Evaluating technology for elders: Towards a measure of attitudes

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"After bread, the first need of the people is education"
Danton (1759 – 1794)

Dedication

For my parents and grandparents

Abstract

Technology is ubiquitous in modern day society and has the potential to enhance one's quality of life. Numerous innovative assistive technologies are designed to aid elderly people in every day activities and enable them to maintain a measure of independence longer. One such assistive technology was the PAM-AID walking aid: a robotic walking aid designed to provide frail, visually impaired elders with the physical support of a rollator, coupled with the navigational assistance necessary for safe, independent mobility.

A user-centred design approach was integral to the design and development of PAM-AID and the first part of this thesis, details the research undertaken to ensure that, as far as possible, PAM-AID met the needs of potential users. Studies were conducted with carers and elders to establish elders' requirements for PAM-AID. The results of these studies directly influenced the functional specification of the first PAM-AID prototype. Following an iterative design life cycle, further studies were conducted to evaluate the usability of the first and second prototypes and the results of these studies enabled informed design decisions could be made. Therefore, elders were involved at every stage of the design process, to ensure that PAM-AID was an efficient and acceptable technology to this user group.

However, throughout this preliminary work, an interesting discrepancy in elders' attitudes began to emerge. It became evident that although elders thought that PAM-AID was a useful walking aid for other frail elderly people, they did not think that PAM-AID was beneficial for them personally. In other words, elders' attitudes indicated that they might not use or accept PAM-AID, even though they would clearly benefit from this innovative technology. Indeed, other research has shown that many assistive technologies are often under utilised or discarded by elders, even when the potential benefits of the technology are clearly evident. This was a pivotal point in the research

programme, as it highlighted the importance of monitoring elders' attitudes to predict future use of and acceptance of assistive technology.

Since no applicable tool exists for measuring individuals' attitudes to technologies such as PAM-AID, the main empirical work of this research programme involved the development of a psychometric scale: the Attitudes to Technology Scale (ATS). The inductive approach to development of this scale involved: the generation of items, the reduction of the items into meaningful subscales, as well as the demonstration of the scale's reliability and validity. Throughout its development, the scale was applied to a number of different types of technology such as ATMs, computers, microwaves, mobile phones, VCRs and the Internet. The scale has been used to investigate the effect of age and sex differences in terms of attitudes to technology. Thus, the ATS is unique in that it has been developed for use with all types of technology and with individuals of all ages. The limitations of the scale have been noted and further work is needed to address these limitations.

It is hoped that this scale will have both academic and commercial research applications, but above all, the ATS could be applied to continually monitor users' attitudes during the design and development of new technologies. It is proposed that the measurement of users' attitudes should be an integral part of the design life cycle, resulting in more useable and acceptable technology.

Outcomes of this work

Publications

O'Neill, A-M., Petrie, H., Gallagher, B., Hunter, H., Lacey, G., & Katevas, N (1999). Initial evaluations of a robot mobility aid for frail and elderly visually impaired persons. In C. Buhler & H. Knops (Eds.), Assistive Technology on the Threshold of The New Millennium. Amsterdam: IOS Press. ISBN: 1 58603 001 9.

O'Neill, A-M., Petrie, H., Lacey, G., Katevas, N., Karlson, M-A., Engelbrektsson, P., Gallagher, B., Hunter, H., & Zoldan, D. (1998). Establishing initial user requirements for PAM-AID: a mobility and support device to assist frail and elderly visually impaired persons. In I. Placencia-Porrero & E. Ballabio (Eds.), Improving the quality of life for the European citizen: technology for inclusive design and equality. Amsterdam: IOS Press. ISBN 90 5199 406 0.

Commercial device

Since the completion of the PAM-AID Project in 1999, the PAM-AID walking aid has had a name change and is now called GUIDO. It is now a commercial device and is being marketed by a company co-founded by one of the originators of the PAM-AID Project, called Haptica (http://www.haptica.com).

Glossary of terms used throughout this thesis

Assistive technology: "Assistive technology is a product or service that enables independence" – Foundation for Assistive Technology: www.fastUK.org

Blind: approximately equates to a person being registrable as "blind" by their local authority. They are people with a visual acuity level of 6/60.

Elders/elderly: refers to individuals who are aged 75 years and over

Partially sighted: approximately equivalent to being registered as "partially sighted". This includes people with a visual acuity level of 6/60 to less than 6/18.

Sex and/or Gender: The term 'sex' is used to refer to the biological distinction between males and females and the term 'gender' will refer to the culturally defined gender-appropriate behaviours associated with 'masculinity' and 'femininity' (Unger, 1979).

Technophobia: Avoidance/resistance of new technology. A negative attitudinal response to technology (Brosnan, 1998) - although not a phobia in the classical sense. Other terms are used interchangeably in the literature: computer anxiety, technostress and computerphobia.

Visually impaired: refers to those individuals who are registered or eligible for registration as blind or partially sighted.

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Chapter 1

Introduction and overview of thesis

1.1 Overall aims

The overall aim of the research presented in this thesis was to investigate how the measurement of peoples' attitudes towards technology, could lead to producing more functional and acceptable technology. A valid and reliable scale for the measurement of attitudes was designed to provide valuable information to developers during the design of new technology, particularly when the technology is designed for specialist user groups, such as the elderly. Consequently, a major aim of this research was to construct a scale that could be used to measure users' attitudes towards technology. For this scale to be of maximum value, an important goal was to make it applicable to all users and to all types of technology. Therefore, a scale was constructed to be a universal template that was not technology specific for use with users of all ages. Furthermore, such a scale was designed to enable predictions based upon users' attitudes, regarding future use of and acceptance of technology. The rationale for producing the Attitude to Technology Scale was that this would enable the measurement of users' attitudes towards technology, which should be integral to the design life cycle and should become a major tool in the field of HCI.

1.2 Rationale

Technology is an integral part of everyday life, and in many cases, has the potential to improve individuals' quality of life. This is particularly so for disabled and elderly people. Indeed, assistive technology[1] can help elderly and disabled people to perform tasks and communicate with others, which they would otherwise be unable to do (Edwards, 1995; Hollins, 1989; Howey, 1995; Stevens & Edwards, 1996). However, not all technological innovations prove to be useful, usable or acceptable to the people they are designed for (Landauer, 1996; Norman, 1988) and poor design often results in user frustration and increased errors (Neumann, 1991, Swartout & Balzer, 1982). In order to achieve a well-designed, useable piece of technology, it is necessary to involve potential users at all stages of the research, design and development process. This begins with gathering the requirements of users, and continues to involve the potential users in evaluations of the technology throughout the design life-cycle (Carroll, Kellogg, Rosson, 1991; Dix, Finlay, Abowd, & Beale, 1993; Murphy & Davidshofer 1994; Nielsen 1993; Norman & Draper 1986; Petrie, 1997; Shackel, 1991). Indeed, the specification, implementation and testing should be "intertwined" (Swartout & Balzer, 1982).

In this thesis, two sets of studies are presented, the second which, was born of the first. The first set consisted of a number of usability studies, conducted as part of the EU-funded PAM-AID Project *(see section 1.4)*, involving the design and development of a robotic walking aid for frail and elderly, visually impaired people. This research was the preliminary stage of the PhD programme, as it was during this work that the author realised the importance of measuring the users' attitudes towards PAM-AID, for the following reasons: The potential users of PAM-AID were very elderly (70 to 90+ years of age) and were several generations apart from the author and her technical researcher associates (20 to 35 years of age) working on the project. It was essential that the researchers should attempt to bridge the ***generation gap***

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[1] See Glossary

and measuring users' attitudes would provide valuable information for them to do this.

- It soon became apparent during the project, that the user group had extremely limited experience of technology, even of relatively simple technologies such as cassette radios, televisions and microwaves. It was important that the researchers should attempt to bridge the ***technological gap*** and measuring users' attitudes would provide valuable information for them to do this.

- During the studies with elderly users, they displayed very different reactions to the idea of using PAM-AID, some were clearly more anxious about using the walking aid than others. It was considered important to objectively measure these reactions, which would provide valuable information about the ***individual differences gap***.

- Although users had been selected because they would benefit from using PAM-AID (i.e. they were frail, visually impaired and needed support and guidance whilst walking), many users could not see how the walking aid would benefit them personally. Interestingly, they acknowledged that PAM-AID could be a useful walking aid to *other* elderly visually impaired people. There was a resistance among some users to the idea of using a device such as PAM-AID, even though they would benefit from walking with such a device. In order to investigate the ***acceptance gap***, it was considered that measuring their attitudes would provide valuable information to the researchers.

As the project progressed, it was recognised that measuring users' attitudes could also be an important feature of the user-centred design process in general.

The initial PAM-AID work identified a need for an attitude measure that would provide valuable information regarding elders' attitudes towards PAM-AID during the design and development stage of this technology. Although every effort was being made to identify and incorporate the needs of elders in the design of PAM-AID, it could not be assumed that this would foster positive attitudes and increase future use of PAM-AID among elders. Thus the preliminary PAM-AID research has been included in this thesis because it formed the basis, which lead to the main focus of this PhD programme: the development of the Attitudes to Technology Scale.

1.3 User-centred design and attitude measurement

The process of user-centred design *(see section 2.7)* often includes an element whereby users are asked their opinion about a technology and an indication of their attitudes can be gathered using rating scales. This method of collecting attitudes can be useful, but often, the questions have not been validated or tested for their reliability. Measuring attitudes using a valid and reliable tool would be valuable when used during the design and development of technologies. If the attitudes of potential users were to be measured alongside usability measures, this would provide developers and human factors specialists with a richer source of information when attempting to improve the match between users and technology. Indeed, a valid and reliable measure of attitudes would enable the comparison of different user groups and the design could be tailored more specifically to each group's needs. For example, there may be attitude differences between young and old age groups towards a technology that has been designed for both groups to use. If so, the technology could include different interfaces targeted at each user group. Furthermore, measuring attitudes of users could be carried out at different stages of the design and development process, for example, during the evaluation of a first prototype and then during subsequent evaluations of the refined prototypes. One would expect users' attitudes to become more positive towards the technology as the design is refined and being able to monitor the degree of change (if any) would be indicative of whether the design has been improved.

Measuring attitudes may also enable developers to predict future use and acceptability of the technology by potential users. This may be particularly important to guide when and how the technology should be introduced to users. Training could be tailored and pitched specifically for people according to their attitudes. Furthermore, measuring users' attitudes before and after training is given, would provide a measure of the effectiveness of the training.

To-date, the measurement of attitudes towards technology, has mainly been confined to the measurement of attitudes towards computers. A plethora of scales has been developed to measure attitudes to computers and computer anxiety and these scales have produced a wealth of information on the correlates of computer attitudes and anxiety (such as age and sex differences). The main disadvantage of these scales is that they are technology specific and therefore cannot be used for alternative technologies such as PAM-AID. Also, many of these scales had been developed using young, student samples and were not applicable to elderly samples.

The following sections of this chapter introduce the PAM-AID project and the PAM-AID walking aid and demonstrate how the initial research highlighted the importance of measuring people's attitudes towards technology, prompting the development of the Attitudes to Technology Scale (ATS). This chapter concludes by giving brief summaries of the remaining chapters to provide an overview of the thesis.

1.4 The PAM-AID Project

The PAM-AID Project was supported by the European Commission from January 1997 to June 1999. The idea for the PAM-AID walking aid came about when a Computer Scientist, Gerry Lacey, based at Trinity College (Dublin) visited an elderly aunt in a residential nursing home. Lacey noticed that several of the elderly residents were only able to walk with the assistance of a carer due to their frailty and visual impairment. While many frail people are able to maintain mobility with the aid of a Zimmer frame or rollator, those who have the additional disability of visual impairment are unable to use such walking aids as they do not provide navigational assistance. As a consequence, these people are almost entirely dependent upon others for their mobility. This inspired Lacey to develop an aid to assist people with both a mobility and visual disability (Lacey & Dawson-Howe, 1997; MacNamara & Lacey, 1999).

