller & Mace, 1998)

The full list of principles is provided in Appendix A.

3.4 Adaptive systems and interfaces

A user-adaptive system:

> *“…adapts its behaviour to the individual user on the basis of non-trivial inferences from information about the user”.* (Jameson, 2003)

Later Jameson (2008) defines an adaptive system as:

> *“An interactive system that adapts its behaviour to individual users on the basis of processes of user model acquisition and application that involve some form of learning, inference, or decision making”.*

Oppermann (1994) makes a distinction between adaptable and adaptive interfaces;

- **Adaptive interfaces** detect user preferences, build user models and adapt their behaviour with little or no purposeful user involvement, whereas
- **Adaptable interfaces** are modified by a deliberate and conscious choice of the user.

A review of adaptive systems and interfaces is provided in section 5.1 below.

3.5 End users

As stated in section 2.3 above, the end users of the MyUI demonstrators are the elderly and stroke survivors. These are defined as follows.

3.5.1 Elderly or older person

A definition based purely on chronological age would be inappropriate for this project, as people age very differently. Some frequently occurring characteristics among the older population are as follows (Smith, Norris & Peebles, 2000; Brault, 2005; Donald et al, 2010):

- Significant age-related sensory impairments.
- Limited mobility.
- Higher use of medical services.
- Higher use of age-related support services; e.g. delivered meals.
- Predominately indoor living (UK).
- Living alone or specialised accommodation, e.g. warden aided or care homes.
- Loneliness and isolation.

Some elderly have few or none of these characteristics. The elderly targeted by MyUI are those who have some or all of these characteristics.

3.5.2 Stroke survivor

Stroke is a sudden partial loss of brain function due to circulatory blockage (ischemic) and/or leakage (hemorrhagic) of blood vessels within the brain (UK Stroke Association). Its frequency increases with age, especially old age. Stroke is a common cause of fatality; however many people survive one or more strokes; there are more than 2.5 million stroke survivors in the USA (Jack et al, 2001). Following a non-fatal stroke, a patient will receive acute medical care for a period, and then rehabilitation programmes. Many move on to more independent living, albeit often with significant remaining impairments. The stroke survivors, who will form one focus of MyUI, are those who are no longer in receipt of acute medical care and are rehabilitated to some form of independent living, but still have impairments as a result of the stroke. (People in these circumstances sometimes prefer the word “survivor” rather than “victim” or “patient”.)

3.6 Industrial Users

As stated in section 2.3 above, the industrial users of the MyUI demonstrators are physiotherapists and caring professionals. The users of this document and the MyUI adaptation principles will be the technology developers. These are defined as follows.

3.6.1 Physiotherapist / physical therapist

Physical therapy and physiotherapy are professions, which seek to restore and maintain physical function along with consideration of the general well-being of patients. Physical therapy is concerned with quality of life in terms of physical, psychological, emotional and social well being (WCPT, 2007). The focus of physical therapy is, however,

> *“to develop, maintain and restore maximum movement and functional ability…providing services in circumstances where movement and function are threatened by aging, injury, disease or environmental factors….Physical therapy involves the interaction between physical therapist, patients/clients, other health professionals, families, care givers, and communities in a process where movement potential is assessed and goals are agreed upon, using knowledge and skills unique to physical therapist.”* (WCPT 2007)

Similarly, physiotherapy

> *“…uses physical approaches to promote, maintain and restore physical, psychological and social well-being, taking account of variations in health status. Physiotherapy is science-based, committed to extending, applying, evaluating and reviewing the evidence that underpins and informs its practice and delivery.”* (CSP 2002)

3.6.2 Caring professionals

Caring professionals

> *"have a primary commitment to care for their clients; personalised care is central to their practice as professionals. ... The needs of clients are said to take precedence in their work. ... they are professions imbued with a service ideology"* (Abbott & Meerabeau, 1998).

A prime distinguishing feature is that caring professionals are paid to look after, or care for, other people and that they strive to do this as best they can (i.e. in a professional manner). Caring professions include those working in: health care (e.g. nurses, midwives, health visitors, physiotherapists, occupational therapists, speech therapists); social care (e.g. social workers, probation officers); and elderly care (e.g. care assistants, care workers).

3.6.3 Technology Developers

Designers and developers of technological artefacts (such as interactive televisions and computer systems) are recognised as the main users of the MyUI project. The main beneficiaries or end users of the adaptation engine, which is the main focus of this document, are the defined MyUI end user groups. However, the designers and developers are also important stakeholders of the MyUI adaptation as it might change their current practice of designing and developing user interfaces significantly:

- A perfectly designed system-initiated UI adaptation will take away the burden of designing for different user groups.
- They will have to foresee potential (run-time) adaptation paths of the user interfaces.

4. Methods

4.1 Rationale for methods

The methods used to elicit and identify the user adaptation requirements included literature review, focus groups and interviews with older people users and a range of professionals with expertise in care of older people and stroke survivors. The rationale for the adoption of this mixed method approach is explained in this section.

A review of academic literature was carried out first to determine existing scientific knowledge in this area - i.e. the needs of our target elderly users. This literature review is presented in chapter 5 below. Some of the studies cited involved thousands of older people, or even whole population data from census information, which this project could not hope to replicate. However, to ensure the work would be properly focussed on our specific user groups, and in order to embrace aspects of user-centred, inclusive and participatory design methods, field studies and interviews were conducted in Spain and the UK. A reading of the academic literature helped to inform the design of these supplementary user studies.

Eliciting requirements is generally a somewhat qualitative and subjective process, sometimes involving attempts to resolve conflicting demands from different users. Andy Crabtree (Crabtree, 2003) commends ethnographic study methods for the *"wild and wicked problem"* of eliciting requirements and for designing collaborative systems. At the early requirements stage of a project, methods tend to be more observational and conversational, qualitative and to some extent subjective.

Qualitative field-based methods may be thought to generate less objective data than quantitative lab based approaches, and there may be concerns that the findings cannot be generalised to a wider population. With good research design these concerns can be mitigated. Qualitative methods are very effective for creating deep and rich understanding, and are therefore particularly suitable for generating ideas and hypotheses, for understanding fields characterized by ambiguity and complexity, and for requirements elicitation and early evaluations in a process of iterative refinement (Brantlinger et al, 2005, Creswell, 2007; Lamsweerde, 2009). For such authors, qualitative methods can generate genuine knowledge (i.e. "science"). Rather than attempting to address quantitative concerns of validity and reliability of their results, qualitative researchers should demonstrate credibility and trustworthiness. Qualitative methods can generate deep understanding, especially of ambiguous and intangible concepts, but are less able to create statistical proof. (Brantlinger et al, 2005).

Iterative design methodologies (Sharp, Rogers and Preece, 2007) including the spiral model (Boehm, 1984), help to mitigate the uncertainties of a requirements investigation, by involving users in evaluations of prototypes of increasing fidelity throughout the project. Work Package 5 in this project will fulfil this role, by carrying out studies of early MyUI prototypes.

Lindgaard et al (2006) propose a hybridization of the practices of User Needs Analysis and Requirements Engineering. They appeal for a detailed study early in the design lifecycle of users, tasks and environment, before designing products, echoing the classical Ergonomics concern with user, task, environment and product. The value lies not only in the outcome of this task analysis, but also in the process itself, in influencing the analyst/designer and informing subsequent phases. For these authors, requirements elicitation arises from:

- Study – preferably field-based - of the users, the environment, the task and the effectiveness of any existing technology
- Questioning and exploration into what obstacles and frustration points exist and how a system might be improvable

- "Allocation of function" work, to determine what aspects of a task might be improved by automation or technological support, and what parts are best done by the human.

In the tradition of user-centred design, it is valuable to conduct field studies in the user's own environment. Such studies help researchers to understand the users, their current usage and their requirements (Sharp, Rogers and Preece, 2007) and develop rapport with the user community, keeping the design user-focused (Lindgaard et al, 2006; Muller, 2002).

Previous experience of the authors and the academic literature on studying older people (e.g. Goodman et al, 2004), suggests that Focus Groups can be more effective than individual interviews, especially if held in a group context and in the user's environment, e.g. in a day centre. Such Focus Groups use visual aids and practical experiences to facilitate discussion. In one relevant example, various handheld devices were passed round the group for them to attempt to understand and use. This provided rich qualitative feedback, rooted in practical experience, and also initiated other comparisons to devices they had used in other contexts.

The project did consider the use of bulk questionnaires as a method to provide more objective and quantitative data. However questionnaires can prove problematic for older people with cognitive and/or sensory impairments (e.g. difficulty seeing, reading or understanding the text or in writing a response). There is also a high prevalence of privacy and confidentiality concerns among older people. For this reason, and also on the advice of a care professional in a day centre, we preferred the use Focus Groups for the older user groups. This was supplemented with semi-structured interviews with professionals involved in the care of older people and stroke survivors.

4.2 Detail of methods used

Following the above rational a multi-method approach was adopted, illustrated in Figure 2 below.

Academic literature was studied first so that subsequent research would build on existing knowledge. Field studies can then be conducted focussed more specifically on our target users and environments, to confirm, contradict, supplement or challenge data from the literature.

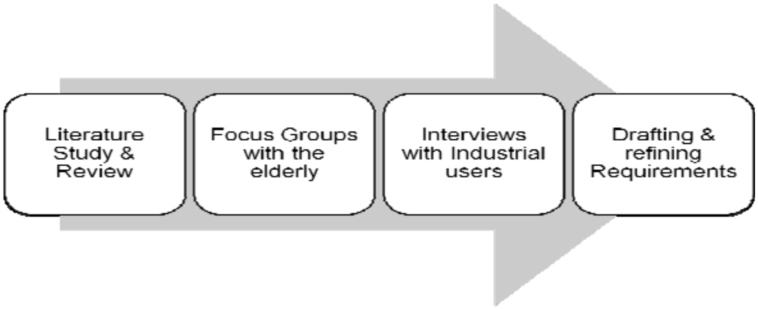

Figure 2: Requirements derivation methodology.

Focus groups with samples of elderly people in the UK and Spain, and structured interviews with Physiotherapists and caring professionals, were conducted to confirm, contradict or supplement what had been learned from literature. This also provided a more in-depth and ecologically valid understanding of the users, their environments, their objectives, their existing use of relevant technologies and hopes, difficulties, preferences and achievements with it. Appendix F gives the instructions for running a Focus Group with older people.

Key areas addressed by these focus groups and interviews were:

- What types of controls and displays are used effectively, efficiently, satisfyingly and safely by these users; especially the sorts of displays and controls which might be used to interact with proposed technology (i.e. interactive TVs, remote controls, digital frames).
- The environmental factors which might be relevant in the proposed working environments (domestic homes, physiotherapy clinics, day centres, care homes etc).
- What impairments and limitations relevant to the use of such technology exist, and how these impairments might change over time.
- What sort of sensors might be acceptable to these users.
- What forms of interface adaptation might be beneficial, and which (if any) types might be unacceptable for any reason.
- What problems and challenges do the elderly have with existing technologies, and what possible improvements might be achievable with better technology.
- Exploration of what types of activities or interfaces might be attractive and enjoyable for them to use.

The interviews and Focus Groups also questioned what are the difficulties and obstacles posed by existing user interfaces, and how might these be overcome (i.e. beginning “Allocation of function” work, to determine what aspects of a task might be improved by automation or technological support, and what parts are best done by the human.)

Experience Reports were used to document the activity and outcome of Focus Group sessions with user representatives. Two examples of experience reports are presented (anonymously) in Appendix B:-

B1: UK Focus Group with older Day Centre Service users and staff at Day Centre “DCA”, Nottingham, UK.

B2: Spanish Focus Group with Elderly House residents and staff at an Elderly House in Getafe near Madrid, Spain.

Interview templates were generated for use with elderly people / stroke survivors, physiotherapists and other professionals. A semi-structured interview method was applied, in which the interview questions were used as a checklist to ensure that the interviewers covered the general topics of interest to MyUI in each interview. However, the specific questions were used as a basis for discussion, and respondents were encouraged to elaborate on their answers as appropriate. These interview templates are presented in Appendices C & D as follows:

Appendix C: Interview template for physiotherapists

Appendix D: Interview template for professionals caring for elderly people

Data from all three sources (literature review, focus groups and interviews), together with subject matter expertise and technological expertise within the consortium were used to derive requirements relevant to MyUI. Draft Requirements were reviewed by a panel of experts in the care of older people, stroke survivors, physiotherapy and interactive TV, and refined in the light of feedback from the panel. Requirements tables are presented in Sections 7-11 of this deliverable.

5. Literature Review of Established Knowledge

This review covers four subject areas:

- Adaptive Systems and Interfaces
- Characteristics and variability of older people and stroke survivors
- Characteristics and variability of their environments
- Existing standards and guidelines for designing technology for these users

5.1 Adaptive Systems and Interfaces

5.1.1 Distinction between adaptable and adaptive systems

Adaptability *"A system is called adaptable if it provides the user with tools that make it possible to change the system characteristics."* (Oppermann, 1994)

The goal of adaptability is to enable the user to configure a user interface according to his personal preferences.

Adaptivity *"A system is called adaptive if it is able to change its own characteristics automatically according to the user's needs. […] The system initiates and performs changes appropriate to the user, his tasks, and specific demands."* (Oppermann, 1994)

Thus, an adaptive system changes itself in accordance with changes in user interaction. When a system is used frequently a user learns additional functions. This learning process is saved in a user model and enables the system to automatically self-adapt to the user's state of knowledge and adjusts the interaction.

Adaptive user interfaces are especially useful for systems that are used frequently because of the possibility of gathering enough data on the user to design an applicable user model so that the user can be assisted adequately and carry out routine tasks more efficiently.

An adaptive system can also have an adaptable component so that the user can make changes to certain parameters. (This section links back to 3.4).

5.1.2 Classification of adaptive systems

Dieterich et al. (1993) suggests that the adaptation process contains four phases:

1. Initiative – in which a decision for adaptation is made.
2. Proposal – in which alternatives for the system are developed.
3. Decision – in which one of the alternatives is selected.
4. Execution – in which the selected adaptation is performed.

Each of these phases can be done automatically by the system or manually by the user of the system. If all phases are executed manually, it is an **adaptable system**. If all of the phases are carried out automatically it is an **adaptive system**. Some combinations in which different phases are performed automatically or manually are possible. These are illustrated in Figure 3.

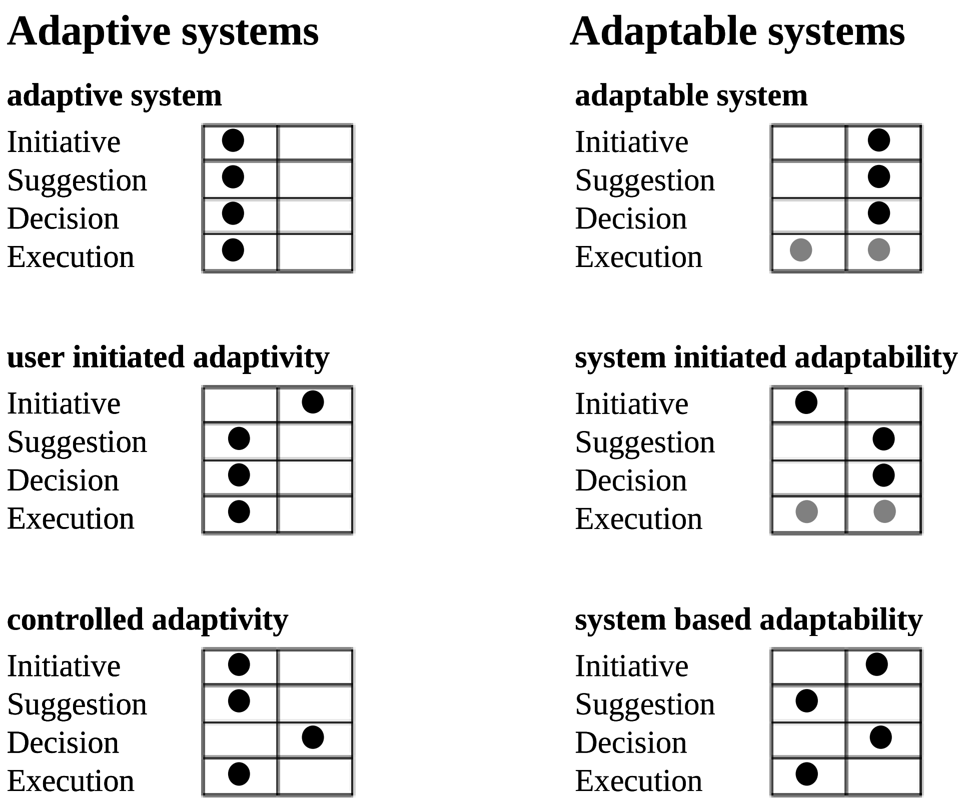

Figure 3: Adaptive and adaptable systems (Dieterich et al. 1993).

