Inclusive design of an interface for a hospital system for information, communication and entertainment

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ABSTRACT

This paper describes the features offered by a hospital portal system for information, communication and entertainment and the work underway to develop an interface to the portal such that all patients regardless of their age, disability, computer experience or native language can use it easily and effectively. The paper discusses the need for inclusive design of the interface to the portal and reports the results and evaluations accruing from the development of the interface to date.

1. INTRODUCTION

Many hospital patients are isolated from telephone/electronic contact with their family, friends and workmates for the vast majority of their hospital stay, which is often a period of intense emotion. The role of the patient also requires the surrender of control over their life, which can be distressing, particularly as this loss of autonomy is often exacerbated by isolation. Relatives and friends also become disturbed by what they perceive as inadequate contact/information. The net result from a nursing point of view is added work on emotional support and as a messaging service.

Conventional mobile phones are banned from use within hospitals because their radiation poses a hazard to important electronic equipment including patient monitors, defibrillators and infusion pump controllers. However, recent advances in telecommunications hardware and software have made possible a safe solution to patients' communication problems, which is more convenient, less expensive and more reliable than existing systems. As a result of a collaboration of clinicians, hardware and software developers and providers a working prototype is now available for installation in hospitals. The system or portal consists of cordless (not mobile) high bandwidth audiovisual send/receive devices whose emissions fall well below the safety levels recommended by the Medical Devices Agency. The receivers communicate directly with a touch screen and telephone headset peripherally, and with a central server via landlines. Because the final link to the bedside need not be hardwired, disruption attendant upon installation can be minimal. Indeed landline installation in corridors and ducts can be coordinated with high-speed digital line installation being undertaken to provide a backbone for electronic patient records or administration projects.

2. THE HOSPITAL PORTAL

The hospital portal prototype incorporates a range of information, communication and entertainment facilities that can be delivered directly to the bedside. For example the facilities provided include:

- Choice of terrestrial and cable/satellite TV channels (Figure 1).
- Near video-on-demand for classic films and 'box-office' movies.
- Selection of national, local, hospital and Internet based radio stations.
- Outgoing telephone services using a large button keypad, displayed on the screen (Figure 2).

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- On-screen visual indication of incoming calls (audible / screen message) with controllable audible ringing tone.
- Full function voice mail service which is simple to operate and can be selected by the patient or by ward staff to eliminate interruptions caused by incoming calls, for example during ward rounds.
- On screen video games.
- E-mail.
- Hospital intranet access (Figure 3).
- Internet access to dedicated or ‘white list’ websites as specified by the hospital for example to health information sources such as disease-specific self-help groups.
- Nursecall facility with priority under the control of the patient.

The portal can also be adapted to serve clinical purposes, such as reminding patients to do their physiotherapy and providing copies of advice as already offered in hard copy in most units. Other novel patient-centred applications include meal ordering, pain monitoring, mobilisation and exercise prompts and motor retraining for stroke victims. It is also possible for nurses or consultants to use the portal to display at the bedside, via a secure link, patient records and imaging scans/X-rays.

Figures 1-4. *A selection of facilities offered by the portal (television, telephone, internet, general menu interface).*

3. INITIAL TRIALS AND CURRENT WORK

The interface to the portal has from the outset been designed with ease of use in mind. For example the main interface mechanism is a touch screen interface incorporating simple menus and large icons (Figure 4). Trials have already been undertaken in an orthopaedic ward at the Derbyshire Royal Infirmary in order to gauge initial patient feedback (Figures 5-8). Results so far have been exceedingly encouraging – *“it is wonderful really, especially for those patients that are bed-ridden. I have found it particularly nice to be able to watch TV from the bed and to use the telephone so easily”.*

However, whilst the interface is simple to use by the general population, it is currently inadequate with regard to use by some older patients. This is particularly true in relation to those patients who have auditory or visual disabilities, cognitive impairments, literacy problems, those who are inexperienced in the use of computers or those for whom English is not their first language. The focus of our work is therefore to research, develop and evaluate a 'design-for-all' interface to the hospital portal such that all members of the patient community may benefit from the facilities of, and stimulating environment created by, such a system.

4. THE NEED FOR INCLUSIVE DESIGN

Computer technology has the potential to enhance quality of life and independence for older people by providing access to information and services, including health care services (Czaja, 1997, 1998). However, age related declines in ability can be a barrier to accessing and using information and communication technologies if the interface has not been designed in a way that takes these changes in ability into account.