1.4.1 Main aims of the PAM-AID Project

The PAM-AID project aimed to build an intelligent, indoor mobility aid for frail and elderly visually impaired people, which would provide both physical and navigational support for walking. The main objective of the PAM-AID walking aid was to allow users to take independent exercise whilst retaining personal autonomy. In order to achieve a well-designed and usable piece of technology, the project involved establishing the user requirements from the potential user group: rapid prototyping; construction of prototypes; user and carer training and system evaluation. A number of studies were conducted with potential users throughout the project that are reported in this thesis and the subsequent design and development of PAM-AID was based upon the findings of these studies. The user-centred procedure is illustrated in Figure 1.1 below:

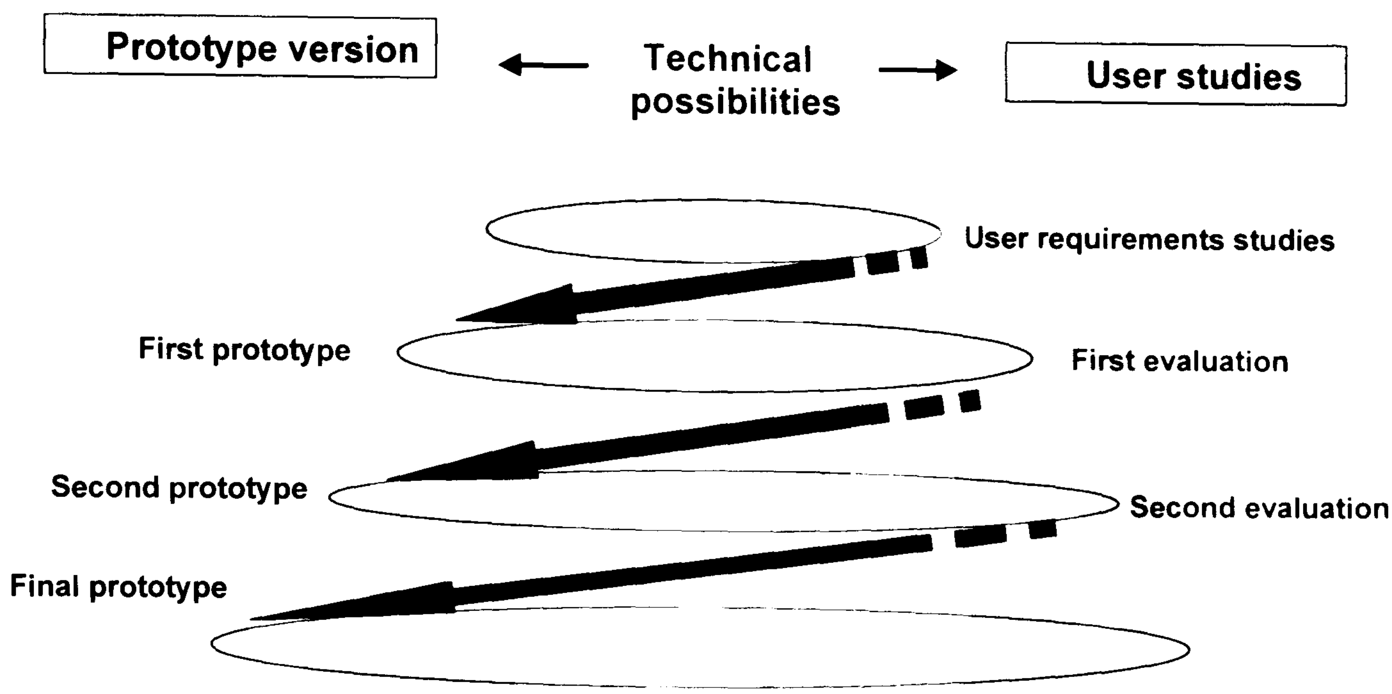


Figure 1.1 User-centred approach of prototype development

Initially, two user requirements studies were conducted, the first with carers of frail and elderly visually impaired people, and the second with the potential users themselves. The results of these studies informed the design of the first PAM-AID prototype that was subsequently evaluated by frail and elderly visually impaired people in the UK. The results of this evaluation study provided valuable information for the next design iteration. Users evaluated the second PAM-AID prototype in Ireland and again the results informed the design of next prototype. Details of the functional specification of the first and second PAM-AID prototypes are given in chapters 5 and 6.

1.4.2 *Measuring elders' attitudes to PAM-AID*

The preliminary work on the PAM-AID project, highlighted the importance of measuring elders' attitudes towards the technological walking aid. This would provide valuable information that would bridge the (i) technological gap; (ii) generation gap; (iii) individual differences gap and (iv) acceptance gap.

Although usability questionnaires were designed to gather elders' subjective ratings regarding different aspects of PAM-AID, such ratings only gave an indication of attitudes and could not be taken as valid and reliable measures of their attitudes. Indeed, "single items do not produce responses by people that are consistent over time. A person, may answer "yes" today and "no" tomorrow." (Spector, 1992, p.4). In order to achieve valid and reliable measurement of attitudes, an applicable psychometric scale needed to be used. This would enable a precise measure of attitudes that is reliable over time. The summated scores would give an indication of where users' attitudes fall on a quantitative measurement continuum. However, the only existing scales available were scales developed to measure attitudes to computers/information technology *(see section 2.5)*. One scale is the Technology Acceptance Model (TAM) (Davis, 1986), which holds that it is a reliable and valid predictor of technology acceptance. For the initial studies evaluating PAM-AID, this model was adapted to make tentative investigations into users' attitudes towards PAM-AID but it had limited value and highlighted the need for a more acceptable and general tool that would enable the measurement of attitudes to technology.

1.5 The Attitudes to Technology Scale (ATS)

The PAM-AID Project highlighted a need for a scale that would enable the measurement of elders' attitudes during evaluations. Consequently, a new scale was constructed with the intention that it could be used during the design life cycle of new technologies and this work has been the main focus of the PhD programme. However, it was thought to be critically important to develop a scale that would be applicable to users of all ages, as this would enable comparative analysis across age groups.

Another decision had to be made about the new scale – should the scale be developed for one specific technology or should it be developed so as to be applicable to many different technologies? Since the scale development process is long and needs large samples throughout, it did not seem like a practical option to develop a scale from scratch for each different technology. Davis developed the TAM so that the names of different software could be inserted into the items of the scale, therefore enabling the TAM to be applied to different software. Therefore the development of the Attitudes to Technology Scale (ATS) was based on the same principle, so that the names of different technologies could be inserted into the items. This would mean that the ATS would be a universal template applicable to different technologies and would be a far more practical tool for academic and commercial researchers.

1.6 Structure of thesis

The research presented in this thesis has involved the elicitation of user requirements and the evaluation of a technological walking aid for frail and elderly people. Following on from this, an attitude scale was constructed for validly and reliably measuring attitudes towards technology.

This thesis has 10 chapters, which are briefly summarised below to give the reader an overview of its structure.

Chapter 1: Introduction and overview of thesis.

Chapter 2: Rationale for the research and a review of the literature.
This chapter presents a review of the literature that is related and relevant to this research, namely, the research areas of human computer interaction (HCI), attitude theory, psychometrics, gerontology and the psychology of technology. This chapter also gives an overview of the existing research within these areas, which was drawn upon by to inform and direct the current

work. These areas are not mutually exclusive and this chapter shows how they relate to one another, forming the basis for this current research programme.

Chapter 3: Establishing the user requirements study for PAM-AID.

These preliminary studies to establish the user requirements for PAM-AID are presented. Twelve carers and 38 elders were interviewed to establish their opinions regarding the walking aid and the different interface options. The results helped to inform the design of the first prototype. Tentative investigations into the attitudes of potential users towards PAM-AID were made and results showed that although elders thought that the technological aid was useful, they would not be interested in using it themselves. It was this finding that showed the complexity of people's attitudes and lead to further investigations into elders' attitudes in the next evaluation studies.

Chapter 4: Evaluating the PAM-AID prototypes with elders.

An evaluation of the first prototype was conducted with 8 frail and elderly visually impaired users. A main aim of this study was to evaluate the usability of the user interface with potential users of PAM-AID so that informed design improvements could be made to the next prototype. The refined second PAM-AID prototype was later evaluated with 16 elders to again establish the usability of the interface. Both evaluation studies involved investigations into user acceptance and attitudes towards PAM-AID and it soon became clear that elders could be resistant to using PAM-AID, even though they would clearly benefit from using the aid. It was this preliminary evaluation work that identified the need to measure users attitudes as part of the user-centred design process. However, there was not a measurement tool that was applicable to elders for a technology like PAM-AID. Thus, the following chapters detail the main work that forms this PhD programme: the development of an attitude scale to measure users' attitudes to technologies like PAM-AID.

Chapter 5: The development of The Attitudes to Technology Scale.

This chapter details the development of a summated Likert scale that can measure attitudes to technology of people of any age. The development of the Attitudes to Technology Scale (ATS) has involved following the 5 major stages of scale development. The research detailed in this chapter follows stages one to four and is presented in two parts. Part 1 details the work carried out with 15 participants, all were experts in the field of Human-Computer-Interaction (HCI) in order to define the construct of interest and design of the pilot questionnaire. Part 2 details the work carried out to pilot the questionnaire with 200 participants and the reduction and refinement of the scale using exploratory factor analysis and item analysis.

Chapter 6: Establishing the construct validity and the predictive power of the ATS.

This chapter reports the research undertaken to establish evidence towards the validity and predictive power of the ATS. Initially, a small investigation was carried out to see if the ATS had face validity. A large study was then conducted to gather evidence of construct validity by correlating the ATS with two other valid and reliable measures. The ATS was given to 235 Internet users together with The *Computer Attitudes Scale (CATT)* and The *State-Trait Anxiety Inventory (STAI).* Furthermore, this study also attempted to address whether the ATS could be used to predict individuals' level of use of the Internet. The effect of age and sex on attitudes to the Internet were also analysed as well as the statistical analyses to see if the ATS was maintaining an acceptable level of internal consistency.

Chapter 7: Effect of age, sex and frequency of use on attitudes towards technology

This chapter reports two studies investigating age and sex differences regarding individuals' attitudes to technology. In the former, people's attitudes towards microwaves and videocassette recorders (VCRs) were measured, and in the latter, people's attitudes to mobile phones were measured. Both studies found no differences between males and females but there were significant differences between younger and older users of VCRs and mobile phones in terms of their ATS scores. There were no significant differences between age group for microwaves. In addition, the second study examined whether ATS scores could predict frequency of use.

Chapter 8: Conclusions to thesis.

This chapter ties the multidisciplinary threads together, to show that a coherent research procedure had evolved. A review of the results of the studies is given as well as a synopsis of how the results relate to previous research. Recommendations for future research to address the limitations of the ATS are documented. Overall conclusions for this research are given, together with recommendations for the use of the Attitude to Technology Scale

1.7 A summary of the main issues

Preliminary work:

- To investigate the requirements of elders towards an innovative technological mobility aid called PAM-AID

- To investigate the usability of the PAM-AID device and the elderly users' attitudes towards this technological aid

Main work of research programme: To develop a valid and reliable attitude scale that is a universal scale which can be applied to all types of technology

- To develop a scale for all users regardless of age that can be incorporated into the usability process

- To use this scale to investigate the age and sex differences regarding attitudes to technology

- To make a contribution to knowledge, particularly in the fields of HCI, gerontology, disability and the psychology of technology.

Chapter 2

Rationale for the research and a review of the literature

2.1 Introduction

The work presented in this thesis is a fusion of several different fields of research, namely, the fields of human computer interaction (HCI), attitude theory, psychometrics, gerontology and the psychology of technology. These distinct areas have formed the basis for this current research but they are by no means mutually exclusive. Chapter 1 of this thesis gave details of the aims and issues central to this piece of multidisciplinary research. The user-centred approach to the design of the PAM-AID walking aid placed one foot of this research in the camp of HCI, gerontology and visual impairment. The construction of a psychometric measure of attitudes placed the other foot in the camp of psychometrics, attitude theory and the psychology of technology. This chapter will give an overview of the relevant literature and research as well as the rationale for the current research.

Before the literature is reviewed however, this chapter will first give an overview of the current and predicted demographic changes within Europe as they have had an important impact upon the development of new technologies.

2.2 Aging Europe

A number of technologies have been designed with the chief aim to improve quality of life for elderly people, but they have also been developed to relieve the burden on both human and financial resources within society as a whole.

The predicted increase in the elderly population in western society is well documented (Eurostat, 2002; Hugman, 1994). Increased life expectancy largely attributed to improved health and hygiene, means that there are increasing numbers of elderly people. For instance, the average life expectancy of UK males has increased from 72.2 years in 1990 to 77.9 years in 2002 (CIA World Factbook 2002).

Of the 59.7 million people living in the UK in 2000, 10.7 million (18%) were aged 65 years or more, of which 4.4 million people were 75 years over and 1.16 million people were aged 85 years and over (Population Trends 2001).

The number of people aged 65 and over in the UK is increasing and it is projected that, by the year 2011, at least 11.9 million people will be aged 65 and over. It is also expected that in 2021, this will rise to 12.2 million (National population projections, 2000).