The characteristics of these adaptive systems differ with regard to the starting point of the user initiation of the adaptation (user initiated) or selection of an adaptation (controlled). If the user is intervening in more than one phase, the systems are referred to as adaptable systems, since it is no longer an automatic adjustment. If the system initiated an adaption, independent of who carries out the implementation, the system is called a system initiated adaptive system. Also, the type of execution - by system or user - is irrelevant for the classification of adaptive systems. In the case of system based adaptive systems the user decides on the timing and nature of adaptation.

Thus, the classification of a system is based on initiation and execution of adaptation. The configurations illustrated in Figure 2 are described as follows:

Adaptive systems:

- **Adaptive system:** the system makes the decision as to what is adapted and if adapted.
- **User initiated adaptivity:** the user decides to make changes to the system interaction.
- **User controlled adaptivity:** the user decides if the proposed adaption is made or not.

Adaptable systems:

- **Adaptable system**: the user configures the system according to his personal preferences.
- **System initiated adaptability**: the system suggests an adaption. The user then decides if the adaption is made or not.
- **System based adaptability**: the user chooses to make changes to the system interaction. The system makes suggestions for the adaption; the user decides whether or not to accept the suggestion.

5.1.3 Composition of adaptive systems

An adaptive system can be considered to consist of three stages (Weibelzahl et al, 2004; summarising Totterdell & Rautenbach, 1990; Oppermann, 1994 and Jameson, 2001):

- Afference – collection of observational data about the user.
- Inference – creating or updating a user model based on that data.
- Efference – deciding how to adapt the system behaviour.

This section examines these three stages in more detail.

5.1.3.1 Collecting Data – Afference

In order to adapt itself, a system must have data that provides conclusions about reasonable adaptations. A distinction is made between implicit and explicit data collection.

Implicit data collection

In implicit data collection the system independently collects data as a background task; users are not directly involved and may not be aware that this is happening. Four different types of data are characterized:

(1) **Context-sensitive** or **task-oriented data.** The present context of the user is particularly important and the system analyzes the process currently performed by the user (e.g. which screen-mask is currently displayed to the user). Generally these transactions will be designated as naturally occurring events (cp. Jameson 2001). Therefore these are actions that users perform during the normal use of the system.
(2) **User characteristics**. User-specific information related to the operations and functions carried out by the user is collected. In addition, general operating parameters of the system can be of interest such as the analysis of server log files. According to Jameson (2003) independent systems e.g. publicly accessible sources on the web can also be used for data collection.
(3) **Technical characteristics** concerning the human-machine interface. Depending on the system, users can interact with different devices (PC, mobile phone ...) and user interfaces (Web browsers, application ...). Also, the bandwidth for data transmission can vary.
(4) **Environmental characteristics.** These are dependent on technical characteristics, because the sensors for data collection can vary from system to system. In principle the sensor system provides the possibility to collect information about the environment. The use of many different sensors is possible, for example to facilitate:

- Location and positioning.
- Measuring the ambient brightness.
- Face recognition.
  Emotion detection.

Sensors can collect data either continuously or at particular stages.

The advantage of implicit data collection is that the user can perform his or her usual interaction with the system. However, this is also a disadvantage insofar as the implicit data collection is not transparent for the user (cf. Jameson 2003). Since the user does not know what data is collected (when and how), it causes him to feel insecure or even violated in respect of his privacy so that he takes a critical view of using the system.

Explicit data collection

In explicit data collection, the users are actively involved in data collection. Earlier explicit approaches consider the inclusion of users in the design process of adaptive systems (e.g. Liang, 1987). This approach is often not practicable, since normally there are several iteration phases required. Additionally, it is difficult to include the whole variety of different users during the design phase. Explicit data collection can be divided into two areas.

- Settings the user actively performs in the system. It can be differentiated between settings the user sets for personal use and settings that are made for other users, e.g. the allocation of rights by administrators.
- Explicit retrieval of information. Techniques such as conventional questionnaires (multiple choice or standardized) and rating systems, but also packaged or disguised queries in the form of a game are used.

Generally, explicit and implicit data collections are able to collect the same data. However, according to Jameson (2003) it should be considered that the users' response is not to be trusted unconditionally. For example, users might not answer truthfully because they consider the response to be inadequate (Social Desirability). In this case the psychological methods and findings related to the design of a questionnaire have to be observed. Another disadvantage is the rather complex data entry, depending on the type of information and the amount of the collected data. According to Carroll & Rosson (1989) users of a system are generally unwilling to accept major efforts (from their perspective) not goal-directed queries.

5.1.3.2 Evaluating Data – Inference

In the inference phase the collected data is processed and evaluated in consideration of adaptation.

Possible reasonable conclusions include:

- Which action(s) the user wants to perform next.
- Which knowledge the user has in relation to the system / topic.
- How do current influences from the environment affect the interaction with the system.
- Which adaptations are technically possible, useful and allowed.

The calculation of such user models is not trivial. According to Kobsa (2004) different approaches can be pursued.

- Rule-based approaches are combining user actions with certain inferences, such as certain characteristics of the user or the classification in certain user groups - so-called stereotypes (see below).
- Algorithms for prediction of actions, such as Künzer et al. (2004), attempt to use the collected data to calculate the most likely next action of the users.
- Probabilistic methods take into account the uncertainty of conclusions and include the possibility, that conclusions derived from data may be contradicted or that there are several possible conclusions.
- By using machine learning techniques it is attempted to detect patterns in the collected data and to draw conclusions on that basis. Thereby the behaviour of the system can change over time as opposed to purely rule-based approaches.
- In collaborative filtering other users, which are most similar to the current user, are used to make a conclusion.

According to Oppermann (1994) there is a difference between semi-automatic and automatic adaption. With semi-automatic adaption the user can affect or even prevent the adaptation.

Besides the problem of correct evaluation and interpretation of the collected data, the complexity of calculation in terms of system resources and time, which is necessary for conclusion should also be considered (cp. Jameson 2001). Because of insufficient data at the start of a system, the amount of minimum necessary collected data is also very important.

A user model contains all data the system has collected on a certain user. This data can be demographic data, areas of interest, preferences, characteristics and behaviour patterns [ISO 9241-129, S.16]. The user model is the pivot for an effective adaption. Only if the user is modelled correctly is an optimal adaption of the system possible.

On the first use of a system there is no user data available to create a fitting user model so a basic user model is created. To change this model to an individual user profile there are several different methods as follows:

- **Stereotypes -** Before the first use of a system a user is asked certain questions to determine which stereotype(s) to use for an initial user model. The classification of a user according to one or more stereotypes allows the system to make first assumptions about the user that enable early adaptations at the first use of the system (Kobsa 1993, p.156). As soon as data is collected the chosen stereotypes should be compared to this data and removed if they do not match (Kay 2001, S.279). This way an individual user profile can be created.
- **Cold start -** If a system is based on a cold start it allows the user to start interacting without having any data on the user (Ishikawa (2007), p.129; Zigoris (2006), p.397). The first sets of collected data are the base for the adaption. Behaviour patterns can be saved to allow for a review of later interactions.

At the start no comparisons with already collected data can be made. It is therefore especially important to regularly review the adaptations to undo faulty adaptations. Characteristics of the user profile that lead to such a faulty adaption should be corrected. The reliability of the collected data increases correspondingly to the frequency of use of the system.

5.1.3.3 Implementation – Efference

Efference is the implementation of adaptation as well as the change of the system itself. An adaption can be suggested or made as soon as the system has collected enough data on the user. Such an adaption can take place in three areas of the system (Brusilovsky, 2002):

- **Content**: Adaptations that deal with the context of the situation occurred.
- **Presentation**: Adaptations that concern the design of the interface, e.g. font size or colour, layout of user interface elements etc.
- **Navigation**: Adaptations like the creation of keyboard shortcuts, etc.

All adaptations need to be consistent in their behaviour, have the same effect in the same context and have a consistent look and feel (ISO 9241-129).

5.1.4 Overview of existing adaptive systems

This section gives a short overview of existing adaptive systems that were developed between 1991 and 2010. These systems differ greatly and show clearly that there are a large variety of areas in which adaptation can be implemented. This section also contains a review of the pros and cons of each of the systems.

5.1.4.1 Doppelgänger

Doppelgänger was intended to produce a personalized, printed Newspaper for the user (Orwant, 1991). For this purpose a profile with a steadily increasing amount of information was generated. This formed the system's base to estimate the user's interests and daily activities. In the case of false estimations the system asked the user specific questions to avoid future mistakes.

Pros:

- Several applications share a common database of information about the user and communicate with one another about the user (electronic newspaper, paging service, mail filtering service, video games).
- Diverse types of sensors contribute to an extensive user model (e.g. motion sensors, sensors for certain parameters of computer use, etc.).
- Unobtrusive user modelling: Users are always able, but are never forced to interact directly with the user modelling system.
- Effective extrapolation for compensation of missing data: default values from stereotypes,

Cons:

- Insufficient means for collecting systematic feedback about the appropriateness of system behaviour. Therefore, the users receive emails which provide the users with the possibility to check and modify the stored data.

5.1.4.2 Flexcel

Flexcel enhances Microsoft Excel by an adaptive User Interface (Thorrtas et al, 1993). The system submits suggestions to the user (e.g. shortcuts) that the user has to accept intentionally. All kinds of adaptations by the system can also be adapted by the user, giving him control at every moment.

Pros:

- Users have control over their own user profiles.

Cons:

- Some of the user dialogues for adaptability seem very complex.
- The adaptation mechanisms are considerably restricted by the selected software application (Microsoft Excel) and the typical hardware capabilities at the time of development (published in 1993).

5.1.4.3 Lumière-Project

The Lumière-project led to the later MS-Office assistant (Horvitz et al, undated). The assistant can recognize certain intentions of the user (e.g. write a letter) and introduces features that might help the user with this task. The user can also ask the assistant specific questions.

Pros:

- An interesting approach combining temporal reasoning and Bayesian user models in order to manage the uncertainty of recognising user goals from a stream of user actions over time.

Cons:

- The main focus lies on recognising user goals in order to provide appropriate help. Modelling more stable aspects such as the user's background and competencies is given less important.

5.1.4.4 Lifestyle Finder

Lifestyle Finder gives the user suggestions for interesting websites (Krulwich, 1997). For this purpose the user is classified by the system in one of 62 clusters, which are similar to stereotypes. The data needed to classify the user is gathered by an avatar, which poses questions to the user.

Pros:

- User profiling and clustering is based on publically available demographic mass data.
- User modelling works with a defined set of 62 user clusters. This helps to manage the complexity. However, 62 clusters is still a lot.

Cons:

- Adaptation covers only the selection of content, i.e. suggestions provided to the user. The user interface is not adapted.
- User modelling covers aspects such as purchasing history, lifestyle characteristics and survey responses. Transferring the taken approach to other (more relevant) user characteristics might be problematic.

5.1.4.5 ELM-ART II

ELM-ART II is an assistant for learning programming languages by suggesting lessons to the user (Weber & Specht, undated). If the user chooses a difficult lesson and succeeds, ELM-ART II stops proposing lessons that would teach material that is already known.

Pros:

- Adaptive annotation and navigation support are based on tracking of actual user behaviour and inferences.

Cons:

- The approach is mainly applicable to optimizing learning or development paths by presenting a suitable sequence of lessons and tasks.
- Learning about the user is based on recording which sites have been visited and which tasks have been solved. A transfer of this approach to MyUI user modelling would require a translation of relevant user characteristics and usability/accessibility problems to a set of tasks that can be tackled or accomplished by a MyUI user.

5.1.4.6 SUPPLE

Supple is an application that adapts the display of objects considering window size and user preferences (Gajos &Weld, 2004). User preferences are determined by user input.

Pros:

- The approach includes a run-time rendering of the user interface. User interface elements (widgets) are selected in order to provide the best suited rendering for a given device and a given user. Further adaptation mechanisms concern the navigation structure and the layout of the graphic elements.
- User interface adaptation relies on an abstract functional specification. Adaptation is considered as minimizing the estimated user effort for interacting with the interface which is described by cost functions for potential user interface widgets.
- Information about the user is collected by analysing user traces, i.e. coherent sequences of user manipulations on the user interface. If a similar approach can be adopted in MyUI, essential information about the user can be collected without external sensors and during the interaction (i.e. without additional steps for configuration or confirmation).

Cons:

- SUPPLE does not provide an authoring tool allowing designers to create interfaces in a way that preserves SUPPLE's flexibility, yet allows the designer to feel in control of the final product. This is considered as a major barrier to industrial adoption.
- The approach does not address accessibility issues and the support of special user needs with regards to impairments.
- Adaptation focuses on layout and selection of appropriate controls and display elements. Other user interface design areas such as navigation support or data entry are not covered to the same level of detail.

5.1.4.7 I-Mailer

I-Mailer supports the user in processing emails (Kabassi &Virvou, undated). On the one hand the system benefits from user models that are used for the adaptive changes of the system. On the other hand, the user's actions are observed, allowing the system to warn the user of actions that might be counterproductive to earlier actions and to predict the user's probable action.

Pros:

- A library of stereotypes is used as a fallback for cases when the user model does not include enough information about a particular user.
- User models are stored on a server, user model updating is done via web services. This supports the access to user models from different devices and locations.

Cons:

- The application field is restricted to email management. Much of the work is dedicated to issues which are highly specific for an email program, e.g. plausibility checks during deleting a certain folder, specific system reactions, etc.
- Most adaptive interaction features seem to address the plausibility of current user activities. It is less clear how more stable user characteristics are used in order to provide an individual user interface.

5.1.4.8 Pillows as Adaptive Interfaces in Ambient Environments

The system is implemented in an actual pillow that enables interaction with other devices (e.g. TV) by using a Touchpad (Nack et al, 2007). The system uses sensors to gather information about the actual usage of the pillow. RFID-Tags are used to inform the system about position, behaviour and physical state of the user. Furthermore all input is saved, so the system can compare the actual action with earlier inputs. This enables the system to estimate the user's desire or whether the last action might have been a faulty one.

Pros:

- A user and context model is established and updated in an unobtrusive manner. Biometric sensors and tracking of user interactions provide rich data about the user, his intentions and his context.
- One device – a pillow – serves as an interaction device (as a remote control for various devices like TV, stereo, etc.) and a hub for various sensors.

Cons:

- Sensor information is collected on a very basic level, e.g. heart rate, pressure, RFID, etc. The user model contains only simple (and mostly current, short-term) user characteristics such as current biometric status, current action, and current interest.
- Adaptation focuses on three very simple processes: stimulation, relaxation and representation of a user. It is questionable if more complex adaptation features can be developed on the basis of the same conceptual framework.

5.1.4.9 AUGUR

Augur is a context-sensitive assistant program (Hartmann et al, 2009). For example, it can help buying tickets on the website of the German Railways, by gathering necessary information from other applications, such as MS Outlook. The user may rate the system's proposals or delete them immediately.

Pros:

- Augur differentiates between three different presentation levels of adaptation: highlighting, suggesting, and automatic system action. By selecting the appropriate adaptation mechanism, confidence levels of the existing knowledge about the user are considered.
- There is a high level of user control over the system behaviour.

Cons:

- Augur learns typical user habits and preferences by recording user interactions and recognizing common sequence patterns which help to establish links between data from different applications. There is no obvious way how this strategy can be transferred to building up user models that include information about impairments and problems of use.
- Augur's main focus is on auto-completion of data entry forms and suggestions to trigger certain functions in a given situation. Both approaches can make the interaction more comfortable or efficient but for overcoming actual barriers of use different (and more substantial) adaptation mechanisms will be needed.

5.1.4.10 SmartCal

SmartCal is a calendar assistant (Krzywicki et al, 2010). Similar entries are used by SmartCal to create patterns that help the system to assist the user on future entries. All patterns can be edited or even created by the user.

Pros:

- The user model is collected during interaction in a minimally intrusive way. Similar to AUGUR, SmartCal uses typical patterns in previous user interactions to support the user by providing suggestions for the current task.

Cons:

- The user model and adaptation mechanisms are specifically focussed on calendar use. The extrapolation to other application fields and other user characteristics is not straightforward.
- Adaptation mechanisms concentrate on suggestion pop-ups. This will not be a suitable approach for the MyUI project.

5.1.5 Cause of adaptations

There are different causes, or triggers, for adaption:

- Frequent use of a function of a system.
- Change of the level of knowledge of the user.
- Adjustment/ correction of user input.
- Accessibility.

5.1.5.1 Frequent use of certain functions

Within a system there are certain functions that are used frequently by a user like the use of predefined keyboard shortcuts or quick access to different applications. Since the used functions, as well as, the users vary greatly, every user needs an individual adaption to support the user with these frequent functions and increase their efficiency.

5.1.5.2 Change of level of knowledge

"The user's knowledge is a changeable feature. The user's knowledge can both increase (learning) and decrease (forgetting) from session to session and even within the same session. This means that an adaptive system relying on user knowledge has to recognize the changes in the user's knowledge state and update the user model accordingly." (Brusilovsky 2007, p.6).

To introduce new or additional features to a user, adaptations can be a way that also increases the learning effect of said user during frequent use. The state of knowledge can also decrease e.g. if a user rarely uses a system. If this is the case adaption can be a way to aid the user by providing support.