Our aim is to design the portal interface so that it can be accessed by everyone, regardless of age or ability. If a product is designed so that it is easy to use for older and less able people then it will also be easy to use for those who are younger and more able. This is the premise of inclusive design. Any interface that is not designed according to inclusive design principles, taking into account the needs and abilities of those who are older or less able, will exclude a proportion of the population that may be in most need of the information and facilities the system provides.

Work in this area is particularly important as older people form a significant client group numbering some 10.8 million in the UK (Office National Statistics, 2001a), with 1 person in 6 being aged 65 and over, a figure that is predicted to rise to 1 in 4 by 2031 (Age Concern, 1998) and whose proportion of the population will exceed that of the under 16s for the first time by 2016 (Office National Statistics, 2001b). Additionally almost half of the older population is aged at least 75, with even larger relative increases being experienced in people over 85 (Age Concern, 1998).

Figures 5-8. *The hospital portal in use by patients at Derbyshire Royal Infirmary.*

Studies into patient demographics show that older people also make up a high proportion of inpatients and that these figures are increasing annually (Department of Health, 2001). Additionally, as a person's age increases so does the average length of time they spend in hospital (Age Concern 2002). The General Household Survey (GHS) of 1998 reports that, over a three-month period, 27% of those aged 75 and over had attended a hospital casualty or outpatient department, compared with 16% of people of all ages. Furthermore, the average length of stay in hospital is longer for those aged 75 and over (12 nights for men and 13 nights for women) compared with all other ages (7 nights) (Office for National Statistics, 2000). According to the Office for National Statistics (2001b) in 1998-1999 nearly two fifths of hospital and community health service expenditure in England (around £10 billion) went towards people aged 65 and over. Expenditure per head on that age group being greater than for any other age group.

Disability also increases with age particularly in relation to issues such as visual and auditory impairment, cognitive loss, mobility decline etc. Around half of all disabled people in the UK are aged 65 and over. Only 4% of those with a disability are 16-24 in age, compared to 23% aged 65-74 and 26% aged 75 and over (Department of Health, 1998). It is estimated that some 5% of the population aged 65 and over and 20% of the population aged 80 and over suffer from dementia (Age Concern, 2002); between 30-60% of people aged over 65 have some level of hearing loss (RNID, 2002); and 70% of people with impaired vision are over 70 years old (Cawthra, 1999; Department of Health, 2001). Older people are more likely to experience multiple impairment such as both failing sight and hearing, and chronic conditions such as osteoarthritis. Older people are also more likely to experience long-term illness. In the General Household Survey (GHS) of 1998, 59% of people aged 65-74 and 66% of those aged 75 and over reported having a longstanding illness, compared with 33% of people of all ages (Office for National Statistics, 2000). The GHS also reports that older people are likely to under-report chronic illness or disability.

5. DESIGN CONSIDERATIONS

Clearly, it is important that any information and communication technology (ICT) system that is intended for use by hospital patients should be designed to be accessible to all. Ageing can result in a combination of accessibility issues. Declines in sensory, perceptual, motor and cognitive abilities that occur with the normal aging process have implications for ease of interaction with ICTs and, hence, implications for interface design.

5.1 Age Related Changes in Ability

There are a number of sensory, perceptual, motor and cognitive effects of ageing that can affect performance of tasks, and which have implications for the design of the hospital portal. Many studies (see Morrow & Leirer, 1997 for an overview) have shown age-related declines in a range of abilities including:

- Visual and auditory perception
- Divided and focused attention
- Sustained attention
- Information processing in working memory
- Recall from semantic memory
- Speech processing
- Language production
- Movement control.

Performance is more likely to reflect these changes under complex task conditions (Morrow & Leirer, 1997).

Very little research has been carried out on what makes an interface easy for older adults to use. Some authors have described the various declines in abilities that occur with age and the implications of these for human-computer interface design (e.g. Morris, 1994; Czaja, 1996; Hawthorn, 1998a, 1998b, 2000). One study, by Ellis and Kurniawan (2000) involved participatory web site design with older users in order to make an existing web site more user-friendly for older users in terms of display format issues.

It is also important to remember that members of the older generation are likely to be new to computer technology, having retired without using computers or the Internet. Thus, they will not be familiar with many Interface design characteristics more experienced users take for granted, that is they will not have built up the conceptual models of how these technologies work.