The demographic picture in the UK is also typical across other European countries *(see Table 2.1; Grundy & Harrop, 1992).*

Table 2.1 Proportions of total populations aged over 65 years, EC countries, 1997

Country	Percentage over 65	Relative order
Belgium	14.8	4
Denmark	15.6	1=
France	14.0	6
Germany	15.3	3
Greece	13.7	7
Irish Republic	11.3	12
Italy	14.5	5
Luxembourg	13.4	8
The Netherlands	12.8	11
Portugal	13.1	10
Spain	13.3	9
UK	15.6	1=

Source: Eurostat, adapted from Hugman, 1994 (p 48)

Statistics (actual and predicted) for the European Member States[2] during the period 1996–2020, show that the proportion of people aged 60 years and over will be 27% and will increase further to 30% by the year 2030 *(Figure 2.1)*. This means that the numbers of people in Europe aged 60 years and over will increase from 77 million people in 1996 to 100 million people by 2020. More specifically, there has been a dramatic increase in the numbers of people over 80 years of age. Indeed, it is predicted that in 2020 there will be 21 million people in this age category. This is an increase of 300% since the 1960s.

[2] Statistics are based on Europe 19: Austria; Belgium; Denmark; Finland; France; Germany; Greece; Iceland; Ireland; Italy; Liechtenstein; Luxembourg; Netherlands; Norway; Portugal; Spain; Sweden; Switzerland; UK.

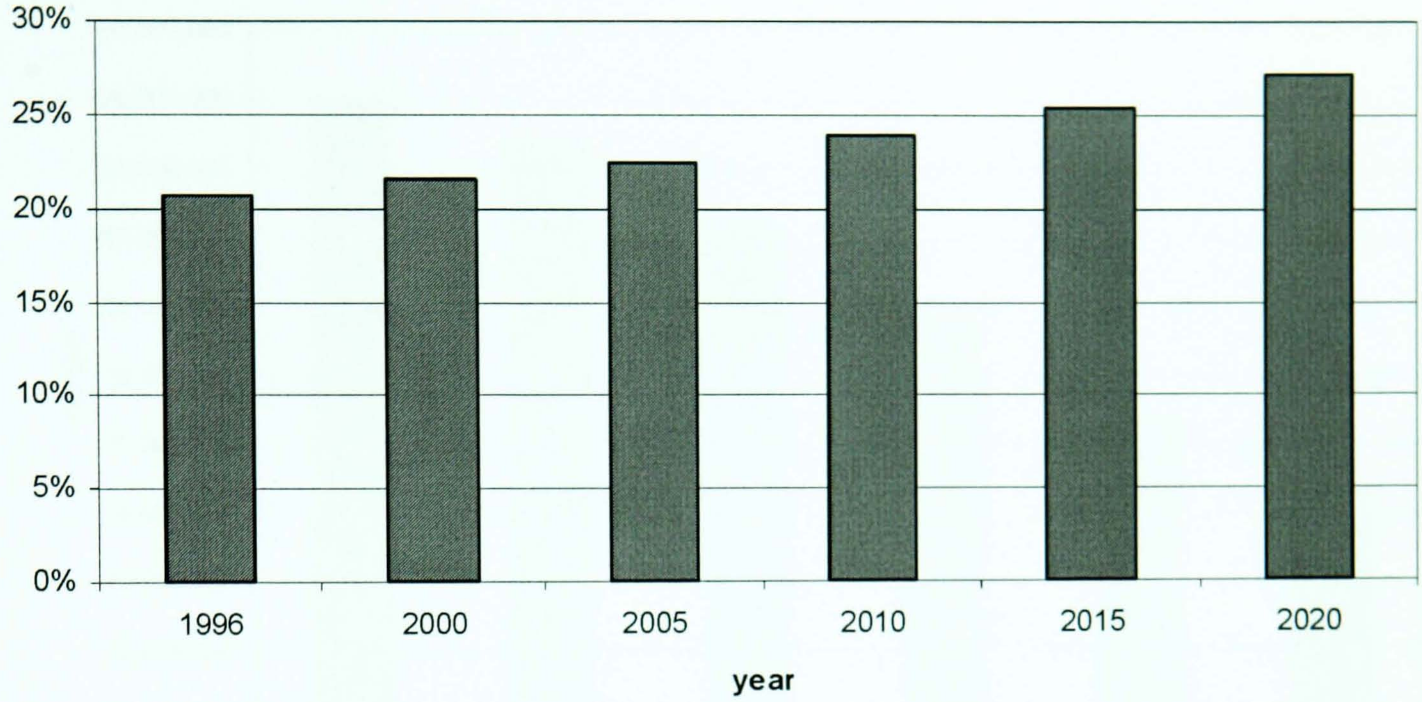


Figure 2.1 Forecast percentages of older people (60 years and over). Source: Bühler & Schmitz (1999).

In contrast, lower birth rates have lead to a decline in the numbers of working age adults, young people and children. Statistical forecasts suggest that this demographic picture is a stable one and it is unlikely to reverse (Eurostat, 1997). Statistics show a demographic shift where the numbers of young people between the ages of 0 – 19 years will decline by 13%; this will have an effect of a decline in the total population from 2020 onwards *(Figure 2.2)*.

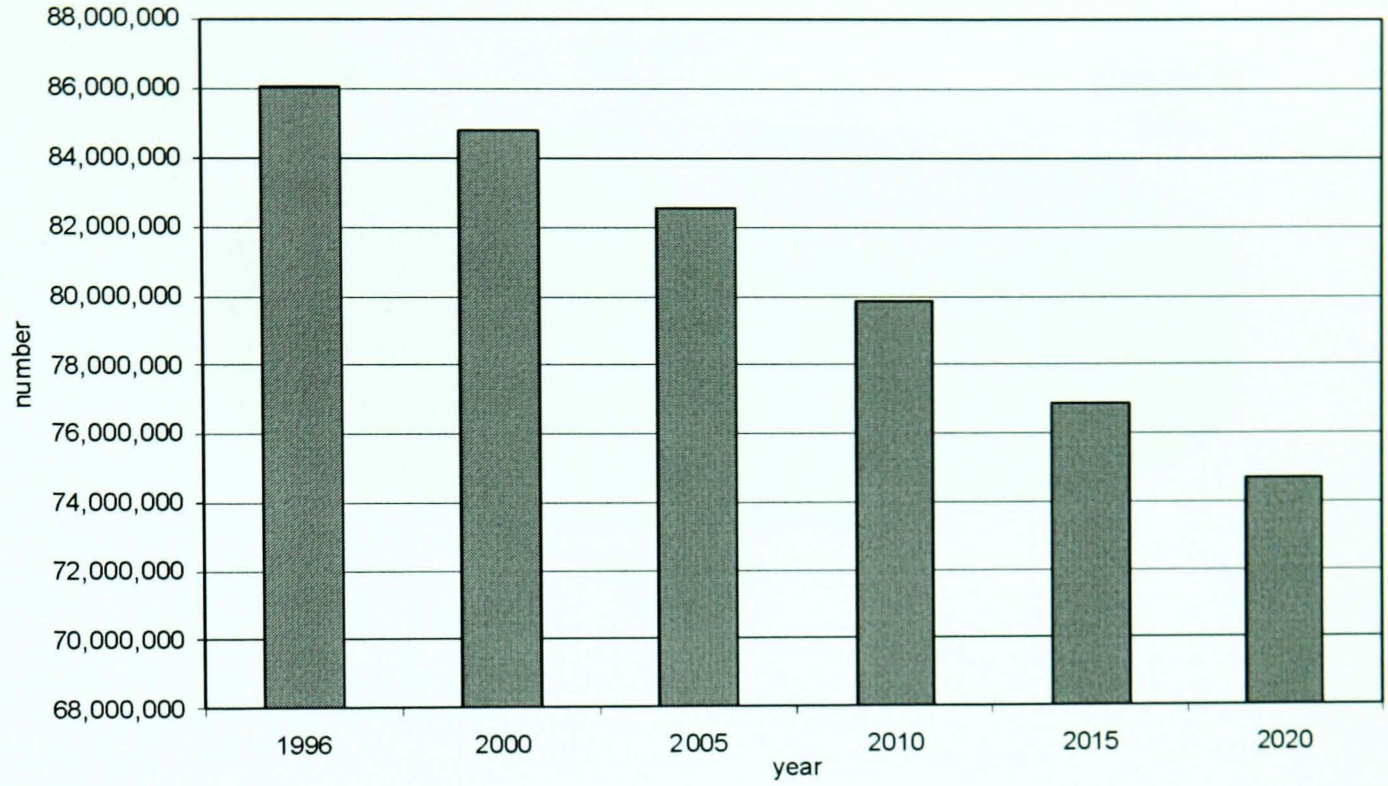


Figure 2.2 Forecast percentages of younger people (0 – 19 years). Source: Bühler & Schmitz (1999)

There are also falling numbers of people in the age group 20-59 years of age. Figure 2.3 shows the percentage of age groups in 1995 and this clearly demonstrates that 45% of the total population in 1995 were dependent members of society, supported by the remaining 55% who provide the majority of the workforce.

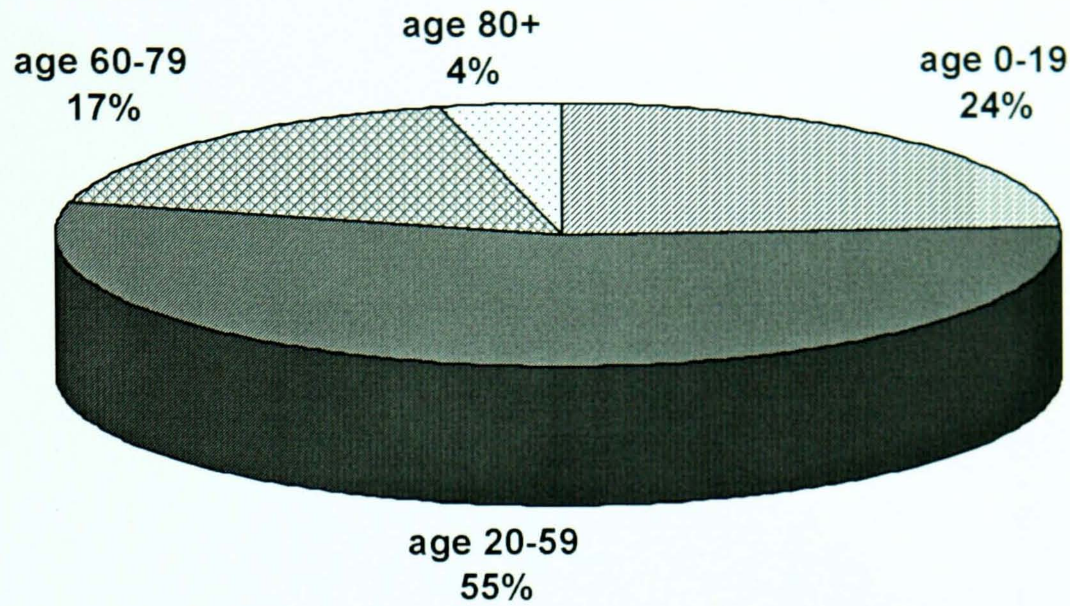


Figure 2.3 Percentage of age groups in 1995. Source: Bühler & Schmitz (1999).

This decline in young people and people of working age coupled with the increase in the elderly population has produced a major shift in the demography of Europe. According to Eurostat, the ratio of middle generation persons to older persons in 1999 was 2.75:1, this will fall to 1.99 : 1 in the year 2020 *(Figure 2.4)*.