5.1.5.3 Adjustment/correction of user input

Mistakes can occur during user input. By comparing the input with saved behaviour patterns an adaptive system can find error patterns and execute auto correction mechanisms. If a user seems to have made an error the system can prompt the user and offer to automatically correct it. A system dialogue that helps the user to correct the error himself is also possible if the behaviour of the user differs from his regular pattern but it is not an error, these differences should be included in the pattern.

5.1.5.4 Accessibility

An adaptive system needs to be accessible for everyone. To achieve this goal adaptations have to be made that reduce barriers such as: complex design of dialogues, physiological or mental characteristics that complicate interactions, and different types of input devices. Especially for MyUI, the adaptations that address these barriers are important as MyUI specifically addresses users with such problems.

5.2 Variability of older people and stroke survivors

5.2.1 Human variability – classification

This section on human variability classification will be added in the final version of the deliverable. Work is currently ongoing to ensure compatibility between the MyUI ontology (being developed in parallel) and the WHO classification system. (*http://apps.who.int/classifications/*).

5.2.2 Human variability- issues

This section presents an overview of the potential impact on human capability and functionality of aging and stroke. It should be noted that many of these overlap; stroke can happen at any age but is much more prevalent in older age ranges, and many older people have experienced strokes (sometimes minor ones). It is also acknowledged that not everyone will experience these effects, or at least, that they may experience some of them to some degree – human variability is a key concept for MyUI and this section identifies characteristics of variability between and within individuals, that are relevant to the MyUI project.

5.2.2.1 Aging

Research commissioned by the UK Department of Trade and Industry collated anthropometric, range of joint motion, physical strength and performance data in adults aged over 50 years drawn from 12 countries worldwide (Smith, Norris and Peebles, 2000). The report presents data illustrating human physical variability in older adults and a review of changes in cognitive and psychomotor functioning with age (op cit, pp.4-13). In summary, we decrease in height and – to a lesser extent – weight; our joints become less mobile and our strength in many muscles (including e.g. hand grip) diminishes.

Table 1 presents a summary of the changes that can occur to vision and hearing in aging (Smith, Norris and Peebles, 2000). Vision becomes impaired in various ways; poorer visual acuity; poorer contrast discrimination (which can be mitigated with brighter lighting levels); poorer peripheral vision and smaller field of vision; poorer dark adaptation, reduced accommodation (especially the ability to focus at short distances); increased glare effects and poorer colour discrimination. Vision correction aids sometimes improve one area but compromise another; e.g. varifocal spectacles can reduce field of vision. Hearing sensitivity decreases in older people, especially at high frequencies, and also other factors concerning auditory perception - including temporal resolution and frequency discrimination. These auditory factors can reduce speech recognition abilities. Tactile sensitivity of the hand is usually quite resilient to aging.

Table 1: Effects of aging on vision and hearing (Smith et al., 2000)

Vision	**Effect of Aging**
Acuity	Decreases in linear nature
Discriminable differences	Decreases
Visual field	Reduces after approximately 55 years old
Dark adaptation	More light required
Glare	Increased glare effect
Colour sensitivity	Loss in sensitivity
Hearing	
Sensitivity	Decrease in sensitivity at higher frequencies
Frequency discrimination	Degrades
Temporal resolution	May degrade
Shadowing	May degrade
Attention	May degrade

Table 2 presents a summary of the changes that can occur to cognitive and psychomotor functions in aging (Smith, Norris and Peebles, 2000).

Table 2: Effects of aging on cognitive and psychomotor function (Smith et al., 2000)

Working Memory	**Effect of Aging**
Processing efficiency	Degrades
Performance	Deficits more likely when used in conjunction with other processing mechanisms
Long Term Memory	
Episodic	Performance declines
Semantic	System tends to remain constant or improve – degradation is due to processing speed not memory system
Procedural system	
Conditioning	Degrades
Skill learning	Degrades, especially for new tasks
Priming	Little, if any, degradation
Psychomotor Skills	
Reaction time	Degrades proportionally
Movement time	Degrades proportionally

There is no uniform pattern of steady cognitive decline with aging, and sometimes losses can be reversed especially after traumatic loss e.g. through stroke or brain injury. There are however many significant trends: there is a general slowing down of processing speed; working memory capacity and efficiency are reasonably well preserved (an assertion disputed by some) though it becomes harder to use these in conjunction with other functions; recall from episodic memory declines; semantic memory remains constant or increases, though recall may be slower; certain aspects of learning ability decline; reaction time declines. To counter this depressing catalogue, it’s worth noting that some authors identify areas of improvement, including sound judgement, emotional maturity, accumulated experience and other characteristics, which might collectively be described as “wisdom”.

In addition to these gradual degradations in healthy older people, older people are more prone to a range of disease and accidents, which can also impair their mobility and neuro-motor, sensory and cognitive faculties. Common among these are falls, dementia, cardio-vascular events including strokes, cataracts and macular degeneration affecting eyesight etc.

Much of the literature on aging is of necessity based on (between subjects) population studies at a snapshot in time, and therefore cannot distinguish between the effects of aging and the effects of other broader societal changes over the decades such as change in nutrition, education, culture, economies, experience of technologies, etc.

5.2.2.2 Stroke

Stroke is a sudden partial loss of brain function due to circulatory blockage (ischemic) and/or leakage (hemorrhagic) within the brain. Around 150,000 people per year suffer a stroke in the UK, and at any time about 250,000 people are living with disability as a result of a stroke (UK Stroke Association). Common resulting impairments in survivors include loss of neuro-motor (i.e. muscular) control (which can affect breathing, speaking, swallowing, walking, handling etc), problems with perception, cognition issues (comprehending, learning, remembering, speaking, deciding etc) and emotional and psychological problems (Jack et al, 2001).

The (UK) Stroke Association summarises the common problems resulting from stroke as weakness or paralysis, problems with balance, swallowing, speech (both understanding and articulating), tiredness, eyesight and other sensory problems including pain, difficulty perceiving and interpreting, problems with thinking, learning, concentrating and remembering, incontinence, mood swings, depression, anxiety and loss of confidence (UK Stroke Association).

Recovery of lost brain cells is not possible but recovery of function is, to varying extents, possible - sometimes involving relearning quite basic abilities, producing “neural reorganization” or “cerebral neuroplastic changes” and resulting in positive patient outcomes (Jack et al, 2001).

Much rehabilitation work tends to focus on regaining motor skills, and to a lesser extent on cognitive abilities, particularly speech (which requires both). These are areas where relearning is most possible and most valuable for independent living.

Rehabilitation programs involving therapists improve the recovery of function but are expensive, so contact time and therefore efficacy are limited (Jack et al, 2001). Relearning of function is laborious for older patients who typically suffer stroke. (Typical mean age is 70 and one study Crosbie et al, (2008) kindly categorized participants under 72 as “young”!) The importance of stroke rehabilitation will grow as the population ages (older people being more prone to stroke) and as improvements in other therapies increase life expectancy after stroke.

5.2.3 Human variability – prevalence

No single source has been found of prevalence of various impairments in older people, but a general overview can be derived from a variety of sources.

Wormald et al (1992) conducted a study of visual disability in (n=288) patients of 65 or over in London, UK; 51% were 75 or over. In visual acuity tests (with spectacles if worn), of the 65-74 year olds (n=101), 1% were blind, 1% had low vision and 1% had visual impairment; whereas of the 75+ age group (n=106), 8.5% were blind, 14.2% had low vision and 19.8% visual impairment. Women tended to have worse visual acuity than men.

A 1998 study (Tas et al, 2007) of (n=7368) people aged 55 or more without dementia in Rotterdam, the Netherlands found that 31.8% had a disability of some kind, based on a composite index of ability at routine daily tasks, and half of those had severe disability.

A statistical study across USA of over 65s in 2005 (Brault, 2005) found that:

- 51.8% have a disability including 36.9% a severe disability.
- 10.1% have a vision disability including 2.8% severe.
- 11.2% have a hearing disability including 1.5% severe; 9.2% use a hearing aid.
- 2.1% have a speech disability including 0.3% severe.
- 38.1% have a disability in walking or using stairs including 22.4% severe.
- 5.2% used a wheelchair and 17.9% use canes, crutches or a walker.
- 8.2% have difficulty grasping including 0.9% severe.
- 19.1% have a limitation in “Activities of Daily Living”[1], with 15.1% needing assistance.
- 11.4% had a mental disability.
- 7.4% had difficulty managing money or bills.

If disabilities are categorised under the 3 domains: Communication, Physical and Cognitive, then:

- 29% had disabilities in one domain (2.3% communication; 26.1% physical; 0.6% mental).

[1] Going out, managing money, preparing meals, doing housework, taking prescriptions or using the phone

- 16.7% had disabilities in 2 domains (11.2% CP; 0.3% CM; 5.2% PM).
- 5.9% had disabilities in all 3 domains.

A Gloucestershire, UK study of people aged 75 and over (Donald et al, 2010) found that in 2001:

- 3.3% of people aged 75 to 84 were in care homes.
- 16% of people aged 85 or over were in care homes.

and in 2008:

- 16.1% were unable to walk beyond "their gate" (i.e. into public space).
- 22.4% unable to walk inside without aid.
- 23.8% had had a fall in the last 3 months.
- 25.9% required a hearing aid.
- 5.2% were visually unable to read.
- 6.1% were memory-impaired.
- 12.8% were frequently sad or low.
- 47.2% had limited energy.

This study was based on a postal questionnaire, so some people with reading or writing impairments may have self-excluded, though there was a high overall response rate.

A 1996 study of cognitive impairment in Canadian people over 65 (Graham et al, 1997) found:

- 8% had dementia.
- A further 16.8% had cognitive impairments but no dementia ("CIND"); this included 5.3% with circumscribed memory loss.
- Patients with CIND were three times as likely to be living in institutions as those with no cognitive impairment.
- 65% of people over 85 had cognitive impairment (with or without dementia).

There are also figures showing in more detail how the prevalence increased with age, and how it differed by gender. The sampling method meant that people in the younger (65-74) age category were somewhat under-represented.

Finally, a 1996 study of (n=10377) people aged 65 or more across England (Melzer et al, 1999) used interviews to elicit both the Townsend Daily Living measure of disability and the AGECAT measure of cognitive disability. They concluded that 15.7% of this population have a disability; 10.6% of males and 19.2% of females. Cognitive impairments are about half as common as physical impairments. A smaller percentage has both cognitive and physical impairments. Of those who had disabilities, 3% were independent, 14% needed care less often than daily, 62% needed some kind of care every day, and 21% needed continuous care.

In section 8.1 below this data is used with other data to identify the most important characteristics and impairments for the purposes of the requirements defined in this deliverable.

5.3 Environmental variability

5.3.1 Environmental variability - classification

When designing for the elderly user, the immediate environment should be taken into consideration. Relevant features of the environment can be classified as follows:

- Lighting conditions – levels of light, type of, distribution of, controllability of etc.
- Noise and sound – levels and acceptability.
- Vibration and motion issues.
- Temperature and climate issues, including temperature variability, drafts, humidity, airborne particles, swarming insects, ionising radiation, noxious aromas or dangerous gases.
- Space, furnishings and architectural issues.

5.3.2 Environmental variability- issues

5.3.2.1 Lighting

For visual comfort and good optical performance, the following should be considered:

- Level of light (optimum levels).
- Light distribution.
- Type of light 'if a coloured object is viewed under white light, it is seen in its natural colour' (Sanders & McCormick, 1992). Artificial light, however, can affect the way the eye perceives coloured objects in the room according to dominant wavelength, luminance and hue.
- Contrast levels/shadowing (Grandjean, 1988).
- Glare: higher levels of glare are required to obscure objects for younger subjects. The difference between older and younger subjects is about 2:1. 'The greater disability glare sensitivity of older subjects is undoubtedly due to age-related changes in the eye that increase the scattering of light within the eyeball' (Sanders & McCormick, 1992).

Boyce (1981) states that changing the features of a task such as by increasing the size or contrast of features will achieve greater improvements than a higher level of illumination. However, a number of studies (e.g. Bennett, Chitlangia & Pangrekar, 1977; Hughes & McNelis, 1978) have found that with increasing age, higher levels of illumination are necessary for task performance. This increase in lighting however must be balanced against creating unwelcome levels of glare, since those with opacification of the lens find it difficult to see in higher levels of light.

Vision deteriorates with age in a number of ways, including: long-sightedness, caused by a thickening of the lens, and the development of opacities in the eye. There is also typically a marked decrease in the amount of light reaching the retina (up to 66% at age 60 – Sanders & McCormick, 1992). When the lens thickens it yellows, reducing the amount of blue light filtering through: this results in a reduced ability to sort and match colours, therefore increasing the errors between colours on the blue-green spectrum and reds (Verriest, Vandevyvere & Vanderdonck, cited in Boyce 1981). Recommended contrasts in colours are given in BSI Guidelines: '...black on yellow or light grey are general purpose combinations which provide strong definition without too much glare...' ISO/TR 22411 (2008), 8.5.2.

5.3.2.2 Noise

Humans are less sensitive to low frequencies (i.e. below 1000Hz) and typically more sensitive to higher frequencies (Sanders & McCormick, 1992). Therefore a low frequency sound of the same intensity as a high frequency sound will not sound as loud. To be of equal loudness, the low frequency sound must be of greater intensity (sound pressure) than the high frequency one. Loudness is subjective.

There are 2 types of hearing loss:

- Nerve deafness.
- Conduction deafness.

Nerve deafness can be caused by damage to the ear through continuous exposure to loud noise; it is also most commonly associated with the degeneration of hair cells in the cochlea caused by the aging process. This type of deafness means that hearing loss is greater in higher frequencies than lower ones.

Conduction deafness is usually caused by some condition, e.g. middle ear adhesions, scarring following ruptured eardrum, ear wax etc. This is more evenly spread across different frequencies and doesn't result in a total loss of hearing.

'*Presbycusis* is hearing loss due to the normal process of aging' (Sanders & McCormick, 1992). With increasing age, the severity of hearing loss at higher frequencies becomes more pronounced, and is also more prevalent in men than women. Grandjean (1988) states that with a frequency of 3000 Hz, the loss of hearing to be expected at various ages is:

- 50 years: 10 dB.
- 60 years: 25 dB.
- 70 years: 35 dB.

Broadbent (1976) found that the use of noise in conjunction with visual stimuli on a visual display increased the confidence of the user in terms of giving what they perceived to be 'correct' or 'incorrect' responses. In quiet conditions, there may be greater hesitancy. Loud noise can encourage the user to focus more on the task and not to let their mind wander. However, perception of meaning can also be hindered by loud noise.

In the case of the elderly, caution should also be exercised, since the loss of hearing at higher frequencies may necessitate a reduction in background noise to aid clear hearing.

5.3.2.3 Vibration

Vibrations are classed as mechanical oscillations. Anything, which has the properties of mass and elasticity can be set in oscillation. The different parts of the human body react differently to vertical vibrations. The natural frequencies of the smaller components of the body (e.g. muscles, eyes etc) are in the higher frequency ranges (Grandjean, 1988). Vibrations above 30 Hz are likely to set up resonances in fingers, hands and arms. The body's damping effects will however temper these oscillations to some degree.

The impact of vibration on eyesight is important as it impedes efficiency of operation by reducing visual acuity and increases blurring of the image.

5.3.2.4 Climate

Extremes of temperature cause discomfort and illness and impair performance.

Walls, ceilings, etc can influence the heat exchange process, whereby the body gives off or absorbs heat from the environment. However, where the air is very humid, the body's ability to lose heat by perspiration is impeded. Level of humidity is therefore important. Clothing influences heat exchange (Sanders & McCormick, 1992).

Low humidity can cause discomfort such as dry nose, throat, skin and eye irritation. The latter is most pronounced when the humidity is at 30% or lower and the effect is most obvious after around 4 hours.

An increase in core temperature can result in heat stress. High heat generates a cardiovascular response (Sanders & McCormick, 1992). There are wide variations between individuals in their tolerance to heat. Those who are physically less fit, women, those carrying excess body weight or who are taking in alcohol are more at risk.

The elderly are also more at risk due to inefficient sweat glands and less water in the body.

Overheating can lead to sleepiness, loss of performance and increased susceptibility to making mistakes whilst cold leads to restlessness and distraction, interfering with concentration (Grandjean, 1988).

Cognitive and perceptual motor performance was found in studies to decline once temperatures reached approximately 27 degrees C/83 degrees F. (Sanders & McCormick, 1992). An excessive drop in core temperature can result in cold stress. There is limited evidence of the effects of this on performance. However, physical work is inhibited due to a lower muscle temperature, which reduces muscle strength.

Tactile sensitivity may also be substantially reduced when the temperature is too low (Sanders & McCormick, 1992). This is connected to finger skin temperature. The reduction in sensitivity means that precise manipulation of objects (or buttons) is more difficult.

Reaction times are also affected by cold (e.g. when making cognitive decisions). This is key where rapid and accurate responses are required.