5.2 Disability

Some disabilities have an impact on a person's ability to access and use standard information and communication technologies. To use the computer people generally need to be able to:

- Use a mouse.
- Use a keyboard.
- See what is on the screen.

Not everyone is able to use a mouse or keyboard and not everyone can see what is displayed on a monitor screen. Those who are unable to do so may use some kind of alternative technology to access computers ("access technology" or "assistive technology"). Access technology is now sophisticated enough to allow a person who has just one functioning muscle group, e.g. someone who can at least blink, to use a computer. Computer interfaces can present barriers to users of alternative technologies, thereby excluding a significant proportion of the population. Interfaces should be designed so that the content and functionality of the system can be accessed, regardless of the technology used. Accessibility is not just a disability issue: people whose eyes and hands are occupied with other tasks, for example while driving, use alternative methods to access

ICT systems, e.g. speech output and voice input. It is important that the hospital portal is accessible to users with disabilities and is designed to be compatible with access technologies.

5.3 Native Language and Computer Naivety

Another factor that may impact on older users from ethnic minority groups is that of English not being their first language (Khoo, 2000). More generally, technological naivety may be another issue, although surveys show that 25% of people over fifty regularly use a computer and 81% of the group surveyed said they found it easy to use a computer with 59% using it to e-mail friends and family and 48% to surf the Internet (Age Concern, 2000). Convergence in the digital technologies is also making an impact in their use (Khoo, 2000; Wright, 2000).

We are therefore currently investigating with patient groups representative of all intended users of the system their requirements for a user-friendly interface to an information, communications and entertainment portal. These groups are being targeted towards the needs of older and disabled people and will specifically address the needs of those people with visual, aural, cognitive and motor impairments as well as those who are technologically naïve or have special learning needs or whose first language is not English.

Prototype interface solutions which embody these requirements and design guidelines (e.g. W3C, 2000; Disability Now, 1999; Trace.wise, Connecticut, NAIC, Abledata, all accessed 2002, McCrindle, 1998; Bright, 1997) are being implemented through incorporation of media types and technologies such as audio, video, graphics, sip and puff, icon and audicon design, speech translation systems, colour, metaphors etc. into the interface. Since February 2002, investigations have been taking place within the Low Vision Clinic of the Royal Berkshire Hospital and in Reading and Oxford Day Care Centres.

6. INITIAL INTERFACE APPEARANCE TESTING

6.1. Aim

The aim of this initial research was to set the parameters for the appearance of the hospital portal interface so that it will be easy to see and understand for all users in the target audience. That is, to determine:

- The appropriate icon and text size, icon polarity, and foreground/background colour combination that should be used in the default appearance of the interface.
- The alternative appearance options that should be offered to users.

6.2. Method

Software was written to present the participants with a number of test screens. Initial pilot tests were carried out with the clients of the Low Vision Clinic at the Royal Berkshire Hospital, in order to refine the software and test methodology.

The final test software comprised 5 screens:

- Initial welcome screen
- Icon size screen
- Icon design screen
- Text size screen
- Colour combination comparison screen

Throughout the testing the font style used for the text was Arial. The monitor screen used for the testing was a 17 inch flat screen. For each test session the illumination at and around the monitor screen was measured.

6.2.1. Participants. The participants for the interface appearance testing were clients of two Day Care Centre, one in Oxford and one in Reading. Clients of such centres have a physical or sensory disability and tend to be older people. Testing was carried out on location at the centres. In total, 94 people were tested (16 men and 78 women), age range 51-96 years (mean 81). This larger proportion of women is to be expected, given the age of the participants and the higher life expectancy of females. Participants were asked to describe any problems they had with their eyesight. The vast majority of participants were visually impaired in some way, ranging from age related sight loss with the need to sit close to the television, read large print books and wear bifocals all day, to more serious conditions such as cataract, glaucoma and macular degeneration. Fifty eight of the participants wore bifocal/varifocal lenses and wore these during the testing. The most commonly reported eye condition was cataract, 14 who had existing cataract in one or both eyes, and 7 who had had the problem corrected by surgery. Five participants had glaucoma and 7 had macular degeneration. Two participants were registered blind. It is important to note that the majority of participants had multiple impairments with hearing loss and mobility difficulties in addition to poor eyesight. A few participants were cognitively impaired.