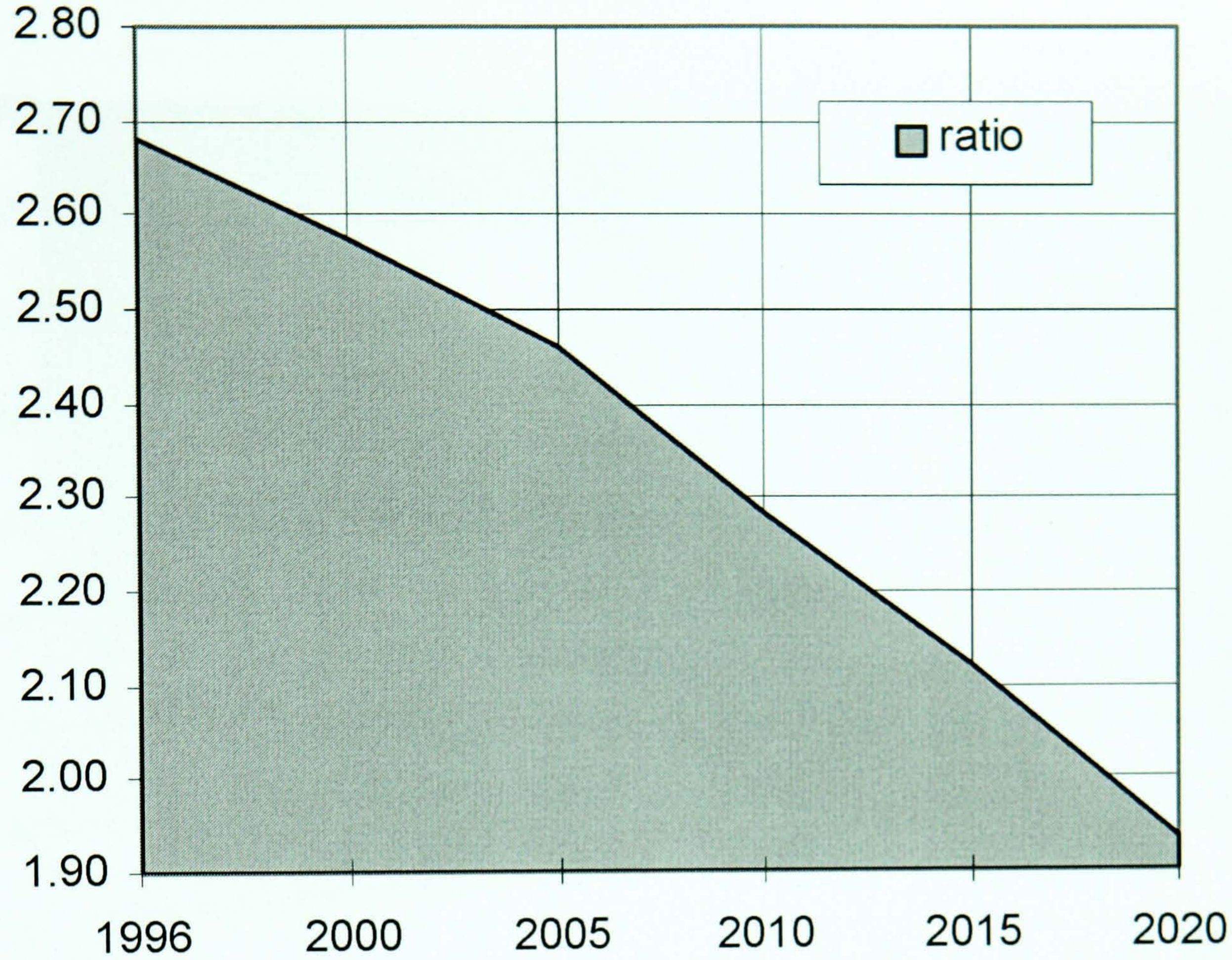


Figure 2.4 Ratio of middle generation persons to older persons in 1999. Source: Bühler & Schmitz (1999)

2.2.1 Age related disability

Ageing generally leads to a decline in physical and mental performance. For example, people commonly experience problems with balance and coordination; they may experience high frequency hearing loss, become long-sighted and may experience a decline in reaction times and body strength. Although many elderly people are not necessarily disabled by such changes, the likelihood of any disability occurring does increase with age. It is estimated that people over 74 years in the UK, are 28 times more likely to suffer a visual disability than people between 16 and 59 years (Bruce, McKennell & Walker, 1991).

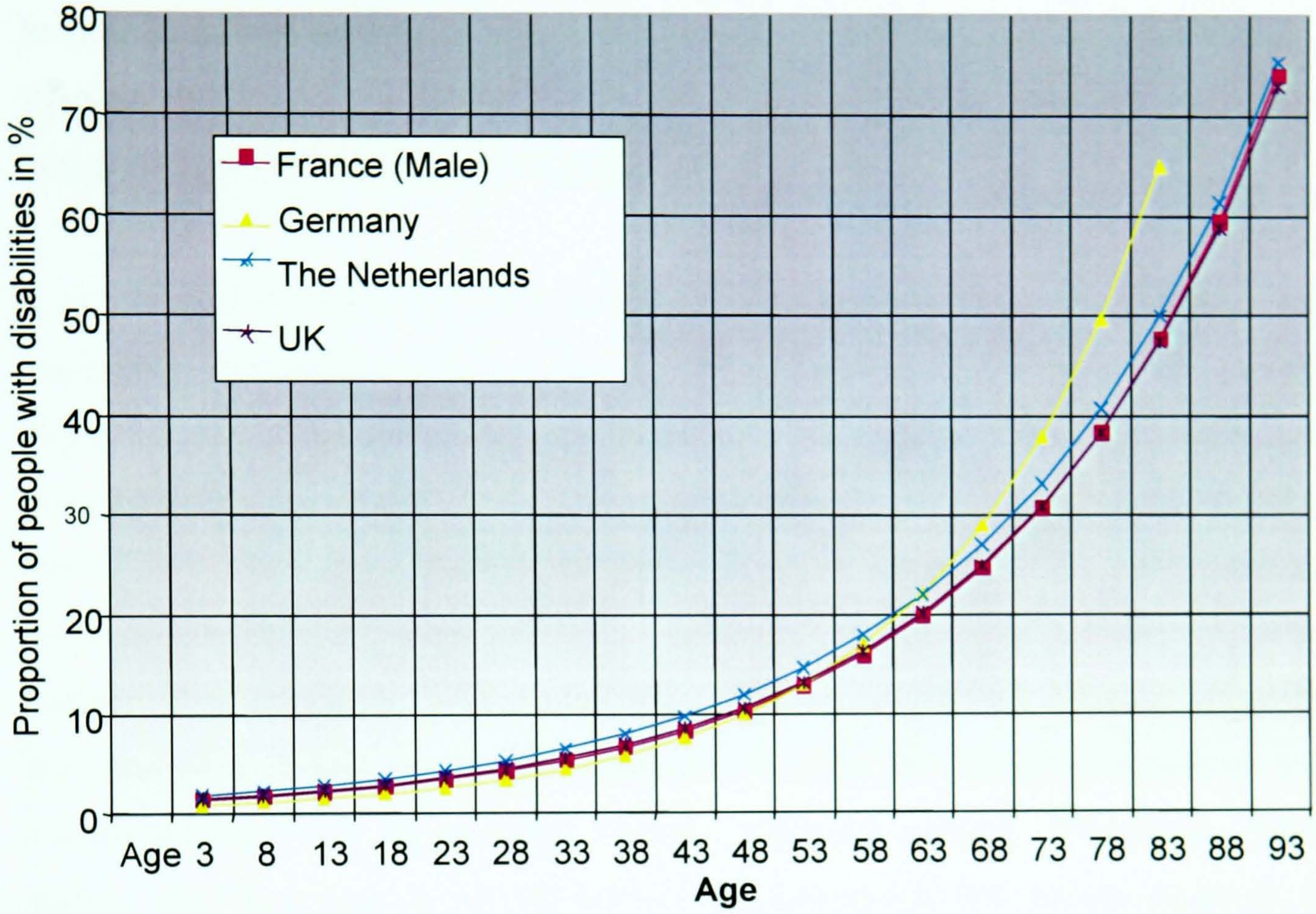


Figure 2.5 Percentage of people with disabilities in France, Germany, the Netherlands and the UK. Source: Bühler & Schmitz (1999)

Although disability classifications may vary across the Member States, 11% of the European population is registered disabled, of which physical impairments are the most predominant disabilities registered (Eurostat, 1997). Of these, motor disabilities are the most predominant followed by sensorial disabilities (hearing loss being the highest in number).

2.2.1.1 *Elderly visually impaired population in the UK*

Focusing more specifically at the disability of visual impairment[3], the distribution of visually impaired people is enormously skewed towards the

[3] See Glossary

elderly end of the population. In fact, at the time of the last RNIB survey, 90% of visually impaired people in the UK were over 60 years of age, this equates to one in seven elderly people being visually impaired (Bruce, McKennell & Walker, 1991). Of the 680,000 visually impaired people over the age of 60 years of age, 500,000 were over the age of 75 years.

It is concerning that the percentage of visually impaired people who are *registered* declines with increasing age. Indeed, only 24% of visually impaired people between the age of 60 and 74 years will be registered, and only 19% of those aged 75+ will be registered. These figures are remarkably low. The RNIB survey found that those who are registered visually impaired are more likely to be aware of, or in receipt of, services for visually impaired people. For example, it is more likely that a registered visually impaired person will be aware of, or have received mobility training, in comparison to a non-registered (but registrable) visually impaired person. Therefore, many elderly visually impaired people are not registered and will not be aware of, or in receipt of, services available to them.

2.2.2 Housing for the elderly

Care of the elderly may need to be restructured to take into account the increasing elderly population, and the limited human resources available. In 1991, around 95% of people over the age of 65 in the UK lived in private accommodation and the remainder (approximately 450,000) lived in institutions such as hospitals and residential homes. Table 2.2, shows that 75% of people aged 85 years and over still live in private households and even in the age group 95 years and over, 52% are still living in private households (Tinker, Askham, Hancock, Mueller & Stuchbury, 2001). Many of these elderly people will be entitled to some form of domiciliary care. This involves certain services such as domestic work; personal care; nursing; "meals-on-wheels" and remedial therapy. This enables the elderly person to continue to live in his or her own home or with family, instead of living in communal establishments.

Table 2.2 Percentage of elders living in private households and communal establishments in 1991 (Tinker et al., 2001)

		Sex		Marital status			Age group		
	All 85+ %	Male %	Female %	Single %	Married %	Divorced/ Widowed	85-89	90-94	95+
Private household	75	84	72	65	91	73	80	66	52
Communal establishment	25	16	28	36	9	27	20	34	48
Total	100	100	100	100	100	100	100	100	100

Source: Census 1991

Those elderly people who live in communal establishments usually have a room of their own and are cared for 24 hours a day by professional carers. An alternative for some elders is to live in sheltered accommodation, in small flats/apartments within a complex, which usually has a communal meeting area for residents. A warden usually lives on the premises and is on-call for emergencies (e.g. falls) but they are not responsible for the everyday care of residents. People who live in sheltered accommodation often rely on 'Home Help' provided by the State, who cook meals and do everyday household chores.

2.2.3 Impact of the demographic shift upon society

The impact of the shift in European demography has a number of important implications upon Western society.

The number of people who are of retirement age (65 years+) is increasing whereas the number of children and people of working age (18-64 years) are steadily decreasing. There is an imbalance in the ratio of 'active' members of society who are working, compared to groups who are economically dependent (e.g. children, students, unemployed, pensioners). This has prompted some authors to speculate that the demographic shift should be viewed in terms of a *demographic crisis* as it is expected that this will place an enormous burden upon human resources, financial resources and the social support systems (Coleman & Bond, 1990; de Jouvenal, 1988). However, even though the proportion of older people is increasing, the numbers of elderly people using welfare services at any one time are relatively small. Thus, the idea of a crisis is based upon the one-dimensional view that equates ageing with increasing dependency (Victor, 1985).

The likelihood of disability occurring increases with age, for example, 90% of visually impaired people are over 60 years of age. Indeed, it is estimated that 17% of the European population will be disabled in 2030, which translates to about 63 million people (Eurostat, 1997). However, it is difficult to make accurate predictions regarding disability statistics, as it is uncertain what medical advances may be made to help people overcome certain disabilities.

The demographic shift may mean that people will have to work to an older age, and the labour market will need to employ more people with disabilities. The increased use of computers and the Internet will mean that more people may be able to work from home, particularly relevant for those who are unable to travel.

Due to transient populations, the structure of European society has changed over the past 50 to 100 years. People are less likely to die in the same area in which they were born, and families have become more dispersed. This means that family support networks have been weakened and elderly people are increasingly more dependent on Government social support systems.

On average, women live between 5 and 9.5 years longer than men across Europe (Eurostat, 1997). As a result, half of women over 65 are widowed whereas two-thirds of men are still married. Many of these women may have not made full contributions to a pension due to staying at home and bringing up children, and this has meant that many elderly women are more likely to be placed on the poverty line than elderly men.

2.3 Designing and developing technology for elders

2.3.1 What is technology?

Technology is a broad term that is difficult to define because it crosses the boundaries of science, art and economy. However, it has been proposed that technology can be defined on three levels (MacKenzie & Wajcman, 1999). On the most basic level, technology represents physical objects such as cars, computers and mobile phones, although this is a somewhat simplistic and narrow explanation. Technology also encompasses the human activities as well as the objects. For instance, the technology of computers involves not only the hardware but also the computer programs and the programmer. Moreover, technology involves knowledge, since technological objects are useless without the knowledge of how to use, design and make them.

2.3.2 Assistive technology for elders

The demographic shift in Western society has resulted in an increase in the number of technologies designed and developed specifically for elders. Many technological innovations are designed so that elderly people can maintain their independence for longer and improve their quality of life by assisting people in every day activities. For example, computers can be applied specifically to the needs of elderly people, they can be used to present self-help programs and provide health instructions, or they can be used to monitor the use of medication and to control 'smart' emergency response systems. For those who are housebound, computers can be used to do tasks such as shopping and banking or to communicate with others via email and searching the WWW for information about interests and hobbies.