5.3.2.5 Space

As people age, motor abilities and sensory perception, particularly visual acuity, decline. However, improvements can be incorporated into the design of living accommodation, which can make life easier for the elderly.

Components should be arranged as far as possible in their optimum position within any given space, according to the needs of the user. However, it is not always possible to do this without having to strike a balance between the positioning of different objects.

There are a number of principles used in the design of a work space (Sanders & McCormick, 1992). These are:

- Importance principle: (components vital to the operation of the system are classed as ‘important).’ These are normally placed in convenient locations.
- Frequency of use principle: items which are used most often should be within easy reach of the user.
- Functional principle: those components which are closely related are usually grouped together in a logical manner.
- Sequence of use principle: where items are used in a particular pattern or sequence, they should be arranged to maximise the efficiency of use.

In the case of the elderly or those with disabilities, additional consideration needs to be given to personal issues such as reach, ease of movement etc. Sanders and McCormick (1992) point out that, in arrangement of buttons, controls etc:

> *"… whatever lower-bound constraints there might be would be predicated on the combination of anthropometric factors (such as of the fingers and hands) and on the precision of normal psychomotor movements made in the use of control devices"*. (p. 479).

Also:

> *'The layout of information and controls will also determine how easy they are to read by someone with a visual or cognitive impairment. Factors to consider include logical grouping of information and controls, line length of text, relevance of information and relationship of controls to actions to be undertaken'* ISO/TR 22411 (2008), 8.3.3.

Pinto et al (1997) discuss the role of ergonomic design and gerontechnology (defined as 'the complex interaction of elderly people with technological products and the built environment') in enhancing the environment for the aged. Their recommendations include the following, which is condensed from Pinto et al (1997):

Environmental

- Ensuring there is sufficient lighting as elderly people require higher levels of light due to visual degeneration.
- Reducing glare as this is particularly problematic for the elderly.
- Uniform lighting and correct location of artificial lights.

Technological

- Ensuring that floor mats are securely fixed.
- Ensuring that floors are not slippery or uneven.
- Doors should have easily perceived and accessible handles and ideally be of a different colour to walls.
- Ensuring that there are few obstructions in the living space.

5.4 Existing Standards and Guidelines

5.4.1 Standards for designing for variability of older people and stroke survivors

According to Abascal and Nicolle (2005):

> *"Current research and initiatives on inclusive design in general will be relevant sources of information for designers. Examples include Clarkson et al. (2003); the new British Standard on managing Inclusive Design (BS 7000-6); CEN/CENELEC Guide 63; and initiatives from the European Commission such as the European Design for All eAccessibility Network."*

and later:

> *"Many sets of inclusive design guidelines are nowadays accessible through the Internet. See, for instance, those collected by COST219bis. The guidelines with the largest impact are the ones for Web accessibility issued by the World Wide Web Consortium's Web Accessibility Initiative (W3C–WAI). For further reading on the use of inclusive design guidelines, Nicolle and Abascal (2001) offer a comprehensive discussion of the convenience of their use, tools and methods of working with them, as well as a number of examples."*

The definitive text used for MyUI developments is ISO/TR 22411 "Ergonomics Data and Guidelines for the application of ISO/IEC Guide 71 to products and services to address the needs of older persons and persons with disabilities". Section 9 is particularly detailed on sensory abilities (30 pages) and physical abilities (29 pages) but has limited material (6 pages) on cognitive abilities. The document builds on, and quotes extensively, from ISO/IEC Guide 71(2001) "Guidelines for standards developers to address the needs of older persons and persons with disabilities".

Although the document is aimed at those responsible for developing more specific standards, it provides much information of value here. It would be futile to attempt to reproduce or summarise that detailed and full report here; instead we will refer to the most relevant portions.

Section 8 describes factors to consider in standards, including:

- 8.2 – alternative formats – this section refers to multimodality of interfaces and gives general guidance (8.2.1), alternatives to visual displays (8.2.2), audio displays (8.2.3), and voice input (8.2.4) and to textual or graphic information (8.2.7).
- 8.3 – positioning of information and controls.
- 8.4 & 8.5 – guidance on lighting levels, and use of colour.
- 8.6 – size of fonts and symbols.
- 8.7 & 8.10 – use and presentation of language including spoken language, and (8.10) pace of information presentation.
- 8.8 – use of graphical symbols & icons.
- 8.9 & 8.20 – auditory signals and acoustic considerations.
- 8.12 – general matters concerning physical accessibility and use of space.
- 8.17 – logical processes to support cognitive limitations.

Section 9 provides detailed ergonomic data on human abilities and limitations, and specifically the effect of aging, including:

- 9.2.1 – a very detailed section on vision (and the effect of good illumination).
- 9.2.2 – hearing.
- 9.2.3 – sense of touch.

- 9.2.5 – balance.
- 9.3 – physical abilities including dexterity, manipulation, movement, strength (including grip), and voice production.
- 9.4 – cognitive abilities including intellect, memory and linguistic ability.

This text however makes no specific reference to adaptive interfaces.

6. Results of user studies

The outcomes of the focus groups and interviews were transcribed as "Experience Reports". Appendix B contains examples of "Experience Reports". All are available on the private area of the MyUI Website. The results have been used to support requirements highlighted in the literature but limited to the target users and context of use of the MyUI demonstrators (defined in D4.1).

6.1 Focus groups

Three focus groups were conducted in the UK, and two in Spain as shown in Table 3.

Table 3: Table of focus groups

Id	Date	Type	Description
ER-FG-01, 2010	8/4/2010	Focus Group	14 Day Centre service users and staff, in Day Centre for older people, Nottingham, UK. Focus on remotes and similar devices
ER-FG-02, 2010	14/4/2010	Focus Group	18 Day Centre service users and staff, in Day Centre for older people, Nottingham, UK. Focus on remotes and similar devices
ER-FG-03, 2010	22/6/2010	Focus Group	13 Day Centre service users and staff, in Day Centre for older people, Nottingham, UK. Focus on remotes and similar devices
ER-FG-04, 2010	22/3/2010	Focus Group	Elderly house residents and care professionals in Spain
ER-FG-05, 2010	25/6/2010	Focus Group	4 Elderly House residents in Getafe, Spain, together with care professionals. Focus on display devices.

6.2 Interviews

Four interviews were conducted with physiotherapists and care professionals in the UK as shown in Table 4. Note also that the Focus Groups sessions in Spain included interviews with highly experienced care professionals.

Table 4: Table of interviews

Id	Date	Type	Description
ER-INT-01, 2010	10/3/2010	Interview	Nottingham: professional in care of older people at Day Centre for older people.
ER-INT-02, 2010	15/6/2010	Interview	Nottingham: Occupational Therapist and a researcher specialising in care of stroke survivors.
ER-INT-03, 2010	28/6/2010	Interview	Birmingham: Physiotherapist exclusively involved in private practice.
ER-INT-04, 2010	28/6/2010	Interview	Birmingham: physiotherapist primarily involved in public (NHS) work, with mainly older patients.

7. Requirements Overview

Requirements were derived from:

- The literature review,
- the user studies detailed above,
- subject matter expertise and technological expertise within the consortium.

Draft Requirements were reviewed by a panel of experts in care of older people, stroke survivors, physiotherapy and interactive TV, and refined in light of feedback from the panel.

Five types of requirements for MyUI have been generated. General overview and requirements tables are presented in the following sections of this deliverable reports and summarised below:-

- **USER REQUIREMENTS** (presented in section 8) – This section specifies the characteristics that any MyUI application must have in order to be sufficiently accessible and appealing to the users to be beneficial. It is based on an understanding of the types of users identified in the DoW, exemplified in the Personas from D4.1, and their characteristics discovered in the literature and field studies above. Accessibility requirements form a major part of this section. It includes some information on the characteristics of displays and controls ("inputs") to be acceptable to the various users, and general observations about complexity of interaction sequences.
- **FUNCTIONAL REQUIREMENTS** (presented in section 9) – These requirements specify how MyUI technologies will sense or infer user abilities and limitations and preferences, and adapt user interactions accordingly. This section specifies the areas of interface adaptation, which would be beneficial, and how adaptation should affect the user interaction. Including issues concerned with the acceptability and consistency of the UI. It will consider the issue of whether we have a limited number of UIs and dynamic selection of the most suitable for the user and environment based on information from the sensors, or whether to have dynamically constructed UIs or whether to make gradual adjustments to parts of the UI discretely (e.g. display brightness). Also whether and how this will access user modelling services from other components (e.g. the ontology). It will also include interaction sequences for how adaptations will be applied and how or whether the user is notified.
- **TECHNICAL REQUIREMENTS** (presented in section 10) – This section focuses on what technological devices may be appropriate to satisfy the User Requirements and Functional Requirements; particularly what types of user sensors and context sensors may be appropriate (e.g. for accessibility and adaptability) and the necessary characteristics or limitations of any devices used in meeting the user's requirements. It will also consider characteristics of controls and displays, and also any necessary infrastructure elements (e.g. telecommunications, networking etc). It will not generally mandate specific technologies (though Appendix E lists some sensor devices under consideration) but will instead specify required characteristics of such technologies. However where items of hardware infrastructure are clearly part of the solution, these will be identified. Details of any interfaces to other technical components (such as the VUL or the ontology) will also be presented here.

- **DEVELOPER REQUIREMENTS** (presented in section 11) – The flexible user interface adaptation facility will be designed to be incorporated into future MyUI applications by developers without having to replicate the design and code of those features. This section will describe the requirements of developers in order to make this possible.
- **NON-FUNCTIONAL REQUIREMENTS** (presented in section 12) – This covers the areas specified in ISO-TR 22411 (2008) as being important to identify as to how the system will deliver its functional requirements; e.g. how fast, how reliably, how securely, what level of backups are required, how affordably, how much maintenance and intervention is required, and what support must be available

All functional, technical and non-functional requirements have some justification in a user requirement and all user requirements have some justification from user studies and/or literature. (The column headed "source" in the table shows the justification with details in the reference section.)

In order to prioritise development, each requirement is categorised as H/M/L, meaning High, Medium or Low priority. This prioritisation was arrived at by expert appraisal of the researchers based on their understanding of the literature and the Experience Reports coupled with a degree of subjective assessment.

8. User Requirements for MyUI applications

This specifies the characteristics any MyUI application must have in order to be sufficiently accessible and appealing to the users to be beneficial. It is based on an understanding of the types of users identified in the DoW, exemplified in the Personas from MyUI Deliverable D4.1, and their characteristics discovered in the literature and field studies above. Accessibility requirements form a major part of this section. It also includes some information on the characteristics of displays and controls ("inputs") to be acceptable to the various users, and general observations about complexity of interaction sequences.

The MyUI adaptation function (which detects user preferences and accessibility needs, and adapts interfaces to meet those preferences and accessibility needs) does not have a user interface of its own; it presents user interfaces on behalf of various applications (including the three proposed MyUI demonstrators). Each application will have its own users and user requirements. This section therefore begins by identifying the relevant user characteristics for the MyUI user groups and the environmental characteristics of their places of usage, and then identifies general requirements, which will apply to any MyUI application in order for it to be accessible and engaging and usable by the MyUI user base. These requirements will be more like general principles or guidelines, which will apply to all MyUI applications; each application will need its own more specific requirements.

8.1 User Characteristics – relevant factors for MyUI

These requirements do not set out to specify a single interface with universal accessibility. Instead we specify adaptive and multimodal interfaces which will enable accessibility to these facilities for a large range of users who currently have less accessible interfaces.

The following sources were key:

- the MyUI Description of Work (DoW) (pages 9-10 "target user group"),
- the personas and scenarios from MyUI Deliverable D4.1,
- the literature study on older people and stroke survivors (section 5.2.2 above),
- Alex Carmichael's "Style Guide for the design of interactive TVs for elderly viewers" (Carmichael, 1999)
- the material on prevalence of impairments (section 5.2.3 above), and
- the findings from the studies of real users (section 6 above).

This deliverable lists the range of user characteristics to be addressed by the adaptive and multimodal interfaces of MyUI to provide significant benefit to a high proportion of potential users.

8.1.1 Physical / motor

- Personal mobility – persons who are fully mobile to those with no mobility whatever.
- Hand strength, dexterity and finger movement – from fully able to little or no ability; sometimes with tremor, sometimes use of one hand only, or weak grip.

- General muscular strength – from near normal to very limited.
- Muscular control – from normal to very limited, including people who are hemiplegic (i.e. have little or no control on one side of the body) or diplegic (both sides), ataxia (poor coordination).
- Musculo-skeletal flexibility – from normal to very limited.
- Speech articulation – from normal to severely impaired (especially in stroke survivors).

8.1.2 Sensory

- Vision – many limitations are common, including poor visual acuity, poor contrast sensitivity (mitigated by good lighting), limited accommodation (both myopia and presbyopia) – often partially corrected by spectacles, difficulty with glare effects, visual field defects including hemi-neglect and those caused by cataract, poor colour discrimination.
- Touch sensitivity – frequently very limited on many parts of the body, though fingertips are fairly resilient.
- Hearing – loss of hearing, especially high frequencies (meaning consonants and some alarms may be inaudible), tinnitus.

8.1.3 Cognitive

- Recall from long term memory – from near normal to very slow.
- Reaction time – generally slower.
- Thinking speed – from normal to slow; especially in divided attention tasks.
- Literacy – from above average to very low, with especial limitations in spelling and typed input in some populations.
- Concentration – often reduced.
- Language comprehension (written and spoken) – from normal to very slow.
- Learning of technologies – can be subject to significant limitations; mitigated if the technology delivers valued benefit, is aesthetically pleasing, uses familiar metaphors and interaction models and is not patronising.

8.1.4 Multiple impairments

- It is worth noting (Brault, 2005) that many older people have multiple impairments, including impairments in multiple domains (e.g. sensory and motor).

8.2 User environment characteristics – relevant factors for MyUI

Based on the following sources:

- the MyUI DoW (pages 9-10 “target user group”)

- the personas and scenarios from MyUI deliverable D4.1,
- section 2.4 above ("Contexts of use")
- the literature study above on environmental variability (section 5.3)
- the findings from the studies of real users (section 6 above)

We specify here the range of environmental factors which will influence the adaptive and multimodal interfaces of MyUI.

In order to design suitable and relevant adaptive interfaces for elderly users, the issue of certain age-related impairments needs to be taken into consideration as these will have an impact on the requirements for the immediate environment.

For the purposes of MyUI, whose aim is to demonstrate the possibility of adaptive and multimodal user interfaces for elderly users and stroke survivors (but is not required to provide products which adapt to all such users) we have considered the following salient factors of environmental variability:

- Levels of ambient light should normally be higher for elderly people, since there is a marked decrease in the amount of light reaching the retina as we age (up to 66% decrease by age 60). Natural light is preferable and an elderly person will often be able to read detail more easily in natural daylight;
- The distribution of light should be considered and care should be taken not to create shadowing;
- Disability glare, from a window or other strong light source, is an important issue for older people, since as we age, lower levels of glare may interfere with vision (a young person can tolerate twice as much glare as an older person). This is because of changes in the eye which lead to 'scattering' of light within the eyeball;
- Reflectivity of surfaces – polished surfaces should be avoided as these will reflect too much light, again causing an issue with glare;
- Flickering light results in over-exposure of the retina, which should be avoided;
- Ambient noise levels should be considered. Broadbent (1976) found that combining sound with visual stimuli on a display increases the confidence of the user by enhancing confirmation of 'correct' or 'incorrect' responses. In quiet conditions there may be greater hesitancy. Some level of background noise may encourage the user to focus more on the visual task. However, because the elderly often suffer hearing impairments which mean that their perception of higher frequency sound is significantly decreased, any background noise should be kept to a minimum;
- The layout of the workspace should be carefully designed with older people in mind as movement, reach and grip may be restricted and there may be arthritis in fingers and hands. Any controls (such as mouse, joy stick etc) will need to be placed within easy reach and controls designed with these issues in mind;
- There is also the increased possibility of a lack of precise psychomotor movements in older people, and allowance should be made for this.
- Cognitive abilities may also be impaired to varying degrees. ISO/TR 22411 (2008), S8.3.3, states that 'the layout of information and controls will (also) determine how easy they are to read by someone with a visual or cognitive impairment. Factors to consider include logical grouping of information and controls, line length of text, relevance of information and relationship of controls to actions to be undertaken'.