6.2.2. Procedure. The Software itself consisted of five screens and was pre-programmed in 800px by 600px screen resolution.

Screen One - Initial Welcome Screen: This screen was not only used to comfort the participants with its universal optician type display but was also used to determine the distance that the user needed to sit from the screen in order to be able to read the letters presented comfortable, for each participant this distance was measured. Four white letters (A,B,F,G) were presented in the centre of a black background, the text size being the largest of the alternative sizes used in the later text size screen (48 point, Arial).

Screen Two : Icon Size Screen: This was the first test screen. It presented four telephone Icons of different sizes (ranging from 3.28cm to 5.12 cm square – 93 to 146 pixels square) , black on a light yellow background, and the participants were asked to indicate the smallest icon that they could see clearly. The Icon used was that specified by BS 6034 / ISO 7001 "Public Information Symbols" (1990) for telephone, due to its universality and bold, uncomplicated shape (see Fig 9). The researcher mouse clicked on the participant's chosen icon to record this in an underlying results file with minimal interface disruption.

Screen Three - Icon Design Screen: The Third screen was used to test polarity design of the icon. It presented two telephone icons, in the size previously chosen by the participant, one above the other. One icon was a dark foreground on a light background (positive polarity) and the other a light foreground on a dark background (negative polarity), as shown in Figure 10 Participants were asked to indicate the icon that appeared clearest to them, which was recorded as before. If necessary, it was possible to record a "no difference" result, in which case the dark on light icon was used as the default for the rest of the testing.

Screen Four - Text Size Screen: This screen was used to test the text size that participants found most comfortable to read. It presented the words "Phone call" in 4 different sizes: 18, 28, 38 and 48 point. The participants were asked to indicate the smallest text size that they could read clearly. This test brings up the issue of literacy – one participant stated that although they would indicate which word were clearer, they were unable to read them as they had never learnt to read. The participant's choice was recorded as before.

Screen Five – Colour Combination Comparison Screen: This screen uses all the results collected from the previous screens and displays a telephone icon with accompanying text, "Phone call", according to the participant's earlier choices, in a number of different combinations of foreground and background colour.

In the pilot study participants were shown 10 individual screens, each presenting a particular text/ background colour combination as recommended by the RNIB (2002) for enhancing clarity. However, it was felt that for ease of use in the final system, the number of alternative appearance options offered to users should be kept to a minimum. Following the pilot study, the number of colour combinations used for the appearance testing were able to be reduced to 6:

Text / icon	Background
Black	White
White	Black
Black	Light yellow
Dark blue	Light yellow
Light yellow	Black
Light yellow	Dark blue

The experimental design used for testing the clearest colour combination was a paired comparisons. Each colour combination was presented with each other colour combination, so that, for each presentation, the participant saw once colour combination on the top half of the screen and the other on the bottom half. The order of the comparisons was randomised so that each participant experienced them in a different order. In addition, to compensate for possible differences in participants' quality of vision in the top and bottom halves of the visual field, the colour combinations shown on the top and bottom halves of the screen were swapped round for half of the participants. Participants were asked to name, 'top' or 'bottom', depending on which colour combination looked clearest to them, or if they about the same, a 'no difference' recording. In total, participants were presented with 15 pairs of colour combinations for comparison.

Using pre-programmed colour contrast presets, fifteen buttons are labelled with a number, each button representing a particular set of foreground and background contrasts, which when pressed are inserted into the two picture boxes (see Fig 9). To present the next pair of colour combinations the researcher hides the two picture boxes so that the user momentarily see a black screen, then randomly selects another button to display another pair of colour combinations for comparison.

Figure 9. *Paired Comparison Example.*

6.2.3 Saving the Test File

All data resulting from the tests was saved electronically during the testing phase in an ASCII format for universality and to enable quantitative analysis to be undertaken. Any comments from the participants were also recorded during the testing process.

6.3. Results

For the icon size test the majority of the participants (66%) were able to see the smallest icon clearly (93 x 93 pixels, or 3.28 x 3.28cm). With the icon design, 44% of participants felt that the light on dark design was the clearer, 34% felt the dark on light was clearer and 22% felt that there was no difference. For the text size the majority, 57%, were able to see the smallest size (18 point) clearly.