Assistive technology[4] can help alleviate the difficulties encountered due to physical, sensory and cognitive impairments (Fernie, 1997). For example, 'Smart' houses incorporate technology such as automated devices to assist elderly and disabled people to live independently within their homes. The 'Smart' house can automatically adjust the temperature, check that doors and windows are shut, and enable the homeowner to communicate with others outside the house (Allen, Ekberg & Willems, 1995). The European Commission has supported some research projects developing new technologies that are being specifically designed to improve the quality of life of elderly and disabled people. The PAMAID Project *(see Chapter 1)* was one such project and is the main focus of the first half of this research programme. The PAM-AID walking aid was designed to increase mobility among frail visually impaired people, by providing them with the physical support of a rollator together with the navigational assistance required for walking safely. Improving one's independent mobility has positive aspects

[4] See Glossary

upon one's physical and mental well-being. PAM-AID would also reduce visually impaired elders' dependency on carers.

The research carried out during the PAM-AID project, highlighted the need to measure elderly users' attitudes towards the PAM-AID walking aid *(see Chapter 1)*. Measuring the attitudes of elderly users towards PAM-AID would provide additional valuable information during the design and development phase, which would help produce a more useable and acceptable piece of technology. Indeed, measuring elders' attitudes towards technology in general may become increasingly more important, as this could indicate their intention to use, and their acceptance of, technological aids.

2.3.3 Measuring elders' attitudes to technology

Assistive devices (both technological and non-technological) are designed to help elderly and disabled people perform everyday tasks that able-bodied persons tend to take for granted. Many of these assistive devices are becoming more technological in nature, as the potential of technology to assist elderly and disabled people is far reaching. However, elders' attitudes may cause them to resist using these devices.

General attitude research has shown that *intention of use* is an indicator of *actual* participation in a range of self-care behaviours and health services (Ajzen, 1985). Therefore, patients who perceive the need for a device, and express their intention to use the device prior to leaving hospital, are more likely to use the device once they return home. On the surface, this may seem common sense, but a number of surveys have shown that users will discard assistive devices soon after they have been prescribed medically, and even when the health benefits to the user are clearly evident (Bynum & Rogers, 1987; DeWitt 1991). Research has also shown that between 50% and 60% of elderly people will discard, not use, or under utilise, the assistive devices that they have been given (Bynum & Rogers 1987; DeWitt 1991;

Page, 1980). Indeed, Brickfield (1985) surveyed 750 people ranging from middle-aged to elderly people about their use of six different types of technology, and found that the use of all types decreased with advancing age. Straker (1992) noted that elders are less likely to use 'high-tech' devices than younger people, as many elders find that technology does not necessarily make life easier, as well as finding that technology is too "dehumanising". It has been suggested that attitudes and perceptions of users need to be understood in order to improve the uptake and the continued use of assistive devices (Wasson, Gall & McDonald et al., 1990) but this is even more important when the assistive device is perceived to be 'high-tech'.

Gitlin, Schemm, Landsberg & Burgh (1996) investigated whether positive or negative attitudes towards assistive devices (both technological and non technological) were potential predictors of future use by elders. They found that users' *perceived need* of the assistive device was the main determinant of whether users would use the device at home. Furthermore, using Bruno's Reinforcement Motivation Survey[5] (Bruno, 1993), they identified those users who had a positive orientation towards the assistive device and they found that there was a trend towards a positive device orientation to predict actual device use. The researchers concluded that awareness of a patient's attitudes ("orientation") towards a device could help inform therapists when to introduce an assistive device to that patient. Interestingly, they also concluded that they needed to investigate more thoroughly the factor of *embarrassment*, particularly in relation to devices used in a public context e.g. mobility aids.

[5] The Reinforcement Motivation Survey (RMS) is a 36 item, forced choice questionnaire containing three scales designed to measure behaviours and motivational factors that have been noted in non-compliant clients: a Brief Type A behaviour scale, a scale measuring negative reinforcement motivation and a scale measuring sensitivity to criticism and failure.

The factor of embarrassment was also addressed with elders during the PAM-AID project. The initial user requirements study conducted with carers, indicated that elderly users would feel quite conspicuous, and quite embarrassed, about using voice input and auditory output functionality when in a public place. This was addressed in the following two evaluation studies presented in this thesis, as this was an important factor that would have an effect on the design of PAM-AID, and the future use of PAM-AID.

Ultimately, assistive devices can improve the quality of elderly people's lives by assisting them to perform simple everyday tasks, and these devices are increasingly becoming more technological. These technological aids can help elders maintain independence for longer, and thus promote physical and mental wellbeing. Furthermore, new technological aids are being developed to help relieve the burden upon the diminishing middle-aged section of society, which supports the increasing elderly and disabled populations. It is of concern that these devices are often not used, or are under-utilised, and this has been linked to the attitudes and perceptions of users. In other words, peoples' attitudes determine whether they will use and accept technology, and this has its foundation in general Attitude Theory.

2.4 Attitude theory and relation to behaviour

This section introduces general Attitude Theory and how attitudes are related to behaviour, with specific reference to the Theory of reasoned Action (TRA) (Ajzen & Fishbein, 1980; Fishbein & Ajzen, 1975) and the attitude accessibility theory (Fazio, 1986). This leads into a section that explains the measurement of attitudes, and the method of scale construction, since this is applicable to the development of the Attitudes to Technology Scale detailed in the second half of this thesis.

2.4.1 Defining 'attitude'

The term 'attitude' was defined by Baldwin (1901), as "readiness for attention or action of a definite sort" and later Thomas and Znaniecki (1918) related attitudes to social behaviour. Allport (1935) conducted a review of attitude literature and concluded with a broad definition: "an attitude is a mental and neural state of readiness, organised through experience, exerting a directive or dynamic influence upon the individual's response to all objects and situations with which it is related". Thus, from early on, attitudes were viewed as mental processes that influence an individual's behavioural response.

More recently, there has been general agreement that an attitude "is a summary evaluation of a psychological object captured in such attribute dimensions as good-bad, harmful-beneficial, pleasant-unpleasant, and likeable-dislikeable" (Ajzen, 2001). Fazio (1986) defined attitudes as a learned association between a concept and an evaluation. Based on this, he developed the attitude accessibility theory (section 2.4.2.2), which explains how the strength of attitudes can vary and this in turn, effects the strength of the attitude-behaviour relation.

2.4.2 Attitude-behaviour relation

Many researchers began investigating the relation between attitude and behaviour. One of the first and well-known studies was LaPiere's study (1934) of racial prejudice, whereby he travelled with a Chinese couple to 251 restaurants and hotels in the United States, being only refused service once. When LaPiere wrote to all the establishments six months later, asking if they would accept members of the Chinese race in their establishment, of the 128 who responded, 90% said they would not accept them. Therefore, this study found that individuals' behaviour might not always be consistent with their attitudes.

This important study and others with similar findings caused theorists to suggest that the same attitude could be expressed in different behaviours. Although two people may hold the same attitudes it is possible that they have learned different responses to those attitudes, depending on the reinforcement that they received. A multi-component view of the attitude concept began to take hold and Rosenberg & Hovland (1960) proposed the three-component view of attitude *(see Figure 2.6)*. This illustrated that a person's response to an object is mediated by their attitude to that object. There are three different responses: Cognitive, Affective and Behavioural. A measure of all three of these responses are necessary to gain an accurate description of an attitude. Although the multi-component view propounded the importance of attitudes, this theory was still seen to be an inadequate explanation of the low attitude-behaviour relation. This lead to a number of investigators recognising that maybe there is not a direct relationship between attitude and behaviour and that other variables must also be taken into account.

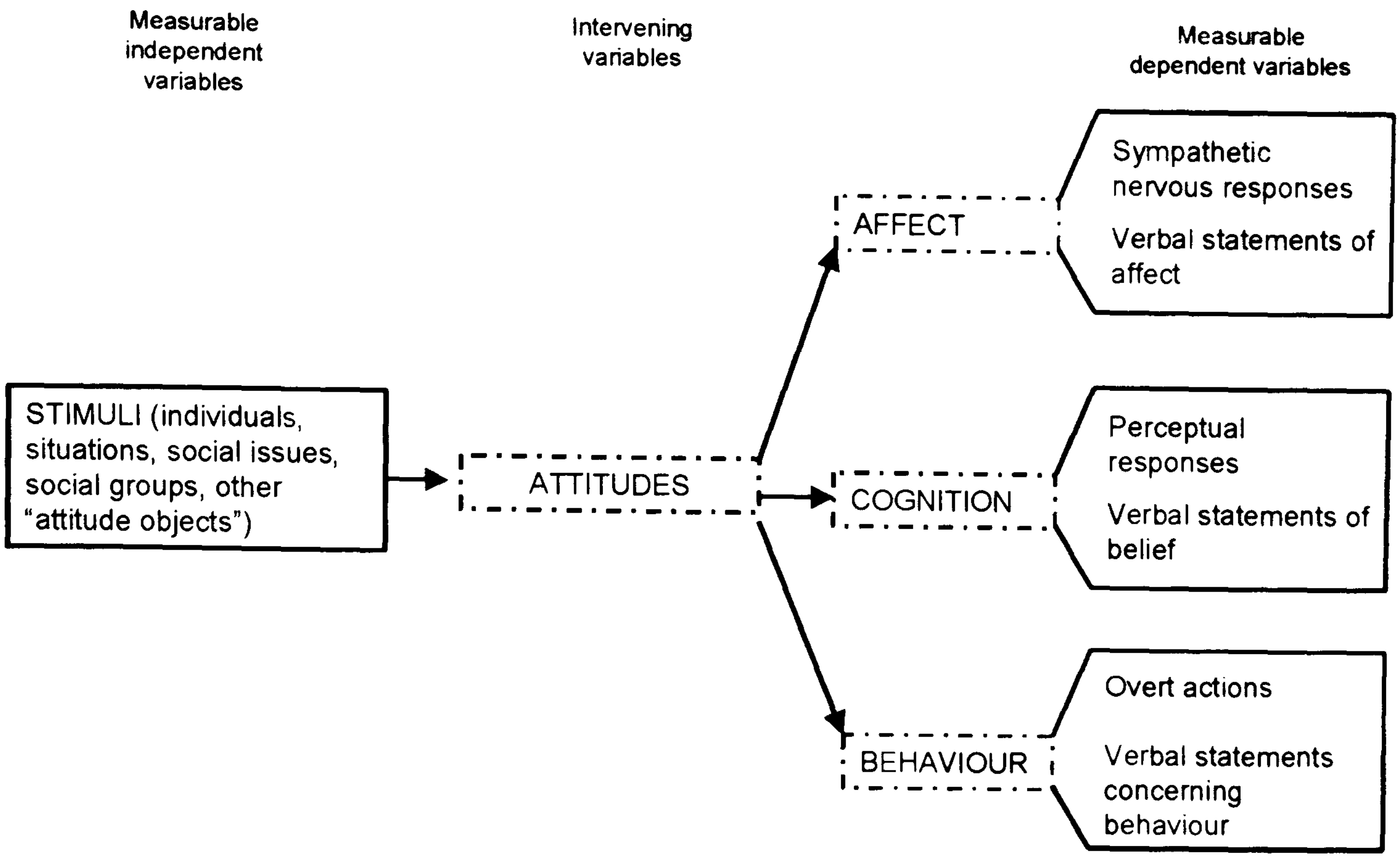


Figure 2.6 Three-component view of attitude (Rosenberg & Hovland, 1960)

Perhaps the most widely cited theory of attitudes and how it relates to behaviour is the Theory of Reasoned Action (TRA) (Ajzen & Fishbein, 1980; Fishbein, & Ajzen, (1975). In contrast with previous theories, Ajzen and Fishbein proposed that attitudes towards an object could predict an overall pattern of behaviour.

2.4.2.1 The Theory of Reasoned Action

Ajzen and Fishbein (1980) developed a theory to predict and understand human behaviour, based upon many years of testing and development. They argued that behaviour is determined by beliefs, but this does not imply that that there is a direct relationship between beliefs and behaviours. The Theory of Reasoned Action (TRA) *(Figure 2.7)* assumes that human behaviour is based upon rational and conscious decision making. That is, an individual's *intention* to act or not to act can predict whether they will perform the behaviour in question and that attitudes are a function of an individual's beliefs. If an individual believes that performing a behaviour will lead to a positive outcome, then they are said to have a positive attitude towards performing that behaviour.

However, they point out that this notion of predicting behaviours from intention does not give any explanation of the reasons for the behaviour. Therefore, their model also involves a second step of analysis, from which the determinants of behaviour are also identified, so that the model provides some understanding of behaviour.