8.3 Physical / motor

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URP01	DoW ER-FG-02 (2010), ER-FG-03 (2010), ER-FG-04 (2010), ER-FG-05 (2010), ER-INT-04 (2010), ISO/TR 22411 (2008): 8.12.1/9.3.1/9.3.2.1/8.12.3.1	Accessibility from a seated position	H	URP05	Controls such as remotes must be easily usable from an armchair or wheelchair, bearing in mind wrist position etc. (N.B. despite all the problems with remote controls, they are popular with older users because they can be operated while seated).
URP02	ER-FG-01 (2010), ER-FG-04 (2010), ER-INT-02 (2010), ER-INT-04 (2010), ISO/TR 22411(2008): 9.2.3.1/9.2.3.2 ISO/TR 22411 (2008): 9.3.1.2/9.3.2.1	Accessible to users with no or limited finger movements	H	URP03	Physical controls such as buttons and knobs should be sufficiently large and well spaced. Alternative forms of input (e.g. speech) may be a suitable alternative. Users may have missing fingers (e.g. amputated due to diabetes), poor flexibility for anatomical reasons (e.g. arthritis), or impaired neuro-motor control due to stroke, Parkinson's disease etc.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URP03	ER-FG-01 (2010), ER-FG-02 (2010), ER-FG-03 (2010), ER-FG-04 (2010), ER-INT-02 ISO/TR 22411(2008): 9.2.3.1/9.2.3.2	Controls, such as buttons, should be large and well spaced	H	URP02	Several day centre users reported pressing several buttons at once; e.g. getting teletext when trying to change volume. (E.g. some users preferred ATM buttons to those on remotes, or calculator with larger buttons compared to smaller)
URP04	DoW, ER-FG-01 (2010), ISO/TR 22411 (2008): 8.12.1/9.3.1/9.3.2.1/ 8.12.3.1/9.2.1	Accessible to users with limited wrist movements	M		Interaction should not require awkward wrist movements/positions. Specific problems are reported with pointing TV remotes at the TV screen from a seated position: wrist problems and inability to see buttons when using the remote may be an issue in this position. In this case, a physical or electrical re-design is suggested.
URP05	ER-INT-04 (2010), ISO/TR 22411 (2008): 9.2.3.2, 9.2.5	Accessible to users with body instability	M	URP01	Users who are unstable while standing / walking may usually be seated while using systems.
URP06	ER-FG-04 (2010), ER-INT-03 (2010), ER-INT-04 (2010), Smith, Norris & Peebles (2000), ISO/TR 22411 (2008): 9.3.2.1/9.3.4.2	Accessible to users with limited strength	M		Grasping may be weak and/or inaccurate in some cases. Hand controls should be shaped to accommodate varying grip sizes and should not require much strength to manipulate.

Id	Source	Title	Priority (H/M/L)	Related Req’t(s)	Description / comments
URP07	ISO/TR 22411 (2008): 9.2.2.4	Provide for users with impaired or no speech	L	URP08	Voice input may support users with limited visual or motor abilities, however there should always be an alternative to voice input. When it is used, it should be restricted to a limited vocabulary.
URP08	ER-FG-01 (2010), ISO/TR 22411 (2008): 9.4.4.1	Provide alternatives to voice controls	H	URP07	E.g. buttons. Voice recognition technology is still of limited usability, especially for users with accents or impaired vocal articulation. (Dysphasia, impaired speech, is a common effect of stroke).
URP09	ER-INT-02 (2010) ISO/TR 22411 (2008): 9.2.3.2/9.3.1.2	Provide alternatives to any subtle tangible interfaces	M		E.g. simpler tactile interfaces such as touch screens or large buttons. Pointer devices such as mice, which are remote from the screen displaying the pointer, can be difficult. Sometimes a touch screen is better for people with poor hand-eye co-ordination.
URP10	ER-FG-01 (2010), ER-INT-02 (2010), ER-INT-04 (2010) ISO/TR 22411 (2008): 9.2.3.2/9.3.1.2	Accessible to users with poor motor control of hands (including hand tremors)	M	URP02	Stroke can impair neuro-motor control of a hand. Hand tremors affect some other older people (e.g. with those Parkinson’s disease). Remedies could include making buttons or clickable icons large and well-spaced enough to allow for less accuracy when selecting.

8.4 Sensory

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URS01	ER-FG-01 (2010), ER-FG-03 (2010), ER-FG-04 (2010), ISO/TR 22411 (2008): 9.2.1/9.2.2	Provide high salience displays	H	URS02, URS03	Provide displays which are easily perceived (e.g. loud sounds, high contrast in visual displays) to maximise the likelihood of awareness by the user.
URS02	ER-FG-01 (2010), ER-FG-03 (2010), ER-FG-04 (2010), ISO/TR 22411 (2008): 9.2.1.3	Provide same sense alternatives to visual displays	M	URS01, URS03, URS15	Consider same sense alternatives to the visual display to cater for various types of visual impairment., e.g. for the benefit of users with limited colour discrimination, if colour is used in text, consider a different typeface also.
URS03	ER-FG-01 (2010), ER-FG-04 (2010), ISO/TR 22411 (2008): 9.2.1	Provide different sense alternatives to visual displays	H	URS01, URS02, URS09, URS10	Wherever possible all interface elements (including displays and labelled controls), which require vision should provide non-visual alternatives: e.g. controls with tactile detection and audible feedback; displays to have audible alternative mode of presentation.
URS04	ER-FG-01 (2010), ER-FG-03 (2010), ER-FG-04 (2010), ER-FG-05 (2010) ISO/TR 22411 (2008): 9.2.2	Provide different sense alternatives to audio displays	H	URS01, URS11	Wherever possible all interface elements which require hearing should provide non-hearing alternatives; e.g. text captions for dialogue; flashing lights for alarms, vibrate mode on devices like mobile phones, subtitles or sign language on broadcast media etc.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URS05	ER-FG-02 (2010), ISO/TR 22411 (2008): 9.2.3	Provide same sense alternatives to tactile displays	M	URS01, URS06	Consider same sense alternatives to tactile displays; e.g. on control keys in lifts (elevators) where Braille is used, raised diagrams or letters may be a good alternative.
URS06	ISO/TR 22411 (2008): 9.2.1/9.2.2/9.2.3	Provide different sense alternatives to tactile displays	M	URS01, URS05, URS13	Wherever possible all interface elements (including displays and controls), which require a sense of touch should provide non-tactile alternatives; e.g. it is important that buttons have high visibility, not just tactile detection, and perhaps visible or audible acknowledgement of when they have been pressed successfully.
URS07	DoW, ER-FG-01 (2010), ER-FG-02 (2010), ER-FG-03 (2010) ISO/TR 22411 (2008): 9.2.1.2.2/9.2.1.3/9.2.1.7	Provide for users with limited contrast sensitivity	H	URS01	Displays and labels on controls should have high visual contrast; e.g. white on a black background. Controls such as buttons should themselves have a high contrast with the surround. Electronic displays should be bright, backlit where possible, and have brightness and contrast controls where possible. Where appropriate, provide manual brightness and/or contrast controls.
URS08	ER-FG-01 (2010), ER-FG-05 (2010) ISO/TR 22411 (2008): 9.2.1.6	Provide for users with limited tolerance of excessive glare	M	ER03	The ability to moderate bright light is desirable. Positioning of displays should be adjustable where possible, or suitable shielding provided. (Mentioned in Focus group in the context of ATMs where the screen is obscured by bright sunlight). (Older eyes are less adaptable to glare effects)

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URS09	ER-FG-01 (2010), ER-FG-02 (2010), ER-FG-03(2010), ER-FG-04 (2010) ISO/TR 22411 (2008): 8.6/9.2.1.2/9.2.1.2.1/9.2.1.7	Provide for users with limited visual acuity – on main displays and also on legends on controls & buttons	H	URS03	Appropriate fonts and font sizes should be employed, and features to adjust font size provided where appropriate. There should be clearly defined edges in electronic displays, etc. Controls such as buttons should be large, have clear legends, a colour contrast from the background and also tactile affordances: the user being able to feel both "finger on button" and "button pressed" conditions.
URS10	ER-INT-02 (2010), ER-FG-04 (2010), ISO/TR 22411 (2008): 9.2.1.5/9.2.1.7	Provide for users with limited visual field	M	URS03	The following conditions should be catered for: visual field defect, hemi-neglect, cataract, reduced peripheral vision, macular degeneration and the wearing of bi-focal or vari-focal spectacles.
URS11	ER-FG-01 (2010), ER-FG-04 (2010), Sanders & McCormick (1992), Grandjean (1988), ISO/TR 22411 (2008): 9.2.2.1	Provide for users with hearing impairments	H	URS04	Volume should be sufficiently loud. Volume adjustment controls should be accessible by the user. Inductance loops compatible with hearing aids should be available where possible.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URS12	ER-FG-04 (2010), [1] ISO/TR 22411 (2008), 9.2.2.1 [2]Sanders & McCormick, 1992, p. 589	Provide for users with reduced detection of high frequencies	H		[1]Volume should be adjustable over a wide range. [2]Where adjustments are made to use lower frequencies, the low frequency sound should be of greater intensity than for high frequency sound. Speech: consonants are more difficult to hear where there is a decrease in detection of higher frequency sound.
URS13	ISO/TR 22411 (2008), 9.2.3.3	Provide for users with reduced touch sensitivity	L		Multi-modal feedback options may be helpful (eg sound when pressing a button rather than tactile feedback alone).
URS14	ER-FG-01 (2010), ER-FG-02 (2010), ISO/TR 22411 (2008): 9.2.1/9.2.2/9.2.3	Controls should give feedback in as many modes as possible	H		E.g. a button with tactile feedback of finger positioning before pressing and also to indicate successful pressing, + brief audio feedback when successfully pressed, and continuous visual feedback of current state.
URS15	ER-FG-01 (2010), ER-FG-03 (2010)	Provide for users with colour perception limitations	M	URS02	E.g. provide a choice of palettes; where colour is used to distinguish different elements in a diagram, consider using text clues too, or different textures (e.g. dotted lines). If colour is used in text, consider a different typeface.
URS16	ER-FG-02 (2010)	Provide tactile affordances on controls	M		E.g. for buttons, users should be able to detect both "finger on button" and "button pressed" conditions by tactile sensation. Especially important on small hand-held devices, which might be used while not wearing close vision spectacles.

8.5 Cognitive

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URC01	ER-FG-01 (2010), ER-FG-02 (2010), ER-FG-04 (2010), ER-FG-05 (2010), ER-INT-02 (2010), ER-INT-03 (2010), ER-INT-04 (2010), Carmichael (1999)	Provide for users who may find it slow or laborious to learn and master new technologies, especially with abstract interfaces	M	URC13, URC14, URC15	Some elderly people fear or dislike unjustified changes in technology or have an emotional attachment to the familiar. Users are more motivated to learn when there is valued content, enjoyable interaction and aesthetic or emotional appeal (URC13, 14 & 15). Also use familiar interaction sequences based on the user's understanding of the task; use familiar metaphors in controls & displays; exploit natural affordances; speak the user's language; use familiar and standard words, symbols, images & metaphors, preferring words to symbols. Provide online (and perhaps real life) Help and Support. Focus Groups 1 & 2 highlighted a deep and widespread distrust of the impending introduction of the digital TV switchover / High Definition/ Freeview (DVB) etc, sometimes based on a poor understanding of the new technology and why it was happening.
URC02	ER-FG-01 (2010), ER-FG-02 (2010), ER-FG-03 (2010), ER-FG-04 (2010); ISO/TR 22411 (2008): 9.4.3.1	Provide for users with impaired long term memory	M		Make knowledge explicit and available ("in the world") rather than expecting the user to rely on "knowledge in the head"; e.g. by providing help facilities, drop down lists etc. (PINs and passwords can prove to be an accessibility barrier to some older people, even to important services such as ATMs).

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URC03	ER-FG-02 (2010), ER-FG-04 (2010), [1] ISO/TR 22411 (2008), 9.4.3.1	Provide for users with impaired short term memory	H		[1]Elderly people may easily forget information, which has been recently presented. Therefore, the system should minimise the extent to which memory of previous actions or operations is relied upon: this facilitates accessibility. To accommodate this: (a) incorporate pauses/ repeat messages/ replay facility (b) display a list of most recent user actions on the screen (c) set an appropriate pace of information presentation
URC04	ER-INT-02 (2010) ISO/TR 22411 (2008): 9.4.2/9.4.2.1/8.10.1/9.4.2.1/9.4.2.2	Give the user time to respond	H		Allow for limitations in reaction time and thinking time, especially in divided attention tasks. Keep speed of presentation to an acceptable (or adaptable or controllable) level, especially when the user has to understand written or spoken language. Speed of thinking and responding is often reduced in older age. Executive Function (i.e. the ability to understand and reason) can be diminished after a stroke.

Id	**Source**	**Title**	**Priority (H/M/L)**	**Related Req't(s)**	**Description / comments**
URC05	Carmichael (1999), ER-FG-01 (2010), ER-FG-02 (2010), ER-FG-03 (2010), ER-FG-04 (2010), ER-FG-05 (2010), ER-INT-02 (2010), ER-INT-03 (2010), ER-INT-04 (2010), ISO/TR 22411 (2008): 9.4.2.2/9.4.3.1	Minimise distractions and too many options or controls. Prioritise ease of use over superfluous functionality.	H	URC06, URC08	Provide no superfluous functionality; hide any rarely required functionality. Minimise the number of unnecessary distracting controls and displays; keep interfaces simple. Make use of sequential workflows where appropriate to minimise distractions. (E.g. "Wizards"). (Focus Group would have preferred remotes with very few buttons and limited features and few channels. Mobile phone users only wanted to phone with it, not take photos; etc)
URC06	ER-INT-02 (2010) ISO/TR 22411 (2008): 9.4.1	Minimise the number of possible errors or faults.	H	URC05	Perception that many devices have too many things that can go wrong. Note that a remote control with a battery that can go flat with poor diagnostic information and unpredictable consequences for the interaction presents an accessibility barrier. Error messages should be meaningful, not scary, blameless and not patronising, or better still avoid error prone activities altogether.
URC07	ER-FG-04 (2010), ER-FG-05 (2010), Carmichael (1999)	Allow for limited literacy.		URC20	The user should not be required to type or spell correctly; provide an alternative form of input if typing is used (e.g. voice communication rather than text messaging, or selection of words from a list, etc). Provide alternative output options if written language is used. Stroke survivors may have impaired recognition of letters, numbers and diagrammatic icons. Consider providing automatic spell check/correction.

Id	**Source**	**Title**	**Priority (H/M/L)**	**Related Req't(s)**	**Description / comments**
URC08	ER-FG-01 (2010), ER-FG-05 (2010), ISO/TR 22411 (2008): 9.4.1/9.4.2	Provide "basic mode" (the start-up default) and expert user mode, so advanced functionality does not confuse.	H	URC05, FRC06	Too many "menus" are unpopular with some older people as it can cause confusion. Displays should be kept simple.
URC09	Literature at 5.1 oben, ER-FG-02 (2010), ER-INT-02 (2010), ISO/TR 22411 (2008): 9.4.1/9.4.2	Provide a consistent interface with familiar controls and displays	H		Provide familiar controls and displays, which are consistent with prior experience, e.g. car pedals in the same order.
URC10	ER-FG-01 (2010), ER-FG-02 (2010), ER-INT-02 (2010)	Provide familiar interaction sequences	M	URC12	E.g. the clear sequential instructions were thought a good feature of an ATM interaction
URC11	ER-FG-01 (2010)	Provide familiar metaphors	M		E.g. in an email application, use metaphors from traditional mail systems: envelopes for messages, recycle bin for deleted material
URC12	Carmichael (1999), ER-FG-01 (2010)	Provide simplified interaction sequences	M	URC10	E.g. offer the use of Wizard type (fully guided) approaches as an alternative to screens with lists of lots of options
URC13	Carmichael (1999)	Consider aesthetic or emotional appeal	M		Displays should be designed to appeal to a more mature market, perhaps by using photographs etc. One user expressed a preference for a device, which her late husband had bought her as a gift for their 40^{th} wedding anniversary.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URC14	ER-FG-04 (2010), ER-FG-05 (2010), Carmichael (1999)	Consider valued functionality	M		Providing features and functionalities that may enrich the users' life e.g. enabling better communication with family and friends. This improves their motivation and ability to learn the interface. (See examples in ER-FG-04).
URC15	ER-FG-01 (2010), Carmichael (1999)	Enjoyable interaction	M		E.g. motivational messages, rewards, etc.
URC16	ER-FG-03 (2010), Carmichael (1999), ISO/TR 22411 (2008): 9.4.1	Stable interface	H		Older people often adapt to change more slowly. Care needs to be taken on how quickly and how profoundly the interface changes. (This may be a trade-off with the objectives of adaptivity).
URC17	Norman (1998)	Use natural affordances	H		E.g. Don't expect elderly users to press "Start" to switch off their computer, as this is not an obviously logical action.
URC18	ER-FG-03 (2010), ER-INT-01 (2010)	Provide a sense of control.	H		E.g. Provide an 'Off' button to switch the device off. N.B. Adaptivity must therefore be implemented with care; some users want their own volume control etc.
URC19	ER-INT-02 (2010), ISO/TR 22411 (2008): 9.2.3.2	Provide for users with limitations in hand-eye co-ordination	M		In one example, touch screens proved more accessible to many older stroke survivors than mice or joysticks.