In the colour combination paired comparisons test, white foreground on a black background was most frequently selected as the clearest (237 times) and blue foreground on a light yellow background was least frequently selected as the clearest (83 times). There is little difference between the other 4 colour combinations (black on white 189 times, black on light yellow 135 times, light yellow on black 172 times, light yellow on blue 146 times). It is also important to note that for the majority of the comparisons (448) the participants stated that there was no difference between the pair of colour combinations presented. For the analysis each participant's choices were converted into frequencies for each colour combination (how often a particular colour combination was chosen as the clearest), which in turn were used to rank the colour combinations in order of preference (1=most preferred, 6=least preferred). This produced a rank order for each user. The rank totals for the colour combinations are shown in the table below:

Black on white	White on black	Black on yellow	Blue on Yellow	Yellow on black	Yellow on blue
238	182	298	357	240	281

As can be seen in the table above, white on black has the lowest rank total, which means that it was the overall preferred colour combination and blue on yellow, with the highest rank total, was the least preferred. Once again, there is little difference between the other colour combinations.

6.4 Conclusions

While it may be sufficient to design the hospital portal interface using the smallest sized icon, as tested above, and a text size of 18 point, it is important to remember that 34% required a larger icon and 43% needed a larger text size. Few users (only the 2 that were registered blind) were unable to usefully see the largest icon and largest text size, in that they were unable to make out what these screens or said. It is therefore concluded that the hospital portal interface can use the smallest icon and smallest text size tested in this project in order to cater for the majority of older users, but should offer the larger sizes as options to users who are unable to see the default settings clearly. User with more serious visual impairments will need to use screen magnification or speech output.

There is little difference between the positive and negative polarity icon designs. The interface could have either design as the default and offer the other an alternative option.

In terms of the interface foreground and background colour combination, the important finding is that on the majority of occasions the participants stated that there was no difference between the two colour combinations presented. Although white on black was most frequently selected as the clearest colour combination and was ranked as the overall clearest, the difference between this colour combination and the remaining 4 is not great enough to justify sole use of white on black for the interface. Usability testing of the hospital portal prototype should include these alternative foreground / background colour combinations, but it may well be found that user orientation and navigation when using the system benefits from colour coding. In this case the default interface colour scheme may need to contain a number of different foreground colours, consistent throughout the system, that contrast well with the background, offering the foreground / background colour combinations tested here as alternative options.

7. CURRENT INTERFACE APPEARANCE TESTING

Whilst visual acuity tests are continuing as opportunities arise, we are mindful of the need to cater for other disabilities and patient requirements. We are therefore also conducting a series of other investigations and activities. For example in order to accommodate users who have problems understanding written language, either due to their educational background or specific learning difficulties e.g. dyslexia, and those whose first language is not English it is vital that the icons used in the hospital portal interface are meaningful. Work is thus underway in this area to identify a portal icon set. Work is also underway to develop more effective sip and puff interfaces, to add audicons to the portal and to visualise how people with different visual impairments perceive the same environment. Further details of any of these projects can be obtained from the authors. Focus groups are also being instigated with a number of elderly and disabled users in order to discuss our findings so far and to ascertain more precisely their requirements for the hospital portal and for computer based systems in general.

8. SUMMARY

In summary, this project is bringing together computer science, engineering and social science academics, with clinical and nursing practitioners and key charities, in order to address a wide spectrum of issues associated with care of the elderly and disabled in hospital. The resultant ‘design-for-all’ interface will enable the identified patient groups to benefit from the development of a hospital portal for information, communications and entertainment and a resultant better quality of stay in hospital with less feelings of isolation and social exclusion.

This programme of study is innovative both in terms of the facilities offered by the portal and in addressing inclusive design across such a wide range of disability groups. Although the target system for the developed interface is the hospital portal it is envisaged that the guidelines and tools developed will be applicable in the wider community across all applications that demand a computer user interface.

Experimental work carried out so far has gathered some useful information to help in the development of an interface for the hospital portal that will be easy to see for older users with age related sight loss, and, consequently, easy to see for all younger users with healthy vision. Further work needs to be done to investigate how the system should accommodate users with more severe visual impairments, e.g. by providing the facility for screen magnification or speech output. We are also now turning our attention to other impairment such as those of a cognitive, motor and auditory nature.