According to the theory, a person's intention is influenced by two determinants, one is a personal factor called the *attitude towards behaviour* and the other being a social factor called the *subjective norm*:

Attitude towards behaviour factor – this determinant of intention is where the individual calculates whether performing the behaviour will have a negative or positive outcome. The beliefs underlying attitudes towards behaviours are called *behavioural beliefs.*

Subjective norm factor – this is a social factor whereby the individual's perceptions of social pressures influence whether or not they perform the behaviour. The beliefs underlying an individual's subjective norm are called *subjective beliefs*. Therefore, if a person thinks that most referents with whom he or she is motivated to comply with, thinks they should perform the behaviour, then that person is more likely to perform the behaviour.

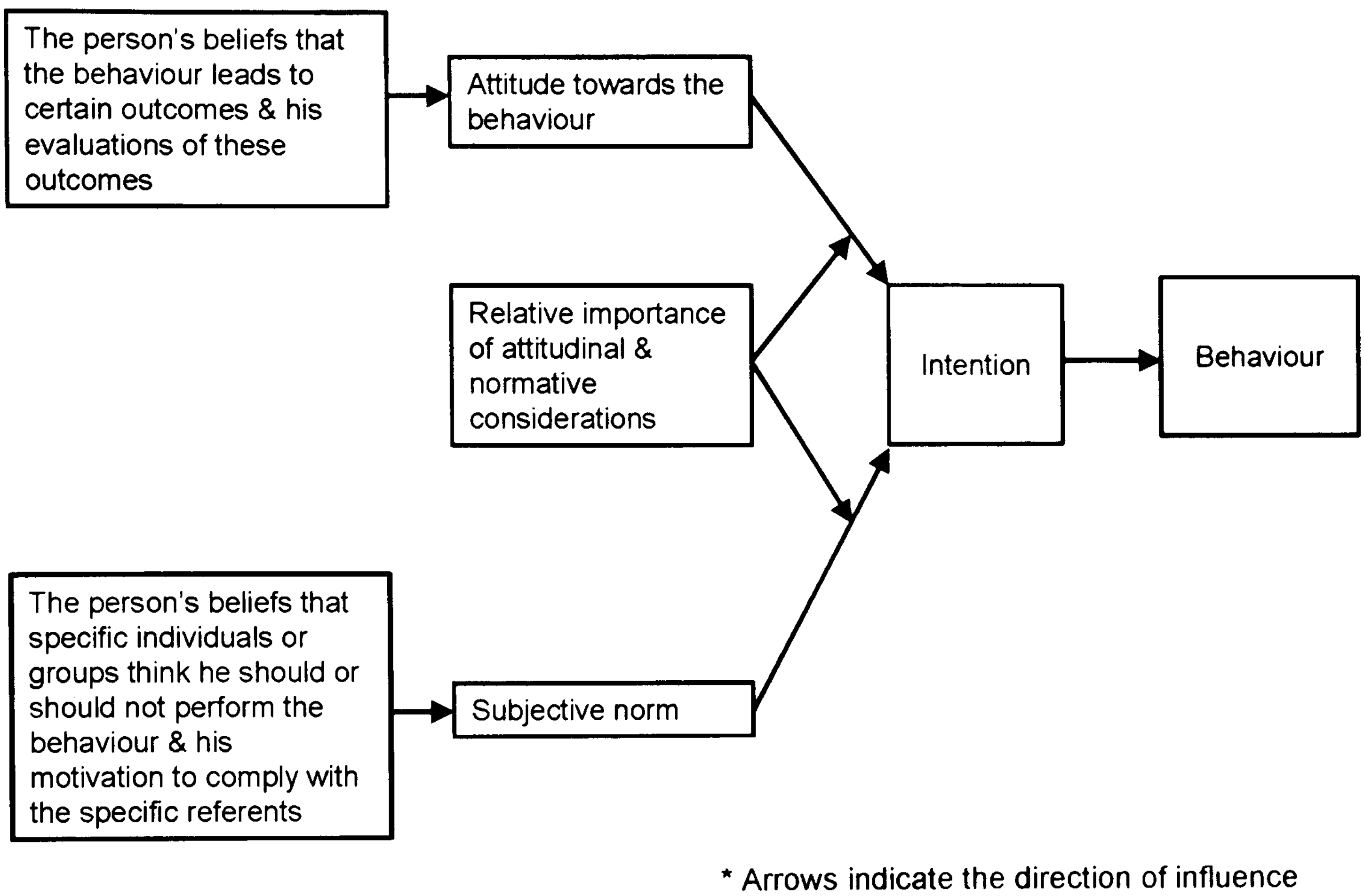


Figure 2.7 The Theory of Reasoned Action (Fishbein, & Ajzen, 1975)

Both of these factors are determinants of intention, but in some cases the attitudinal factor may predominate and in other cases the normative factor may predominate. In other words, these factors may have relative importance for different people, and this gives explanatory value to the theory. Thus, it is possible to predict an individual's intention by measuring his/her attitude toward performing a behaviour as well as his/her subjective norm and their relative weights. The TRA also explains why the individual holds these attitudes and subjective norms by explaining that attitudes are a function of the individual's beliefs. In other words, if the individual believes that performing a behaviour (e.g. using a computer) will lead to mostly negative outcomes (e.g. the computer will break) then the individual will hold an unfavourable attitude to using a computer.

However, the initial version of the TRA was not without its limitations, and so the theory expanded to include a third factor called Perceived Behavioural Control and was then called the Theory of Planned Behaviour (Ajzen, 1988).

This third factor is the degree of perceived behavioural control, which affects behaviour (directly or indirectly) through behavioural intentions.

However, Roberts & Henderson (2000, p.429) note that a major limitation of TRA is that when the theory is applied to practical situations, there are often factors that "do not sit comfortably within its framework". It is particularly difficult to apply when behaviour is not under the volitional control of the individual. For example, an individual's attitudes towards a computer will not be relevant if the individual has no access to a computer. Also, the degree of discretion that an individual has to choose whether or not they use a computer may vary between workplaces. Thus they question whether the TRA or the Theory of Planned Behaviour are appropriate frameworks to use when considering practical situations in the workplace. Similarly, the TRA does not apply to habitual actions that are not continually under conscious processing.

2.4.2.2 Attitude Accessibility Theory

A more recent model (Fazio, 1986) describes the process of how attitudes guide behaviour has received a great deal of interest in the field. The attitude accessibility theory holds that attitudes are a learned association between a concept and an evaluation. Since attitudes are based on associative learning, the strength of the attitudes varies and this is measured by a reaction time paradigm. In other words, the quicker an attitude is expressed, the greater it's strength and, the stronger the attitude is, the more accessible it is. In order to guide behaviour, attitudes need to be accessible. Fazio, Sanbonmatsu, Powel & Kardes (1986) demonstrated that attitudes can be automatically activated when the individual is presented with an attitude issue. The basis of this theory is that attitudes are activated spontaneously and this contrasts with Fishbein's view that attitudes are a result of conscious and effortful attribute evaluation.

Fazio et al., have shown that if attitudes are more accessible this leads to a higher attitude-behaviour correlation. For example, in one study (Fazio & Williams, 1986), accessibility was assessed by how quickly individuals rated candidates for US president four months prior to the election. On the day following the election, the same individuals were asked for whom they had voted. For those individuals who had highly accessible attitudes, 80% of the variance in voting behaviour was explained by attitudes whereas, for those with less accessible attitudes, only 44% of the voting behaviour was explained by attitudes.

Interestingly, this theory has not received much criticism but this could be because it is still a relatively recent theory.

2.5 Attitude measurement

2.5.1 Psychometric measurement

Psychometrics and psychological measurement is concerned with quantifying psychological variables accurately, reliably and validly. Cattell (1981) argued that scientific psychology attempts to understand personality and ability as an astronomer attempts to understand the spectrum of an ancient star or a biologist to understand the biochemistry of mammalian functions. Observation and measurement in the natural/physical sciences is accurate, and measurements carried out over time will be reliably consistent with little variation. For example, the measurement of heat upon metal will produce the same results with each measurement over a time i.e. heat causes metal to expand. Kline (1998) lists many examples of different types of psychological test measuring variables such as: verbal ability; manual dexterity; warmth; dominance; depression; motivation; anxiety; exhibitionism; masculinity and conformity to name but a few. These variables contrast somewhat to those measured in the natural sciences because it is not always self-evident what psychological tests measure.

Thurstone (1929, 1931) was one of the first people to apply psychometric methods to measuring attitudes. He believed that effective measurement depended on restricting measurement to a continuum ranging from positive to negative, or favourable to unfavourable. In general, three types of attitude scale are used: Likert, Thurstone and Guttman scales. Likert scales are the most commonly used for the construction of attitude scales because there are methodological problems with the construction of Thurstone and Guttman scales so that "neither measures up to the requirements of scientific measurement" (Kline, 1998, p. 74).

Likert (1932) developed the summated rating scale specifically for the assessment of attitudes. Likert scales consist of a number of statements, which are then rated by respondents using a rating scale typically ranging from strongly disagree to strongly agree. For example, a Likert item may be as follows:

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
|	|	|	|	|
1	2	3	4	5

This type of scaling assumes that the items are linearly related and the scores from all items can be summated to produce a single score that relates to the attitude of interest. The four main characteristics of a summated rating scale are: (i) the scale must consist of multiple items; (ii) each item must represent something that can vary quantitatively, such as attitudes which can vary from positive to negative; (iii) each item should have no 'right answer' unlike a multiple choice test and; (iv) each item must be a statement, so that respondents can rate the statement (Spector, 1992).

Psychometrics and psychological measurement have the difficulty of quantifying psychological variables in terms of accuracy and reliability. This is because psychological tests and measures are based upon the concept of the *true* score. An *observed* score is one that the individual obtains on a test or attitude scale, but this score is of little use on its own, as we cannot know how accurate the score is. Therefore, we need to estimate the size of the error (E) so that we can estimate how inaccurate the observed score may be. The theory of true and error scores (Brown, 1910; Spearman, 1904a, 1904b, 1907, 1910, 1913) forms the basis for attempting to estimate the size of the error, which is done by replication, that is, by measuring observed scores from the same individuals and from different individuals. Therefore, the notion of the *true* score can demonstrate how accurate and reliable a measurement is.

2.5.1.1 Reliability

There are two types of reliability relevant to psychometric scales: test-retest reliability and internal consistency reliability.

Test-retest reliability: A test or scale should yield the same scores for the same group of people on different occasions. A test-retest reliability study involves giving a scale to a group of participants on two separate occasions and then correlating the two sets of scores. A satisfactory correlation for reliability is .70 or above. Two notes of caution are needed to prevent the correlation being artificially raised; (i) the two test sessions must not be held too closely together (at least 6 weeks in between each of the sessions is recommended) and, (ii) the sample must be representative of the population for whom the test has been developed.

Internal consistency reliability: It is an important criterion of any scale that it is highly self-consistent i.e. all items on the scale must consistently measure the same underlying construct. Cronbach's Alpha (Cronbach, 1984) is regarded as the best measure of internal consistency (Kline, 1998) and involves the comparison of the variance of the total scale score with the variances of the individual items. For a scale to demonstrate internal consistency reliability, the alpha should be at least .70. "The higher the reliability, the smaller the error and the greater the relation of the test score to the true score" (Kline, 1986, p.118). It is recommended that the internal consistency of a scale be measured with different types of samples, as this will demonstrate the generalizability of the scale across a range of sample groups.

High reliability in a scale is a pre-requisite of validity (Nunnally & Bernstein, 1994), and is regarded as a necessary, but not a sufficient, condition for validity. That is, a measure can only be valid if it is reliable, but being reliable does not necessarily mean that the measure is valid for the purpose it was intended. Therefore, one cannot take the reliability coefficient to be evidence of validity, and this is probably why reliability has been labelled the "poor man's validity coefficient" (Rozeboom, 1966).

2.5.1.2 Validity

A scale is said to be valid if it measures what it claims to measure (Cronbach, 1984). Unlike reliability, the process of establishing validity is a far more problematic task and evidence of a scale's validity needs to be gathered by a series of studies. There are a number of different types of validity, each being important but it is strongly recommended that they are not sufficient on their own. Therefore, scale developers often assess some, if not all, of the different types of validity. In general, the process of gathering evidence for validity is a necessary but arduous task that depends greatly upon the judgement of the scale developer.

Face validity: Examining the face validity of a scale is to examine whether the scale appears to measure what it is supposed to measure to both the scale administrator and the respondent. Although this can be seen as rather subjective, it should not be overlooked. If a scale lacks face validity, respondents may not take it seriously and their responses would therefore be invalid.

Construct validity: Cronbach and Meehl (1955) acknowledged the difficulty of demonstrating the validity of scales, and introduced the concept of construct validity. Construct validity holds that the variable being measured by the scale (e.g. anxiety to computers) should be viewed as a construct. A set of hypotheses is formulated based upon the literature on the construct and these hypotheses are put to the test. For example, in the case of a new computer anxiety scale the following hypotheses may be put to the test:

- The scale should correlate at least .80 with other computer anxiety scales
- The scale should correlate at least .50 with general anxiety scales such as the STAI
- There should be an inverse correlation between amount of computer experience and computer anxiety

Depending on the hypotheses set, construct validity can include all forms of validity.