Id	**Source**	**Title**	**Priority (H/M/L)**	**Related Req't(s)**	**Description / comments**
URC20	ER-FG-01 (2010), ER-FG-04 (2010), ER-INT-02 (2010), Sanders & McCormick (1992), ISO/TR 22411 (2008): 9.4.1/9.4.2	Avoid need to understand abstract symbols or icons; consider providing written text as well.	M	URC07	Some elderly people find abstract symbols or icons difficult to understand. Consider using simple text, such as "on" or "off" instead or as well. (While being aware of literacy limitations in some users). Sanders & McCormick suggest symbols and text together are most generally effective.
URC21	ER-FG-01 (2010)	Interfaces should be based on the user's understanding of the task, not on the underlying technology deployed.	H		Older people do not readily buy in to a designer's mental model, which is influenced by the technology rather than the task. This presents an emotional and learning obstacle. E.g. Elderly users dislike using a different interaction to obtain digital channels as opposed to terrestrial ones, e.g. pressing a D/A button to get digital channels, and a "red button" to get extra optional digital channels.
URC22	ER-FG-01 (2010), ISO/TR 22411 (2008): 9.4.1/9.4.2	Controls and displays should have a meaningful layout	M		Some remote devices are better than others in this respect and this should be taken into consideration. Consider e.g. Gestalt principles.
URC23	ER-INT-02 (2010), ISO/TR 22411 (2008): 9.4.1/9.4.2	Provide accessible help and support	H		This should be provided both online and – if at all possible – in real life.

8.6 General User Requirements

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
URG01	ER-INT-02 (2010)	Accessible to people who use assistive devices including AAC devices	M		AAC = Augmentative and Alternative Communication
URG02	ER-FG-04 (2010), ER-FG-05 (2010)	Any language input and output should be available in a choice of languages	M		
URG03	ER-INT-01 (2010), ER-FG-05 (2010)	Ensure users' privacy and confidentiality are respected, and they are aware of it	H	NR01	This may be an issue specifically for certain sorts of sensor, which may be otherwise attractive; e.g. webcams or CCTV. It may also be an issue for data collected about the user.
URG05	ER-INT-01 (2010), ER-INT-02 (2010)	Use non-intrusive devices where possible; ensure other devices are optional	H		This may be specifically an issue for certain sorts of sensor, which may be otherwise attractive, such as head mounted devices.
URG06	Pulli et al ICE (2010), Loughborough Accessibility workshop, 16th June 2010	Avoid use of icons/ devices which label the elderly as either "elderly" or "disabled"	H	URG05	Some disabled or elderly people do not like to use devices, which, although designed to help them, incidentally label them as "elderly" or "disabled". For example, some elderly people do not like to use walking sticks to help them walk, even though they need them – they would rather try to cope without the stick. Therefore, devices should not label the user as elderly or disabled – they should be 'cool' looking and appear as normal as possible.

8.7 Environmental

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
ER01	ER-FG-01 (2010) [1]ISO/TR22411 (2008), 8.4.1/8.4.2 [2]Sanders & McCormick, (1992)	Give attention to ambient lighting	H		[1]Ambient lighting levels should be generally higher for the elderly, as this enables easier access to detail, such as controls and instructions. [2]By age 60, there is 66% less light reaching the retina.
ER02	ISO/TR22411 (2008), 8.4.2 Grandjean (1988)	Synchronise lighting levels	M		Lighting should be designed so that there is no significant shift in lighting levels between the task (e.g. screen) and the ambient lighting.
ER03	Sanders & McCormick (1992) ISO/TR 22411 (2008), 8.4.4	Minimise glare	H		This should be kept to a minimum where possible, as older people have twice the sensitivity to glare as younger people.
ER04	ER-FG-02 (2010), ER-FG-03 (2010) Sanders & McCormick (1992), ISO/TR 22411 (2008): 9.3.2/9.3.2.1/9.3.2.2	Organisation of space, materials, devices	M		The working layout should be designed such that it allows for the potentially reduced flexibility and reach of an older user, eg wrist pain may quickly result from using a TV remote in a compromised position for an arthritic user. Devices (e.g. remote controls) should be easily distinguishable, e.g. by colour, size or labelling. Large items are often easier to find and use than small ones.

9. Functional Requirements for User Interface Adaptation

These requirements specify how MyUI technologies will sense or infer user abilities and limitations and preferences, and adapt user interactions accordingly. This section specifies the areas of interface adaptation which would be beneficial, and how that adaptation should affect the user interaction. It includes issues concerned with the acceptability and consistency of the UI. It will consider the issue of whether we have a limited number of UIs and dynamic selection of the most suitable for the user and environment based on information from the sensors, or whether to have dynamically constructed UIs, or whether to make gradual adjustments to parts of the UI discretely (e.g. display brightness). It will also consider whether and how MyUI components will access user modelling services from other components (e.g. the ontology). It will also include interaction sequences for how adaptations will be applied and how, or whether, the user is notified.

Note - it proved difficult to elicit very much data on requirements for adaptation from users due to their lack of experience of adaptive interfaces and a lack of adaptive devices to offer them to try. There is also very limited literature on adaptive interfaces specifically for older people or stroke survivors. For this reason, Functional Requirements have been largely inferred from User Requirements. Early user evaluation of prototypes or mock-ups is strongly recommended to overcome this limitation.

9.1 General

This table specifies requirements for user adaptation which cannot be categorised as sensory, motor or cognitive. Most of these concern the question of how adaptations occur rather than which ones occur.

Id	**Source**	**Title**	**Priority (H/M/L)**	**Related Req't(s)**	**Description / comments**
FRG01	ER-FG-01 (2010), ER-FG-03 (2010)	Interface must be acceptably stable & unsurprising	H		No unjustifiable surprises especially those which affect performance or enjoyment Consistent interface
FRG02	ER-FG-01 (2010), ER-FG-02 (2010)	Provide an option to go back to previous adaptation	M		Especially for major or significant adaptations e.g. changing modes (visual to audio)

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
FRG03	Literature at section 5.1 above	Some adaptations should be automatic and do not inform the user	L		This should be used with caution and only for very subtle changes, which the user is unlikely to dislike; e.g. brightening a display in bright environmental conditions.
FRG04	Literature at section 5.1 above	Some adaptations should be automatic and do inform the user	L		Tells the user it has changed an option e.g. "We have found more channels and added them to your list of available channels"
FRG05	ER-INT-02 (2010), Literature at 5.1 above,	Some adaptations should offer the user a choice before changing	H		This should be the normal situation; significant changes should not happen unexplained or without consent.
FRG06	ER-INT-02 (2010), Literature at 5.1 above	Some adaptations could offer the user a test and adapt accordingly	M		E.g. colour discrimination test.
FRG07	ER-FG-01 (2010), ER-FG-03 (2010)	Do not "over" adapt for an ability level lower than the user.	M		Do not provide an overly accessible but slow-to-use interface to a user of higher ability - this might seem patronising, tedious or even worrying (about some kind of diagnosis)
FRG08	Loughborough accessibility workshop, 16 June 2010.	Ensure adaptations and any testing to determine need for adaptation are understood as not being diagnostic in any way	H		We do not want to scare the user; the system's inferences of e.g. sensory impairments are relatively simple and imprecise; we are not optometrists, psychiatrists, etc.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
FRG09	Literature at section 5.1 above,	Types of adaptation	H		Some adaptations will be in a discrete area based on discrete data; e.g. sound level adjustments based on ambient noise levels. Some adaptations will be based on an assessment of the user model and comparing it to a range of quite different interaction paradigms provided, and will result in a radical switch; e.g. from button-operated to voice-controlled. Some adaptations may require the user to be offered different hardware, e.g. if the buttons are too small or too close together.
FRG10	Literature at section 5.1 above,	System must allow user control of personal data.	H	URG03	To allow the user control over his own personal data the interface must provide the opportunity to • look at own profile data, • change / modify / complement / delete data elements, • add further characteristics.
FRG11	Literature at section 5.1 above,	System must make sure that misuse of personal data does not occur	H	URG03, NR01	Users fear misuse of personal data therefore the system needs to make sure that misuse will be avoided: • communicate / provide opportunity to obtain information about data collection, processing and data usage • provide opportunity to withdraw from personal data collection.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
FRG12	Literature at section 5.1 above,	Adaptations in one area of the UI shall not lead to undesired changes in other aspects of the UI	H		If stereotypes are used, these have to be designed carefully so that they cover a great majority of our heterogeneous user groups.
FRG13	Literature at section 5.1 above,	Minimise user-initiated profile editing	H		The need for user-initiated user profile editing should be minimised, especially initial configuration (avoid barriers of use of the adaptation features).
FRG14	Literature at section 5.1 above,	Undesired adaptation of the user interface must be avoided	H		Undesired adaptation can arise from errors in sensor recognition or interpretation of sensor information.
FRG15	Literature at section 5.1 above,	Request confirmation to avoid severe adaptation problems	H		The system shall request explicit user confirmation before adaptation actions are carried out that may lead to severe problems.
FRG16	Literature at section 5.1 above,	Provide easy recovery from adaptation errors	H		In case of erroneous adaptation actions initiated by the system, the system needs to provide the user with the possibility to easily undo these adaptations.

9.2 Physical/Motor

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
FRP01	URP10, URP02 ISO/TR 22411 (2008): 9.3.1.1/9/3/1/2	Pointer devices should adapt to fine motor control limitations	M	URP10	Any pointer devices such as mice, joysticks etc should detect the user's aptitude with using them in at least 3 respects: speed of use, accuracy and tremor. Adaptations based on these can include adjusting the gearing between device movement and pointer movement; making targets (e.g. clickable places) larger; creating a damping effect on the pointer response to non-continuous movements.
FRP02	URP10 ISO/TR 22411 (2008): 9.3.1.1/9/3/1/2	Touch screens should adapt to fine motor control limitations	M	URP10	Any touch screens should detect hand dexterity as above FRP01, and make similar adjustments. These could include completely changing the screen layout to contain fewer but larger buttons.
FRP03	URP02, URP06 ISO/TR 22411 (2008): 9.3.4.2	Accommodate varying grip strength	M		Any tangible device should if possible adapt to accommodate users with various grip strength levels.
FRP04	URP07 ISO/TR 22411 (2008): 9.3.5	Any speech recognition input should adapt to understand user's vocal articulation style	H		Consideration for dysphasia following Stroke and potentially other neurological conditions.
FRP05	URC07, ER-INT-02 (2010) ISO/TR 22411 (2008): 9.3.5	Any speech recognition input should elicit responses in broad or narrow vocabulary adaptively	M		Voice activation from simple "yes/no" to full speech recognition. E.g.: if channel names are not recognised, provide facility to move up or down channels sequentially.

9.3 Sensory

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
FRS01	Grandjean (1988), URS07 ISO/TR22411 (2008), 8.4.1/8.4.2/9.2.1	Adjust brightness and contrast of electronic displays	H		Depending on the user's eyesight and also ambient lighting levels.
FRS02	Sanders & McCormick (1992), Boyce (1981), URS07, URS08, URS09, URS10 ISO/TR 22411 (2008), 9.2.1	Adapt to a range of visual impairments	H		• Focal length accommodation • Visual acuity • Visual field defects • Colour discrimination defects
FRS03	Sanders & McCormick (1992), Boyce (1981), URS11, URS12 ISO/TR 22411 (2008), 9.2.2	Adaptive to a range of hearing impairments	H		• Provide a user-controlled adjustment; eg. starting volume on next use is ending volume on previous use • Detect ambient noise levels and adjust accordingly • Consider using lower frequencies in vocal and other audio signals/ outputs. N.B. this applies not only to primary audio outputs but also to elements such as audio feedback to acknowledge successful button press.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
FRS04	URS03, URS04, URS06	Provide alternative mode adaptations for those with high sensory impairments	H		E.g: if user is unable to hear an audio signal, offer a vibrate option, or vice versa – if unable to feel a vibration offer an audio signal.
FRS05	URS07, URS08, URS09, URS10 ISO/TR 2411:2008, 9.2.1	Other visual adaptations	M		It is difficult to achieve but worth considering adapting the interface appropriately if it is detected that the user isn't able to see a particular entity properly. There may be many possible contributory impairments; e.g. colour-blindness, visual acuity, contrast sensitivity, accommodation, glare, visual field defects etc, all hard to diagnose remotely and all with different remedies. (e.g. changing colours, changing brightness, larger fonts, moving the entity on the screen, displaying it on a different screen at a better distance etc).

9.4 Cognitive

There seems to be little precedent in the literature on adaptive interfaces for detecting and then adapting to cognitive impairments. This is a provisional list.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
FRC01	URC04 ISO/TR 22411 (2008), 9.4.2.1	Adapt for reaction time	H		Older people require more time to direct and focus attention on stimuli, comprehend, decide and select appropriate responses.
FRC02	URC02, URC03 ISO/TR 22411 (2008), 9.4.3.1	Provide support for memory loss	H		Consider ways to detect / infer long term and short term memory impairments inasmuch as they affect the interaction, and make appropriate memory support adaptations.
FRC03	URC08, URC03	Select from a range of interaction styles, e.g. based on usage history	M		E.g. new user mode; wizard mode, expert user mode.
FRC04	URG02, ER-FG-05 (2010)	Provide a choice of national languages	H		Including the labelling on remotes.
FRC05	Carmichael (1999), ER-INT-02 (2010), ER-FG-05 (2010)	Adapt between text, symbols and photos as appropriate for the user.	M		Many older people don't like symbols, which may be difficult to interpret and non-standardised. Photos are also sometimes preferred to symbols. Text may be inappropriate for someone with limited literacy.
FRC06	URC08, ER-FG-05 (2010), ISO/TR 22411 (2008): 9.4.2.2	Use simple, easy to follow interaction sequences	H		Options, especially frequent ones (e.g. change channel), should be easy to perform and should not require passing through several menus/ options. Try to minimise the number of steps to select an option.

9.5 Environmental

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
FRE01	Grandjean (1988), ISO/TR 22411 (2008): 8.4.2/9.2.1.8	Adjust brightness and contrast of electronic displays	H	FRS01	Depending on ambient lighting levels (as well as user's eyesight).
FRE02	Sanders & McCormick (1992), Boyce (1981), ISO/TR 22411 (2008): 9.2.2	Adaptive to a range of hearing impairments sound volume levels	H	FRS03	Depending on background noise levels (as well as user's hearing).

10.Technical Requirements for User Interface Adaptation

This section focuses on what technological devices may be appropriate to satisfy the User Requirements and Functional Requirements; particularly what types of user sensors and context sensors may be appropriate (e.g. for accessibility and adaptability) and the necessary characteristics or limitations of any devices used in meeting the user's requirements. It will also consider characteristics of controls and displays, and also any necessary infrastructure elements (e.g. telecommunications, networking etc). It will not generally mandate specific technologies but will instead specify required characteristics of such technologies. However where items of hardware infrastructure are clearly part of the solution, these will be identified. Details of any interfaces to other technical components (such as the VUL or the ontology) will also be listed here.

Id	**Source**	**Title**	**Priority (H/M/L)**	**Related Req't(s)**	**Description / comments**
TR01	FRS01	Means to identify the user's sensitivity to contrasts/ brightness	M		A way (e.g. sensor) to determine the user's sensitivity to contrast is needed to allow for adjustment of brightness.
TR02	FRC01	A way to measure the user's reaction time	M		To adapt to the user's reaction time a way to determine the reaction time is needed.
TR03	FRP01	Means to determine the user's fine motor control limitations	H		A way (e.g. sensor) to determine the user's fine motor control limitations is needed to allow for adjustment of the responsiveness of the input device used.
TR04	URS03, URS04, URS06	The ability to switch to different sense output modality	H		All output should be available in different output modalities. For example: visual, auditory, and tactile (e.g. vibration).
TR05	URP07, URP08	The ability to accept a specific input device based on a given user profile or preference	H		Connect to a variety of input devices, via USB, Bluetooth, infrared, etcetera.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
TR06	URS02, URS05, URC08	The ability to switch to same sense output modality	H		All interface components should be available in different settings that are possible within an output modality. For example: brightness, pitch, volume, contrast, typeface, relief, vibration. Switch based on user profile or preference setting (e.g. basic or expert mode).
TR07	URS14	The ability to combine output modalities	H		Provide audio, tactile and visual feedback at the same time.
TR08	URC03	Ability to act on 'no input'	H		Detect failure to receive input when user input is expected and prompt user when this failure is detected.
TR09	URC05	Detect frequency of function use and adjust interface accordingly	H		Ability to log frequently used functions and hide functions that are never used.
TR10	FRG02	Ability to remember previous settings	H		Ability for the system to remember previous setting and the option to reset to this setting.
TR11	FRG03, FRG04, FRG05	Ability to consult database on status of required adaptation	H		Automatic, for notification, for approval, for choice.
TR12	FRP01, FRP02	Ability of suitable input devices to measure tremor and accuracy	H		Measure tremor transferred to device that is held and accuracy based on deviation of touch-point from centre.
TR13	FRP03	Ability to measure grip strength	M		Measure strength with which a device is being held.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
TR14	FRE02	Ability to detect ambient noise levels	H		Microphone and sound analysis software to assess ambient noise to adjust e.g. volume.
TR15	n/a	Means to wirelessly communicate to sensing devices	M		In order to act on user profile.
TR16	URP04	Offer a good detection range for input modalities	H		Input receiving device should have a good reception for input device signals.
TR17	URP05	Device should allow for remote control	H		
TR18	URP07, URC07	Have the ability to receive and process speech input	M		Have accurate speech recognition technology.
TR19	URS01	Means to grab attention	H		Increase volume or contrast/ brightness for notifications only.
TR20		The ability to communicate to a remote server	H		In order to check if a user profile is detected, fetch the associated interface (settings) and accept any input device.