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9. REFERENCES

Abledata (2002), *Assistive Technology Products Home Page*, http://www.abledata.com/Site_2/htm

Age Concern (1998), *The Millennium Debate of the Age* (1998), http://www.age2000.org.uk

Age Concern (2000), *Older People and IT Fact Card*, May 2000

Age Concern(2002), *Statistics*, http://www.ace.org.uk

K.T. Bright, G.K. Cook and J. Harris (1997), *Project rainbow - colour and contrast design guidance*, Access by Design, Issue 72, Centre of Accessible Environments, London

L. Cawthra (1999), *Older People's Health Information Needs*, Health Libraries Review 1999, Vol 16, pp, 97-105

S. J. Czaja (1996), Interface Design for Older Adults, In: A.F. Ozok and G. Salvendy (eds), Advances in Applied Ergonomics, USA Publishing, pp. 262-266.

S. J. Czaja (1997), Computer technology and the older adult. In: M. G. Helander, T. K. Landauer & P. V. Prabhu (eds*), Handbook of Human Computer Interaction*, 2nd edition. Elsevier, Amsterdam, pp. 797-812.

S. J. Czaja (1998), Gerontology case study: Designing a computer-based communication system for older adults. In: V. J. B. Rice (ed*), Ergonomics in Health Care and Rehabilitation*. Butterworth-Heinmann, Boston, pp. 143-152.

Connecticut Tech Act Project, *Assistive Technology, An Introductory Guide to Providing Devices and Services for People with Special Needs*, http://www.techact.uconn.edu/guide.htm

Department of Health (2001), *Hospital Episode Statistics*, available at: http://www.doh.gov.uk/hes/index.html (http://www.doh.gov.uk/HPSSS/TBL_14.htm).

Disability Now, *Design for All*, 1999, http://www.disabilitynow.org.uk/features.htm

R.D. Ellis and S.H. Kurniawan (2000), Increasing the Usability of Online Information for Older Users: A Case Study in Participatory Design, *International Journal of Human-Computer Interaction*, Vol. 12, No. 2, pp. 263-276.

D. Hawthorn (1998a), Psychophysical Ageing and Human Computer Interface Design, *Proceedings of the Australian Computer Interaction Conference OzCHI'98*, IEEE Comp. Society, California, pp. 281-291.

D. Hawthorn (1998b), Cognitive Ageing and Human Computer Interface Design, *Proceedings of the Australian Computer Interaction Conference OzCHI'98*, IEEE Comp. Society, California, pp. 270-280.

D. Hawthorn (2000), Possible Implications of Ageing for Interface Designers, *Interacting with Computers*, Vol 12, 507-528.

L. Khoo (2000), Retune Your Strategy, TV Takes Contro*l*, *Business2.0*, October 2000, pp. 98-107.

R.J. McCrindle and R.M. Adams (1998), Multimedia Interface for the Disabled (MIND) Project, *International Journal of Virtual Reality*, Vol 3, Number 4, pp35-44. Also on CD-ROM in Vol3, No. 4 and Vol 4, No.1.

J.M. Morris (1994), User Interface Design for Older Adults, *Interacting with Computers* Vol 6, No. 4, pp. 373-393.

D. Morrow and V. Leirer (1997), Ageing, Pilot Performance and Expertise. In: A.D. Fisk and W.A. Rogers (eds), *Handbook of Human Factors and the Older Adult*, Academic Press, pp. 199-230.

NAIC, National Ageing Information Centre (2002), *Assistive Technology and Aging*, http://www.aoa.dhhs.gov/NAIC/Notes/technologydisabilities.htm

Office for National Statistics (2000), Social Survey Division, *Living in Britain: Results from the 1998 General Household Survey*. The Stationary Office, London.

Office for National Statistics (2001a), *Mid-2000 UK Population estimates*, http://www.statistics.gov.uk.

Office for National Statistics (2001b), *Social Trends 31, 2001 edition*. The Stationary Office, London.

RNIB (2002), Accessible Website Design, http://www.rnib.org/digital/hints.htm

RNID, 2002, *Age related hearing loss*. Information leaflet, http://www.rnid.org.uk

Trace.wise.edu, *Accessible Design of Consumer Products, Guidelines for the Design of Consumer Products to Increase their Accessibility to People with Disabilities or Who are Aging*, Working Draft http://www.trace.wise.edu/docs/consumer_product_guidelines/consumer.html

W3C (2000), *Web Accessibility Initiative*, http://www,w3.org/WAI

J. Wright (2000), Retune your Strategy, The Web Strikes Back, *Business2.0*, October 2000, pp. 109-114.