Concurrent validity: Concurrent validity involves the correlation of the scale with existing valid scales measuring the *same* construct. For example, a new intelligence test could be correlated with existing valid tests measuring intelligence. Concurrent validity does produce a dilemma for the scale developer. If there is already another valid scale that measures the same construct, then surely the new scale does not serve any practical purpose. Also, the new scale may include items that are very similar to the items on a comparable scale and any correlation between the two would of course, be high. Therefore, the new scale should differ to some degree from existing scales.

Another difficulty is when the new scale measures something that has never been measured before by other scales, then it is difficult to find other comparable scales for a concurrent validity study.

Content validity and predictive validity: These types of validity are usually only applicable to tests used to measure abilities and not to attitude scales.

2.5.2 Idiographic measures of attitudes

An alternative means of measuring attitudes to the psychometric approach detailed above, is the idiographic approach. This involves qualitative methods focusing on individual cases rather than generalisations from large numbers of people (Lincoln and Guba, 1985). Qualitative methods such as focus groups are a useful means of exploring people's attitudes on a specific topic. Focus groups are used a great deal in market research (Morgan 1988) and usually involve a selected group of individuals, e.g. Conservative voters to gain their opinions about a specific topic e.g. views on asylum seekers. The benefits of a focus group are that an understanding can be gained into the influences of individuals' attitudes from everyday life. Often focus groups are used to provide data for developing and piloting quantitative surveys or for discussing the quantitative results of already conducted surveys. Focus groups have advantages over other methods such as observation or one-to-one interviews because the social interaction of the group can provide more insight into the beliefs, attitudes and feelings of those individuals taking part.

2.6 Process of scale development

An *inductive* approach to scale development means that the scale development process begins with a clearly defined construct from which hypotheses can be constructed for the validation of the scale. This contrasts to the *deductive* approach often taken by many scale developers in the area of computer tecnology, which involves administrating items to participants and then taking an exploratory approach to analysing the data. The inductive approach however, involves developing the scale by an iterative process. whereby the development follows a number of major stages *(see Figure 2.8).* The inductive approach is strongly recommended (Spector, 1992) and consequently was the approach taken by the author during this research programme.

Initially, the scale developer needs to define the construct of interest, which can be done by taking an idiographic approach such as consulting experts in the relevant fields. A consultation with experts can enable content areas to be generated, and also begins the process of validation that should be continued throughout the subsequent stages of scale construction. Once content areas have been identified, the items can be generated and the scale can be designed. A pilot of the scale then needs to be carried out with at least 200 respondents. An item analysis can be conducted to (i) establish the internal consistency of the scale, (ii) establish the discriminatory power of the items and (iii) identify the items with a poor reliability coefficient so that they can be discarded. The items on a scale should be able to discriminate between respondents. For example, an attitude scale should be able to discriminate between respondents who have positive attitudes and those who have negative attitudes. A scale that is unable to discriminate between respondents is of no value. To determine the discrimination of a scale, each of the items is correlated with the total score, the higher the correlation coefficient, the more discriminating the item (Rust & Golombok, 1992).

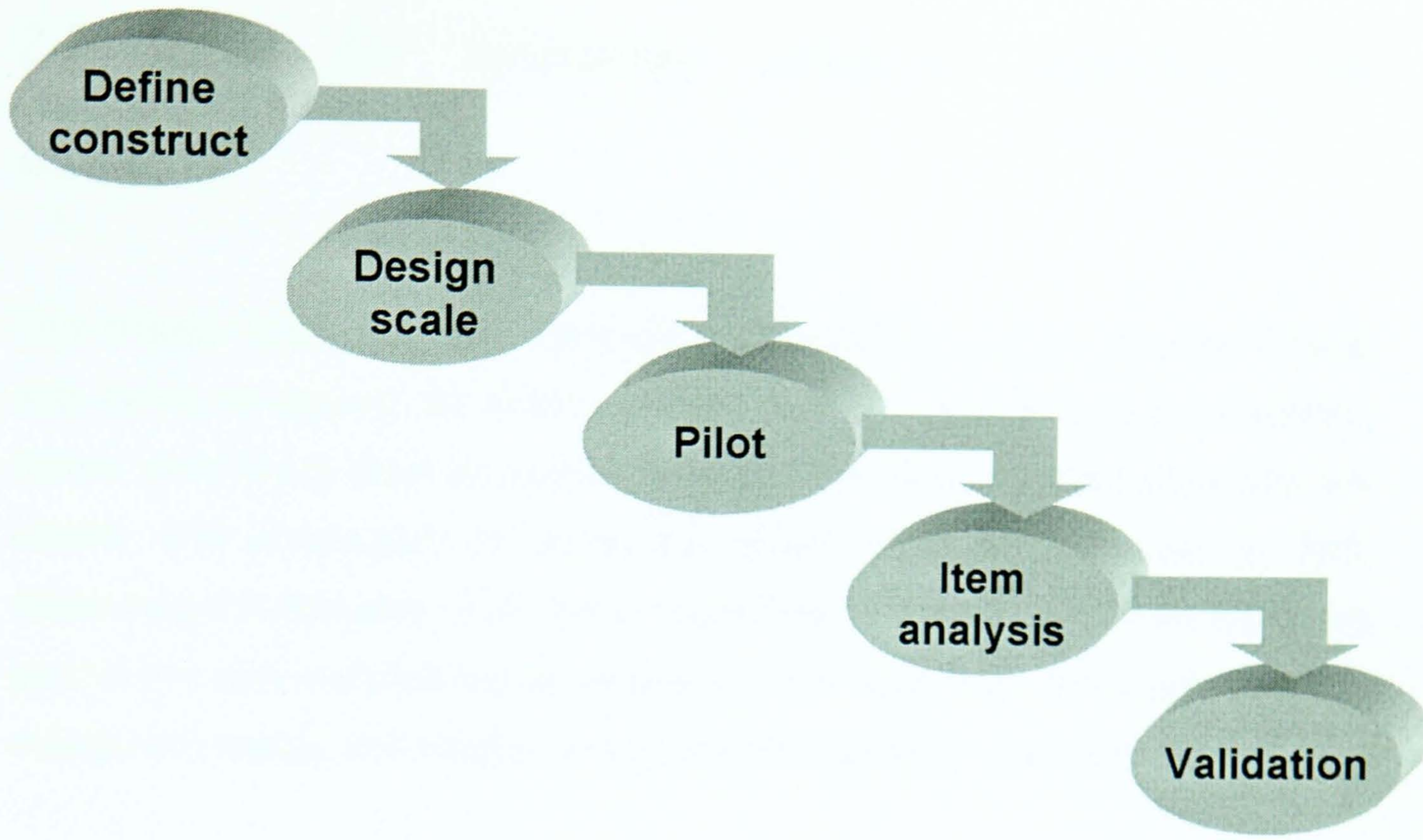


Figure 2.8 The 5 major stages of developing a summated rating scale (Spector, 1992)

Although item analysis may demonstrate that the scale contains a set of homogenous and discriminating items, this is not sufficient and evidence for the validity of the scale must also be given. The validation stage is perhaps the most difficult and depends heavily on the judgement of the scale developer. Kline points out that item analysis is a highly valuable tool for scale construction, particularly in the first step, but it does not "ensure factorial purity" (Kline, 1986, p.133). Therefore, exploratory factor analysis can be used to simplify the often large and complicated correlation matrix into fewer meaningful factors. The scale developer can name these factors (or subscales) depending on the items that have loaded onto these factors.

2.7 Scales for measuring computer attitudes and anxieties

This chapter describes how there are an increasing number of technological aids being developed for elderly people, and has proposed that measuring elders' attitudes to such devices is paramount to ensuring that these aids are usable and acceptable to those for whom they are intended. In fact, measuring the attitudes of all users, regardless of age, would be an important part of the user-centred design process. To ensure that users' attitudes are measured reliably and validly, a psychometric scale should be used.

As yet, there does not appear to be any attitude scales that are suitable, or applicable, to different types of technological devices. However, a plethora of scales have been developed, measuring people's attitudes and anxiety towards computers *(see Table 2.3)* and much research has been carried out to provide evidence that these scales are psychometrically robust. Also, studies have been conducted to test the behavioural validation of these scales to establish whether the scales can be used to predict actual computer usage.

One example, given below, is the Computer Attitudes Scale (CAS) *(see Table 2.3)*, developed by Nickell & Pinto (1986) to measure both positive and negative attitudes towards computers, which has gone through extensive examination in terms of its psychometric properties. Rainer & Miller (1995) conducted a study to assess the instrument's predictive ability, construct validity and reliability. They found that the CAS had acceptable construct validity, reliability, and stability over time and the ability to predict computer usage. Furthermore, Nickell and Pinto (1986) examined the test-retest reliability; predictive validity; concurrent validity; construct validity and the internal reliability of the instrument.

Table 2.3 Scales measuring attitudes and anxiety towards computers

Name of scale	Type	Authors/ developers	Behavioural validation
The Technology Acceptance Model (TAM)	General attitude	Davis (1986, 1989, 1993)	Davis, Bagozzi & Warshaw (1989)
Computer Attitudes Scale (CAS)	General attitude	Nickell & Pinto (1986)	Rainer & Miller (1995)
Computer Attitude Scale (CATT)	General attitude	Dambrot, Watkins -Malek, Silling, Marshall & Garver (1985)	Dambrot, Watkins -Malek, Silling, Marshall & Garver (1985)
Computer Attitude Scale (CAS)	General attitude	Loyd & Gressard (1984)	Loyd & Gressard (1986)
Attitudes Toward Computer Scale (ATC)	General attitude	Raub (1981)	Morrow, Prell & McElroy (1986)
Computer Anxiety Rating Scale (CARS)	Anxiety	Heinssen, Glass & Knight (1987)	Heinssen, Glass & Knight (1987)
Computer Anxiety Index (CAIN)	Anxiety	Maurer (1983)	Jones & Wall (1984)
Computer Anxiety Scale (COMPAS)	Anxiety	Oetting (1983)	Gilroy & Desai (1986)
Computer Aversion Scale (CAVS)	Anxiety	Meier (1988)	Meier (1988)

Several scales listed in the Table above, focus more specifically on anxiety towards computers. Anxiety is a specific type of attitude, and anxiety towards computers is "a generalised phenomenon with an important effect in schools, businesses, government offices and other organisations that use computers" (Dukes, Discenza & Couger, 1989, p.195). Jay (1981) identified that the negative attitude towards technology takes the form of (i) a resistance to talking about computers or even thinking about computers; (ii) the fear or anxiety of computers and (iii) hostile or aggressive thoughts about computers all of which lead to a resistance to using computers.

The multitude of scales developed to measure computer attitudes and anxiety has lead to a large number of studies that have investigated the correlates of computer attitudes. For example, studies have investigated how computer attitudes are affected by variables such as computer experience, maths ability and (perhaps the most investigated), the variables of age and sex. The effect of age and sex upon attitudes to technology was investigated as part of the current research. Therefore, Section 2.8 will give an overview of previous research that has been conducted to investigate the effect of age and sex upon computer attitudes and anxiety.

2.7.1 The Technology Acceptance Model

The Technology Acceptance Model (TAM) *(see Figure 2.9)* was derived from the Theory of Reasoned Action *(see section 2.4)* as it only draws on part of the model and does not include the user's subjective norms. This attitude scale was developed by Davis (1986, 1989, 1993) to predict people's acceptance and use of information technology. The TAM holds that technology acceptance can be predicted from two attitudinal constructs - *perceived ease of use* and *perceived usefulness*. TAM proposes that subsequent computer usage is dependent upon a person's intention to use a computer, as well as the person's attitude regarding the computer's ease of use and usefulness. Davis, Bagozzi & Warshaw (1989) empirically tested the TAM and found that computer use can be predicted from intentions and that the two attitudinal constructs are reliable determinants of intention to use computers. Later on, Davis (1993) simplified the TAM further and removed the factor of behavioural intention and therefore did not include the factor of perceived behavioural intention that was added to create the Theory of Planned Behaviour. However, some researchers (e.g. Hubona & Cheyne, 1994) have adapted TAM with additional variables. Brosnan (1999) studied how the TAM factors of ease of use, usefulness and attitudes predict behavioural intention when combined with the additional factors of computer experience, computer anxiety, self-efficacy and fun. The analysis showed that actual computing behaviour was predicted by behavioural intention, which was in turn affected by perceived usefulness, which was affected by computer anxiety, perceived ease of use and computer experience. Computer anxiety was also affected by self-efficacy and fun.