11. Developer Requirements

The flexible user interface adaptation facility will be designed to be incorporated into future MyUI applications by developers without having to replicate the design and code of those features. This will be delivered to the developers within the MyUI Virtual User Lab, and for this reason, developer requirements will be explored in Work Package 3 and documented in deliverable D3.1 ("Requirements for integration into industrial user settings").

12.Non-functional Requirements

Non-functional requirements cover the areas specified in ISO standard ISO/TR22411 (2008) as being important - to identify how the system will deliver its functional requirements; e.g. how fast, how reliably, how securely, what level of backups are required, how affordable, how much maintenance and intervention is required and what support must be available.

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
NR01	ER-INT-01 (2010)	Ensure any personal data collected is collected with consent, and used in accordance with local legislation (e.g. Data Protection Act in the UK)	H		This includes user profiling and usage history.
NR02	ER-INT-02 (2010)	Affordable (purchase, ongoing)	H		Cost of the system must be reasonable and affordable for the elderly, especially the ongoing (e.g. subscription) costs.
NR03		Stable (e.g. no Windows automatic update)	H		Any updates must be unobtrusive and be thoroughly tested to work first time; otherwise there should be no updates.
NR04		Obedient and subservient	H		Don't refuse to switch off like Windows sometimes does.
NR05		Reliable	H		System must not crash or lock up. It must be resilient to incorrect interaction sequences (use of time-outs?), e.g. resilient to multiple simultaneous button presses.
NR06		Minimal & simple user maintenance	M		E.g. batteries, applying software patches, renewing licences. (E.g. for batteries; a clear "battery low" indicator is needed, a cognitively and physically simple process to change them, a long battery life and affordable replacements. Better by far not to have

Id	Source	Title	Priority (H/M/L)	Related Req't(s)	Description / comments
					any battery-operated devices.)
NR07		Error handling & diagnostics	H		Error handling must be none intrusive and not alarm or scare the user with alerts/messages. Error handling should be courteous.
NR08		Speed	H		The system should perform its operations without any noticeable delay.

13. Conclusion

This deliverable has presented the results of Task 2.1 – Requirements for User Interface Adaptation. In this work package we are especially concerned to see how new tools with adaptive user interfaces might help the end users (older people and people recovering from a stroke) and also how we can help professionals involved in developing ICT applications and devices to support these users. (WP3 deals with how the Virtual User Lab (VUL) can help commercial developers of technology to create such applications).

Three approaches to understanding requirements were adopted: literature, focus groups & interviews and consortium expertise. Conducting the work in different and diverse European countries has enabled creative reflection on the congruencies and contrasts leading to a coherent and comprehensive picture.

The literature review and focus groups helped considerably in understanding older people's abilities, limitations and variability in using existing technologies with similar characteristics to the envisaged solutions. The document reviewed the existing approaches to adaptable and adaptive systems, and includes an overview of existing adaptive systems and their pros and cons.

The focus groups have benefitted considerably from handing round various types of device to stimulate creative thinking and discussion. However, it is more difficult in such sessions to ask the older people to imagine technologies (such as adaptive interfaces), which we cannot at this stage demonstrate. Therefore, for this type of requirements we have had to rely to some extent on inferences and on interviews with experts. (There is little academic literature on the use of adaptive interfaces specifically by older people and stroke survivors). An iterative and inclusive design methodology would involve providing mock-ups and prototypes of possible solutions and involving end users in evaluation. It is suggested that we take this approach to refining and verifying requirements; indeed Work Package 5, task 5.1, provides for tests of prototypes in this vein.

User requirements were defined for general, physical/motor, sensory, cognitive, and environmental aspects. From the user requirements corresponding functional, technical and non-functional requirements were derived. Developer requirements will be included in MyUI D3.1 Virtual User Lab Requirements.

It is worth noting that older people learn to master new skills and technologies most effectively when they have valued functionality, enjoyable interactions, and appreciated aesthetics. Regular use also helps reinforce learning and maintain currency of skills.

This deliverable will form an input for the following deliverables: D2.2 Adaptation concept and multimodal user interface patterns repository; D2.3 User Interface Adaptation Engine Prototype; and D3.3 Virtual User Lab. It is also co-dependent on the MyUI ontology (D1.1), which is being developed in parallel and beyond this deliverable's timeframe.

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Appendix A – Principles of Universal Design

This whole appendix is quoted from Centre for Universal Design (1997) and specifies seven principles.

PRINCIPLE ONE: Equitable Use

The design is useful and marketable to people with diverse abilities.

Guidelines:

1a. Provide the same means of use for all users: identical whenever possible; equivalent when not.
1b. Avoid segregating or stigmatizing any users.
1c. Make provisions for privacy, security, and safety equally available to all users.
1d. Make the design appealing to all users.

PRINCIPLE TWO: Flexibility in Use

The design accommodates a wide range of individual preferences and abilities.

Guidelines:

2a. Provide choice in methods of use.
2b. Accommodate right- or left-handed access and use.
2c. Facilitate the user's accuracy and precision.
2d. Provide adaptability to the user's pace.

PRINCIPLE THREE: Simple and Intuitive Use

Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration level.

Guidelines:

3a. Eliminate unnecessary complexity.
3b. Be consistent with user expectations and intuition.
3c. Accommodate a wide range of literacy and language skills.
3d. Arrange information consistent with its importance.
3e. Provide effective prompting and feedback during and after task completion.

PRINCIPLE FOUR: Perceptible Information

The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

Guidelines:

4a. Use different modes (pictorial, verbal, tactile) for redundant presentation of essential information.
4b. Maximize "legibility" of essential information.
4c. Differentiate elements in ways that can be described (i.e., make it easy to give instructions or directions).
4d. Provide compatibility with a variety of techniques or devices used by people with sensory limitations.

PRINCIPLE FIVE: Tolerance for Error

The design minimizes hazards and the adverse consequences of accidental or unintended actions.

Guidelines:

5a. Arrange elements to minimize hazards and errors: most used elements, most accessible; hazardous elements eliminated, isolated, or shielded.
5b. Provide warnings of hazards and errors.
5c. Provide fail safe features.
5d. Discourage unconscious action in tasks that require vigilance.

PRINCIPLE SIX: Low Physical Effort

The design can be used efficiently and comfortably and with a minimum of fatigue.

Guidelines:

6a. Allow user to maintain a neutral body position.
6b. Use reasonable operating forces.
6c. Minimize repetitive actions.
6d. Minimize sustained physical effort.

PRINCIPLE SEVEN: Size and Space for Approach and Use

Appropriate size and space is provided for approach, reach, manipulation, and use regardless of user's body size, posture, or mobility.

Guidelines:

7a. Provide a clear line of sight to important elements for any seated or standing user.
7b. Make the reach to all components comfortable for any seated or standing user.
7c. Accommodate variations in hand and grip size.
7d. Provide adequate space for the use of assistive devices or personal assistance.

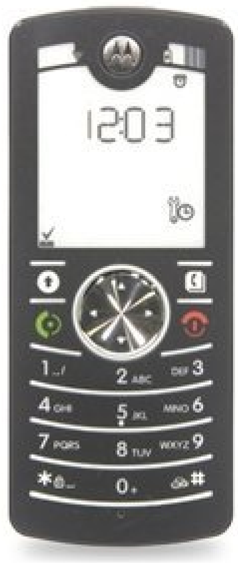
Appendix B – Sample Focus Group Experience Reports

B1. UK Focus Group with older Day Centre Service users and staff at Day Centre "A", Nottingham

Date	**Thurs 8th April 2010**
Activity	Visit of Rob Edlin-White (University of Nottingham) to Day Centre DC A, Nottingham, UK.
In attendance	Rob Edlin-White (UoN), (Day centre staff member), several other staff members, 12 older Day Centre service users.
Description of activities	***Note:*** *this experience report is based on notes taken during the second half of the visit, when the researcher judged it appropriate to start writing, supplemented by hand-written notes reconstructed from memory straight after the visit, all transcribed and edited into this document the following day.* Following discussion with staff member S1, I visited this Day Centre between 11:00 and 12:00, dressed "smart causal" and with a bag containing two hand-held controllers (for TV and Video), a mobile phone, a computer mouse and a few other accessories. 14 elderly Day Centre users were sitting around 3 sides of a large room in a U shape with 2 or 3 staff members / volunteers. A prior activity had finished; some were talking, one knitting, one going through an Avon catalogue with a staff member who was filling in an order form for her. Some were just sitting. The other end of the room had tables laid for lunch and the kitchen could be seen (and smelled) through a large open hatch. There was an air of activity, and I think Radio 2 was playing in the background. I pulled up a chair to join the group relatively informally, next to the Avon lady. A staff member introduced me: "This is Rob who's going to explain what he's going to be doing with you". I explained I was from the University of Nottingham, working on research project about making things easier for people to use, especially as we get older; especially basic things like making phone calls, using a TV, getting cash from a machine, cooking etc. I explained that I was trying to form a general impression, not finding out personal information and they don't have to tell me anything they'd rather not. One or two of the centre users conveyed the message to others who may not have heard me very well. I began with an open question to the group – did they find things like hand-held TV remotes easy to use. A large majority didn't. For several the first major obstacle is selecting the correct remote as there are sometimes 3 to choose from. Large labels would help. There were many general comments about TV controllers being too difficult to use, and one person still had a traditional TV with controls on the set which she much preferred. However two people seemed fully functional with TV remotes: one man with almost no close range eyesight due to macular degeneration who operated the device by feel (he seemed very good at adapting to new ways of doing things), and one apparently very able lady in her late 70s (who had two mobile phones and had been knitting earlier). The conversation then flowed into people's general concerns and worries about "Freeview", "Digital", "HD" and "The Switch"

and whether they'd be able to afford the new versions, whether old TV services would continue to work, whether they'd need new aerials or TV sets, and whether they'd be able to use them even if they could afford them.

To bring the discussion back on track, I showed the group the 3 devices I'd brought (illustrated below) and passed them round. As they were circulating (and eliciting lots of conversations) I spoke to the woman who had 2 mobile phones. She preferred the older one which was large enough to find easily in her bag and had well spaced keys. It had been a present on her 45th wedding anniversary. The smaller one was also good, mainly for incoming calls from her children who had bought it for her. The larger phone has a black on grey display containing the word "Orange" and she was happy for this to be passed round to see whether people could read the word.



	Some of the main comments after circulating these devices were as follows: *(some relating to these specific devices; others sparked off by the activity)* • Buttons too small to see. • Poor colour contrast between buttons and the casing. • Tiny fonts and poor colour contrast (especially the orange on black of the Matsui video remote – bottom device in above picture); prefer bigger letters and white on black. • (after my probe about lighting) 'they tell us to use these low energy light bulbs nowadays so we can't see anything any longer'. • Don't like symbols on buttons; they should use words; different manufacturers use different symbols; they could mean anything; need standardisation if they insist on using symbols. • Buttons too close to each other to press individually; prefer plenty of space between buttons. • Buttons not designed for arthritic fingers. • Have to stand to use the remote so I can point it at the TV and still see what I'm pressing. (Another person gets their finger on the relevant key then points at TV and presses a key "blind", ie. without looking). • Buttons on mobile phone (Motorola F1 phone, top right in above picture) don't move and can't be detected by touch (especially important for visually impaired users). • The Polaroid TV controller (top left in above picture) has a much better and more meaningful layout than the Matsui video control. • I can get the basic channels but it goes funny when I try the *FreeView* ones; my daughter says it's something to do with an "A/D" button but I can't see the reason for it. I summarised these responses looking for consensus or exceptions. They were generally majority but not unanimous – huge variety in eyesight, finger dexterity, understanding, motivation and also fear/dislike of technology. I asked some specific questions. Would they understand the purpose of the keys if they could see them and words were used rather than symbols? Many wouldn't and didn't see the need for so many keys. It was also clear that many of them wouldn't have an understanding of the underlying technology which was being mediated by the controls; e.g. the difference between analogue and digital services. I asked then, what services they'd want from a TV controller. Mainly it was on and off, up and down channels; up and down volume. Several disliked "menus" and didn't see a need for extra channels to be accessed by a "red button". I asked whether an interface involving the TV screen and TV sound, and a very simple hand held control with perhaps only one or two buttons. (The TV screen presenting options, visually and audibly, in sequence in the manner of a VRU, with button pressing just to select). Those who understood what I was describing did think it would be useful, but a pain if they always wanted a high numbered channel. (This of course supports a case for an adaptive interface which offers their frequently used channels first). I asked about voice input; one person has a son whose phone responds to voice input. There was limited experience and limited enthusiasm for this.

	I also asked about touch-sensitive screens such as those that are used in some museums. Some had no experience of these; some liked the ones with large buttons. The limitation is that they are too dependent on eyesight, rather than touch and memory. By way of comparison I asked them about their use of ATMs / cash machines, asking if the bigger buttons and better displays were a good model. Very few ever use ATMs, and one staff member said that of the 70 people they see regularly in a week, only a handful use ATMs. Most ask a son, daughter, trusted friend or neighbour to get money for them. Some get cash over the counter at a bank. I asked the main reasons for not using ATMs. The reasons appeared to be: • Inability to remember the PIN code number (or fear of forgetting it). • Fear of mugging. One person said she used an ATM but only one in the bank premises where there are staff. Also several use a type of cash machine inside the post office where they collect pensions. • The displays are hard to read especially in the glare of sunlight. They did generally appear to agree that the larger buttons and fonts of an ATM are better than the devices they'd been discussing earlier. Sensing that they would soon be tiring of my questions (and detecting from olfactory cues that their dinner would be ready soon) I thanked them for their participation and reminded them that I was only looking for general impressions so we can make things more usable in future; not recording anything about individuals. Someone commented that whatever we invent will probably be "too late for us". I agreed that it was research and it was too early to know what might come out of it or when. Afterwards I had a brief chat with the staff member S1 to check whether she was happy with the way I had conducted the session, whether anything I had said might have sounded patronising or less than respectful, and whether there was anything I could have done better. She was more than happy with the way it had gone. She was happy for future visits along the same lines, and suggested I might like to visit the Wednesday group next time.
Comments / reflections	The session seemed to go very well, was well received by the participants and staff, and elicited some useful qualitative data. Many of the findings are unsurprising. For this user group, TV controllers are too complex, have too many buttons, need clearer labelling, larger fonts, larger buttons with tactile affordances, large gaps between buttons, and better colour contrast. Also the infrared transmitter needs to be positioned, or adaptable, so you can see the buttons at the same time as they are being used, and without wrist strain. There did seem to be a certain level of fear of new technology, intolerance of unnecessary complexity and an unwillingness to buy into a designer's mental model of how things operate. The user interface needs to speak the user's language (which doesn't include concepts such as analogue and digital, and is in written English, not symbol-speak). The sense of touch and memory of button positions is especially important to people with poor eyesight. I didn't elicit any details as to the typical ages and lifestyles of the

	participants, but could do from further visits.
Follow-up actions?	These findings could be useful for informing a more formal study. I have arranged to visit again on Wed 2nd June for a similar session with a different group. If we wish to make more use of this link, we might consider some kind of questionnaire approach; especially if it can be anonymous. I wonder whether it would be appropriate to take or send some kind of gift for the centre as recognition of their help.
Author(s) of report	Rob Edlin-White

B2: Spain Focus Group with older people and care professionals at Elderly House "EH1"

Date	**25th June 2010**
Activity	Visit to the Elderly House EH1 near Madrid, Spain. Focus group with elderly representatives and elderly people.
In attendance	Virginia Suárez, José Alberto Hernández, Elderly representatives (with more than 20 years of experience with elderly users) and four elderly users.
Description of activities	The interview conducted contained a number of questions about the accessibility and usability of several types of controllers and displays, including: • Digital picture frames • TVs and TV controllers • WiiMote • Mobile phones and Apple's iPhone • Cash machines and credit cards A number of devices were brought and handed round for people to try, to facilitate discussion. These were: • A mobile phone (which has small keys and screen) • An iPhone • A TV remote controller (conventional LCD TV controller with DVB and teletext) • A digital picture frame • One WiiMote The session focused on determining what difficulties the elderly have with current technologies, especially concerning accessibility and usability, and trying to find out how to design new products for Elderly users within MyUI. Digital picture frames: This device is new for the elderly, not many of them have ever seen one of those. The cost of the digital frames is expensive (about 100 €). The elderly users like to take pictures, and many of them actually have a digital camera that they use properly, albeit they usually develop their pictures in paper. Navigating through the menus is quite hard, these need to be easier. However, a son or relative may configure the digital frame for the elderly. In

	that case, the use of the digital frame is rather easy. Incorporating presence sensors to the digital frame sounds as a good idea for the elderly. Everything that makes them feel safer is great. TVs and TV controllers: The TV is their favourite appliance. The elderlies have no problem about spending money on the TV, since they spend many hours watching TV. They know quite a lot of features of it, but some are difficult. It is easy to change channels and control the volume, but switching to external devices is complicated (what is AV1?). Concerning the remote controllers, these have too many buttons, and usually in English. Most of these buttons are never used. Using icons instead of names would be better: Use a square together with stop improves accessibility, because the letters are sometimes hard to see and may erase with time. Touch remote controllers would be great, but a touch screen is not a good idea because they would have to get up and walk towards the TV. WiiMote and Wii: Many elderlies know the Nintendo Wii thanks to their grandsons, and some have ever played Wii Sports. They find it nice and enjoyable, especially because they play with other people. Playing alone at home would not be a success, but a Wii at a social club where the elderly users meet and play would be a fantastic idea. The elderly like mental games like Sudoku and BrainTraining. Some are really afraid of anything related to losing memory and Alzheimer, and they feel that playing these games is good for them. Actually, dancing lessons are very popular because they keep them fit and there is some mental effort in remembering the steps. The WiiMote is very ergonomic, light and easy to use because it captures movement and has only two buttons. Mobile phones and Apple's iPhone: Most elderly already have a mobile phone (about 80% of them). They use it mostly for sending/receiving phone calls, and very few of them for something else: Almost none for sending SMS, and a few of them for listening to the radio. The built-in digital camera feature is not popular, because they do not know how to get the pictures out of the phone. They prefer using their proper digital camera that can take to a store and develop the pictures. They can handle the agenda quite well, adding/removing contacts, but they usually complain about editing text with the mobile phone keyboard. Additionally, the menus require several clicks (steps to achieve a goal). The iPhone looks much easier to them, since simple talks require only few

	clicks. The icons of iPhone's applications are very straightforward, and the qwerty touch keyboard is easy for them. Downloading applications from Apple store in the Internet is another story. <u>Cash machines and credit cards:</u> Many elderly use credit cards for regular payment. However, almost none of them withdraw money from cash machines. The reasons are: They do not like handling money in the streets, and they are afraid of getting lost with the menus or losing their card in the cash machine. The first one can be solved placing a cash machine at the elderly social club, where they feel confident and may get some help from other friends or users in case they are lost. Concerning the interface, the screen is usually hard to see, the menus do not contain icons.
Comments / reflections	The elderly, especially the young ones (65 to 75 years old), use technology more than we thought at the beginning. Perhaps they do not master all their features, but they can handle quite well with remote controllers, mobile phones, and even some are beginning to use a PC and browse the Internet. It is important to remember that the elderly users have plenty of time, and some of them are curious and like learning new stuff, especially those who have grandsons and technology is a good reason to talk and play with their grandsons. Of course the elderly have some difficulties in learning how to use new devices, basically: • You need to spend more time with them, since they are not so quick as young people, • and they need to see a clear benefit (motivation). Concerning motivation, every technology device that help them in their daily live (communicating with relatives and friends or using credit cards in daily shopping), make them feel safer (like the presence sensors) or provide a means to keep them socially closer with other age people is an advantage. Additionally, physical and mental games are very appreciated. The main handicap is the cost of devices. Money for the elderly is a synonym of safeness, and they are reluctant to pay a lot of money for a new device, unless they see a clear benefit. For instance, paying a lot of money for a TV is not a problem because they know its benefits, but a digital frame would be expensive for them. Concerning interfaces, icons are preferred over text, screens and keyboards must be large, and menus must require very few clicks to accomplish a goal.
Follow-up actions?	To incorporate the results into the user requirements derivation.

Author(s) of report	Jose Hernandez

Appendix C – Interview template for physiotherapists

The MyUI project wants to strengthen, establish and simplify the development of accessible and highly individualized information- and communication technology products like interactive TVs. The project addresses important barriers towards accessibility which include system developers' lack of awareness and expertise, the time and cost requirements of including accessibility in their products.

One goal of the project is to develop an interactive physiotherapy exercise application for stroke patients and elderly people. The exercise application will be running on an interactive TV set. It will demonstrate how new technologies can be used to establish major advances in the field of remote rehabilitation.

1. General

- Can you tell us about your role in treating elderly and stroke patients?
- What symptoms do elderly and stroke patients generally have?
- What procedures or exercises are normally used?
- What information do you typically gather from patients before treatment?

2. Treatment

- What do *patients* expect to achieve from their treatment?
- What do *you* expect them to achieve from the treatment?
- How often do you normally see your patients?
- What exercises do you expect them to follow between appointments?
- What issues are encountered by patients between appointments?
    - Do patients follow the exercises? If not, why not?
    - Could they be assisted in following these exercises? How?

3. Devices

Do your patients generally use any of the following devices? What difficulties do patients have with these devices? For example, what problems would you expect elderly and stroke patients to experience with using a computer keyboard? What features would make them easier for patients to use? (Consider cognitive, sensory and motor limitations).

- Television
- TV Remote Control
- Telephone
- Mobile phone
- Computer
- Any other devices

What kinds of adaptation would help elderly people make better use of the devices/ technology?

What is it that the device should do that current devices do not do?

Are elderly people able to find the button for the function they are wishing to perform? E.g. volume up/down, on/off – covers reading, recognition and tactile abilities.

4. Environment

What features of the environment need to be considered for the patient to perform the activities safely and effectively?

eg. glare, lighting, space requirements, obstacles, noise, etc.

5. Desired support

If a physiotherapy exercise system were available that was shown on the TV what features would be needed? How useful would guided exercise demonstration be? What interactive features would be needed? Would use be facilitated by a professional or is self use better? Would 'social' use (i.e. the patient participating in a virtual class in a regular time slot) be beneficial?

Physiotherapy Scenario

Below is described a scenario of the use of such a physiotherapy application, please can you give us your comments?

When the stroke patient has returned home they have a need to carry out some exercises prescribed by a physiotherapist. The physiotherapy system is designed to support and reinforce these exercises.

Liam, a physiotherapist, visits Doris in her home to carry out the assessment on her and to prescribe an appropriate exercise programme. Liam conducts the assessment and decides what exercises are appropriate for Doris to carry out. Liam then accesses the system to develop a programme of exercises for Doris to carry out. Liam works out a schedule of exercises to be performed at certain times during each day, for a certain number of days. He then configures the system to monitor Doris's progress and to adapt the exercises to increase their difficulty, to stop some exercises and to start other ones.

Liam then passes the system to Doris and asks her to perform the exercise programme. Doris starts the exercise application. She watches the screen and listens to the instructions. The system tells her that "we are going to exercise your legs".

- Here various exercises can be performed by the system, based on the expert advice of physiotherapists...

Doris carefully and slowly performs the exercise. The system knows that this is the first time that Doris has used the exercise system and takes this into account – running in a slow mode and checking (with audio prompts) that the exercise steps have been completed.

Gradually, Doris gets better at the exercise and the application adjusts to this. It asks Doris to increase the height of the first leg lifting exercise, for example. When the system has detected that Doris has successfully completed the prescribed number of exercise steps of the first exercise, the system informs Doris that she has successfully completed the exercises.

Liam concludes that Doris is able to use the system and can successfully perform the exercise programme he has configured for her. He is able to monitor her progress over the Internet, without having to visit Doris's home and can remotely change the level of difficulty manually.

Questions

How able are elderly and stroke patients at following written instructions on a TV screen? How able are they at following verbal instructions? How able are they at following exercise demonstrations given by a person on screen?

What kind of remote control, or similar device, would be needed or suitable for such a system?

In what ways would the display on the screen need to change/ adapt to suit the patient? Would the patient be able to cope if the display /interface self-adapted?

If an email system that enabled elderly people to communicate by email were available what issues/ difficulties would you anticipate in its use?

Appendix D – Interview template for professionals caring for elderly people

The MyUI project wants to strengthen, establish and simplify the development of accessible and highly individualized information- and communication technology products like interactive TV. The project addresses important barriers towards accessibility, which include system developers' lack of awareness and expertise, time and cost requirements of including accessibility in their products.

1. General

- Can you tell us about your role in caring for elderly patients?
- For what problems do elderly patients generally require your assistance?
- Where do your patients typically live – alone/with family/in a care home, etc.
- How often do you normally see your patients?

2. Lifestyle

Can you tell us the most important issues, which your patients have with:

- Mobility
- Communication
- Socialising
- Eating
- Interests
- Exercise
- Outings/travel

3. Devices

Do your elderly people generally use any of the following devices? What difficulties do they have with these devices? For example, what problems would you expect elderly people to experience with using a computer keyboard? What features would make the devices easier for elderly people to use? (Consider cognitive, sensory and motor limitations). In what ways could the devices be used to improve their quality of life (e.g. to communicate with family and friends)?

- Television
- TV Remote Control
- Telephone
- Mobile phone
- Computer
- Any other devices

What kinds of adaptation would help elderly people make better use of the devices/ technology?

What is it that the device should do that current devices do not do?

Are elderly people able to find the button for the function they are wishing to perform? eg. volume up/down, on/off – covers reading, recognition and tactile abilities.

4. Environment

What features of the environment need to be considered for the patient to perform the activities safely and effectively?

E.g. glare, lighting, space requirements, obstacles, noise, etc.

5. Desired support

How able are elderly and stroke patients at following written instructions on a TV screen? How able are they at following verbal instructions? How able are they at following exercise demonstrations given by a person on screen?

What kind of remote control, or similar device, would be needed or suitable for such a system?

In what ways would the display on the screen need to change/ adapt to suit the patient? Would the patient be able to cope if the display /interface self-adapted?

If an email system that enabled elderly people to communicate by email were available what issues/ difficulties would you anticipate in its use?

Appendix E – Possible sensor technologies

The Virtual User Lab (VUL) will incorporate sensing technologies to meet the technical requirements as specified in the requirement analysis and adopt the user interface and screen content accordingly. The VUL interface program will run on a small portable computational platform and acts as a layer between the application and the user. It will sense the user's actions and capacities with the help of a variety of low-level sensors and support baseline information for the adaptation process. The specific sensors and interaction devices were selected based on their low-cost, easy of implementation and broad availability. Using them we will construct a test-bed that will subsequently provide design information for integrators. The sensors and methodologies we are planning to use during the implementation phase of the VUL are as follows:

Remote controller to access UI and Application functions: The VUL will incorporate a *Wii* controller as the primary replacement for the remote control. It fulfills all aspects of the requirement analysis, specifically accessible from seated position, usable with limited wrist movement (bluetooth interface eliminates need of pointing), usable while standing/walking, the built in accelerometers may be used to detect tremors as well hand movement, may be used as a pointer device, has tactile feedback (vibration) to provide tangible feedback, has audio feedback, displays battery charge levels when turned on, etc. The *Wii* has very few buttons and limited features (as preferred by focus groups), yet through the VUL it transforms the function of a remote control into a fully programmable user interface.

Ambient lighting levels: Light sensor that approximates the human eye in spectral response and its data will allow the system to adjust brightness, contrast and other visual using animated lighting effects.

Hand & finger strength: To measure the users strength of grasp and fingers a low-cost force sensor in combination with simple test exercise will be used. Based on this information the system will then adopt its functionality. Another alternative device in the VUL to measure hand manipulation capabilities is a low-cost data glove that supports independent finger bending measurements along with 6DOF freedom motion & manipulation in a limited motion range.

Buttons-based interfaces and foot pedals to provide alternative controls: Large coloured buttons, placed on the table in front of the user and foot pedals/on-floor keys will allow the VUL to implement a variety of alternative interfaces using a 12 channel switch module.

Touch screens: Add on touch screens are a viable alternative to turn any TV or computer monitor into a source of interaction. The VUL will use these as elements of interfaces designed for people with poor hand-eye coordination or stroke survivors.

Impaired recognition of letters: Different rendering modes, implemented as *shader* effects, will allow the VUL to attract user attention by triggering low-level cortical functions. An example of this is using sand letters, that are designed to use low frequency components and animated light sources in order to direct attention in the visual field.

Presence, body motion and restlessness: An ultrasonic distance detector may serve as a tool to detect if the user is present in front of the interface, move closer or farther. This information will also for the basis of low-level controls as well as higher level user models.

Muscle activity: For some application areas, such as people with severe disabilities, the user interface adaptation may rely on direct data for muscle strength. For this purpose we may use a low-cost EKG sensor that measures electrical signals produced during muscle contractions. It can also be used for making surface EMG recordings important for target groups in rehabilitation fields.

Additional sensors and interfaces: A simple web camera and microphone as well as some specialized input devices, such as programmable OLED buttons will be used. In addition, simple motion capture cameras, eye trackers, etc. may also be used to derive information from the user, but these, as they are generally more expensive, will only be integrated if a certain *myUI* application specifically requires it.

Motivational messages & rewards: High fidelity animated faces of virtual characters, people and even family may be used as personalized alternative to traditional interface feedback mechanisms. Specifically the VUL will incorporate animated faces that that react and respond to the users' actions using non-verbal facial signals. This methodology, called Ambient Facial Interfaces (AFI) is based on theories of neuro-psychology to emotionally motivate people of all ages, race and mental capabilities. Other animated feedback, as per the need of special groups, will also be available to test.

Audio Rendering: The VUL will have a fully 3D sound interface for audio prompts with special localization, and several audio rendering options to support changing voice pitch to better enable the hearing impaired.

High Salience Displays, Limited colour discrimination, Visual prompts, Attention grabbing: The VUL program suite will provide a broad range of animated effects that aim to address a range of user problems and adopt the interface accordingly.

Reaction time, Limited short- or long-term memory: Auto-adaptation setting will allow the VUL to pace information according to the needs of a specific user. The information time line presented by the interface will change the pace according to reaction time inferred directly from the raw interaction data during the process. The VUL system collects all sensor information in the context of the interaction process considered here as a dialogue. This dialogue requires the user to react in a certain expected way to the onset of prompts and choices. We will use this information to estimate reaction time and

Fine motor controls: Using raw data from the Wii, mouse cursor and touch screen, we will aim at detecting limitations in fine motor controls and adopt the interfaces accordingly.

Appendix F – Instructions for running a focus group with old people

Organising the session

- Recruit a group of 3 to 12 older people who are willing to participate, preferably in a Day Centre or place of support for older people.
- Have a prior discussion with the staff to ensure they are happy and supportive.
- Ideally your session should fit naturally into the schedule of activities.
- Obtain all the relevant permissions and ethics approval.
- The design of the session assumes that no video or photographic record will be made (as this may make some participants uncomfortable). If you think it is important to record the session you must obtain consent.
- Ask for a session of 45-60 minutes.

Preparation before the session

- Prepare visual aids and other materials to encourage interaction and discussion, e.g. 3 to 4 hand-held TV Remote controllers with different characteristics and a few other similar technical devices (mobile phones, laptop, iPod, etc).
- Prepare a "friendly" room to facilitate communication and interaction, as well as to create a space for the researcher to be able to talk to (and be seen by) the whole group – eg. arrange chairs in a "U" shape.
- The session can be run by one researcher, but a second person taking notes may be helpful.

During the session

- Try to keep the tone informal and accessible.
- Introduce yourself and explain that you are working as part of a project which is researching how to make devices used in daily life easier for people to use, especially as we grow older.
- Explain that everything is voluntary and no personal information will be linked to an individual
- Ask if it will be okay to take hand-written notes.
- Begin by asking open questions to the group such as:

  "I'm interested in how people use technology so I have some examples of remote controls and other devices for you to look at."

- Show the group the items and visual aids you have brought, and hand them round. Give different things to different people and ask them to pass them on to others; try to ensure everyone gets a chance to see and touch each item, and try to encourage discussion between people. Ask questions like:

  "Discuss what you like about these devices? What are their best features?"

  "Discuss what you dislike about these devices? What are their worst features?"

  "What kinds of problems do you have using these devices?"

  "What would make using these devices easier to use?"

  "Do you have problems using these devices at different times and in different circumstances?"

- Record responses and any of your own observations of difficulties, e.g. problems with eyesight, or understanding, or fear of technology, or hearing, or confusion, or dexterity.
- Collect the items and bring the group back together again for group discussion.
- Try to summarise what you believe they havve told you about each device, e.g. "Some people said they couldn't see the letters on the buttons on this one; is there anyone who could see them okay?"
- Ask if they have any other comments to add.
- Conclude the session by thanking them for their co-operation and reminding them that you are not going to be sharing any personal information, only general impressions.

After the session

- Try to find out from staff members the average age and typical living circumstances of the participants so that your report can say e.g. "a group of twelve people aged between 70 and 85, most of whom live in their own homes, many with support from social services".
- As soon as possible after the session, while it is still fresh in your memory, and based on hand-written notes, write up the session in as much detail as possible using the Experience Report form, for sharing with the project consortium. Remember not to name or identify any individuals – use pseudonyms.