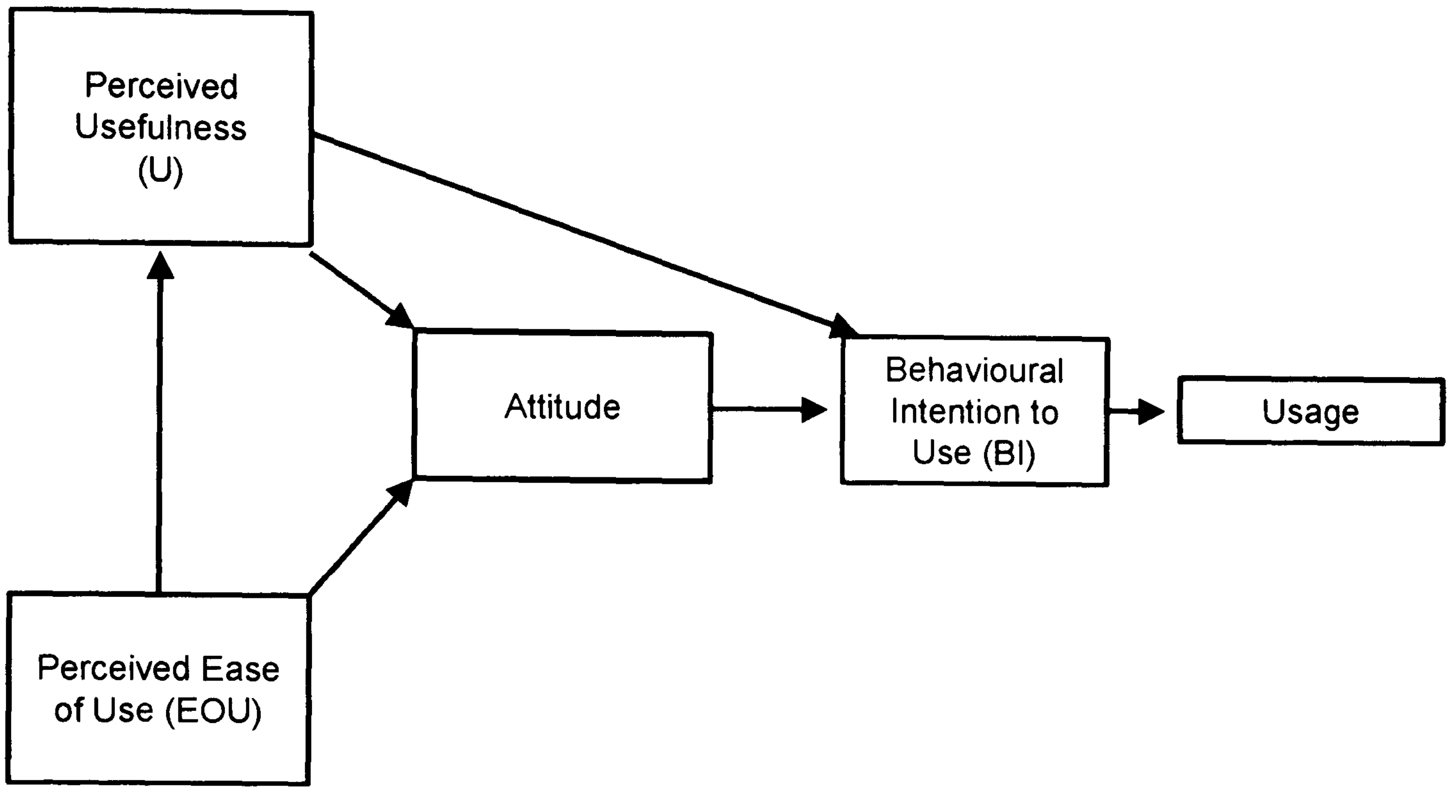


Figure 2.9 Technology acceptance model (TAM) (Davis, 1986)

The TAM was drawn upon during the PAM-AID project, as the factors of perceived usefulness and ease of use were used to question participants about their attitudes towards the walking aid. However, it soon became evident that this was not appropriate for this type of technology, as the TAM had been developed specifically for information technology and may not be applicable for measuring acceptance of other types of technology. It was the limitations of the TAM that motivated the construction of the scale described in the current thesis. This new scale intends to be a comprehensive measure of attitudes, which will include more variables than Davis' model and which can be applied to <u>all</u> types of technology.

The TAM has a particularly interesting format, which influenced the design of the Attitudes to Technology Scale developed during this current research. The TAM has been developed to measure peoples' attitudes to, and acceptance of, different types of software. The scale administrator can insert the name of the software that they wish to measure into each of the individual items. For example, the following item has been adapted for the application WordPerfect but it could easily be adapted for other applications:

"Assuming I had **WordPerfect**, I intend to use it"

The ATS has also taken on this format, so that the name of a specific piece of technology can be inserted into each of the items. Therefore, the ATS is a universal tool that can be applicable to all types of technology.

2.8 Attitudes and performance with computers technology

Using the scales detailed in Table 2.3 above, *ad hoc* measurements of attitude measures of performance have lead to several studies on performance and attitudes. This section focuses on the research to determine the effects of age and sex upon attitudes and anxiety to computers. Furthermore, computer attitude scales have also been used to investigate the emerging phenomenon of technophobia[6]. Research focusing more specifically on anxiety towards computers has shown that there are a large number of individuals who possess a fear of technology.

2.8.1 Effect of age on attitudes and anxiety towards computer technology

Research has found that the elderly are no less interested in learning about computers and other new technologies. In a group of people aged 58 to 91

[6] See Glossary

years of age, the main reason for not using computers (and the WWW) was lack of access and training (Morrell et al., 1998). Indeed, Rogers (1996) found that those older people, who did not use ATMs, claimed that they would use them if they received proper instruction. At best, banks only provide a leaflet explaining how to use an ATM, and the results of this study suggests that the lack of training means that many elders are unsuccessful when using ATMs. When specialised training programmes have been implemented, higher rates of assistive device usage (78%) among elders are reported (Bynam & Rogers, 1987).

Although older adults can perform search tasks as well as young people; the strategies used by older people are often less efficient. Overall, studies have found that older people take longer to complete computer based exercises than younger people (Charness, Scuman & Boritz, 1992; Czaja, Hammond, Blascovich & Swede, 1989) make more errors in text editing exercises (Gomez, Egan, & Bowers, 1989) and require more help (Elias, Elias, Robbins & Gage, 1987). It is possible that the slower performance times exhibited by older people may reflect slower processing of information, but also could indicate greater caution in performing tasks. Adams and Thieben (1991) stated that the slower times exhibited by elders when using an ATM machine was more likely due to caution than proficiency level. They report that elders prefer to take longer than risk the possibility of making errors. These researchers identified that elders' performance can be significantly improved by clarifying the nature of the task using 'definitions training' and by clarifying the sequence of steps required through 'sequence training'. Interestingly, those elders whose performance improved after training were also more likely to state that they now felt at ease with using an ATM and were more likely to use an ATM in the future. This suggests that adequate training can indeed alter people's attitudes, making them more positive and influence future use of that technology.

Research investigating whether age is a correlate of attitudes towards computers and computer anxiety is limited, and has had mixed results. Some studies have found that younger people have more positive attitudes towards computers than older people do (e.g. Kelley & Charness, 1995; Laguna & Babcock, 1997; Loyd & Gressard, 1984) while others found no age differences (Gilroy & Desai, 1986; Massoud, 1991). However, many of these studies have used samples with limited age ranges (e.g. Gilroy & Desai, 1986; Lloyd & Gressard, 1984, Massoud, 1991) and this challenges the validity of their results. Some research has found that older people were more uncomfortable using a library catalogue system compared to the younger users (Rousseau & Rogers, 1998) and others found that elderly people reported being intimidated by ATMs (van Schaik, Petrie, Kirkby & Orpe, 1994). Temple and Gavillet (1990), found that when members of a Senior Centre were offered the chance to take part in a computer course designed to teach the basics of computer literacy, elders with significantly higher levels of computer anxiety refused to participate compared to those who decided to attend the course. The implications of this are that negative attitudes and anxiety towards computers inhibit elders' uptake of computers.

Some studies however, have failed to find any age differences (Gilroy & Desai, 1986; Massoud, 1991). Dyck & Smither (1994) found that even though the older adults (55 years+) had less computer experience and lower computer confidence than the younger adults (30 years and under), the elders had lower computer anxiety, had more positive attitudes towards computers and had more liking for computers than younger adults. In this study, even though the older group had less experience, they had more positive attitudes and less computer anxiety. The researchers suggested that there is less pressure on older people than younger people to be computer proficient, thus reducing anxiety among older people and increasing pressure on the young. This suggests that cultural attitudes could account for any differences found between the age groups. Indeed, Ryan et al., (1992) found that young and old people have shown biased attitudes, *both* expecting older people to be less computer proficient than young people.

Furthermore, elderly people often have less experience with computers and other technologies than younger people and overall, studies have shown that those with greater experience are generally less anxious. However, as with all correlations there is a problem of assigning causation. It is not possible to state that greater experience leads to less anxiety or more positive attitudes because it is equally possible that less anxiety or positive attitudes leads to greater experience. In fact, some studies have found that increasing computer experience does not lead to a reduction in computer anxiety (Gilroy & Desai, 1986; McInerney et al., 1994) and in one study it was shown to increase the level of anxiety (Carlson & Wright, 1993).

2.8.2 Effect of sex on attitudes and anxiety towards computer technology

Although some studies have not found any sex differences in attitudes towards computers (Heinssen, Glass & Knight, 1987; Loyd & Gressard, 1984), other studies have found that females tend to be more anxious about computers (Gilroy & Desai, 1986; Massoud, 1991; Morrow, Prell & McEllroy, 1986; Raub, 1981), and hold more negative attitudes towards computers (Dambrot, Watkins-Malek, Marc Silling, Marshall & Garner, 1985; Popovitch, Hyde & Zakrajsek, 1987; Temple & Lips, 1989) than males. These results are consistent across all ages, from school children (Felter 1985; Sherman, 1980) and undergraduate students (Dambrot et al., 1985) to managers and professionals (Bozionelos, 1996) and also among older adults (Dyck & Smither, 1994). Wilder, Mackie & Cooper (1985) conducted a large survey with 1600 students from Nursery (pre-school) up to 12 years of age. Overall, a higher number of males (of all ages) than females (of all ages) liked computers. Indeed, these attitude differences between males and females have been fairly consistent across a number of different countries. Comparisons between the US and Europe and have shown similar levels of computer attitudes for both populations. Interestingly, this has been the case for both Western Europe (Leutner & Weinsier, 1994; Sensales & Greenfield, 1995) and Eastern Europe (Martin, Heller & Mahmoud, 1992).

Sex differences in computer attitudes and anxiety are also reflected within the domain of higher education too. Even though there has been an increase in women applicants to other 'male dominated' subjects, such as engineering (an annual rise of 4 to 8%, EOC annual population statistics), female applications for computer science courses in the UK are declining, reducing from 25% in 1979 to 16% in 1997 (UCAS, 1997). In support of this, Lightbody and Durndell (1996) reported that female participation is reducing in computer science degrees whilst increasing in 'male dominated' subjects at degree level.

Some research has focused on biological factors to explain the differences between males and females. Maccoby & Jacklin (1974) did a review of studies and supported the contention that males have better spatial ability and females better linguistic ability. Some researchers dismiss this as such differences (when they are found) can be trained away within half an hour (Caplan, MacPhearson & Tobin 1985). Differences in brain lateralisation have also been put forward as a biological explanation but again, evidence for this has been shown to be weak. In contrast, there has been more evidence in support of cultural influences to explain the differences between the sexes.

It has been proposed that the masculinization of technology that has taken place in the West (Chivers, 1987; Hawkins, 1985) has influenced the differences that are prevalent between males and females in terms of their attitudes and anxieties towards computers. Indeed, *both* sexes rate IT as masculine (Archer & Macrae, 1991) and perceive males to be more proficient with computers than females (Williams et al., 1993). Levin & Gordon (1989, p.86) highlight that sex differences in attitudes are highly dependent on experience (as with age differences and attitudes). They conclude that "the male-directed socialisation process might contribute to a self-fulfilling prophecy among boys: they receive a greater amount of positive reinforcement to work with computers, and are provided with greater computer exposure, which gives them greater confidence in their ability to succeed with this new medium".

In an attempt to examine the social and cultural influences upon sex differences in computer attitudes and anxieties, Brosnan & Lee (1998) compared samples from the UK and Hong Kong (HK). In some ways HK and the UK have some similar social factors, for instance, they have very similar educational systems, both have English as their first language and at the time of the study, they were under the same political jurisdiction. Chinese influences in HK are also prevalent and the sample in HK was oriental in origin. The UK sample reported more computer-related experience, less anxiety and more positive attitudes towards computers. However, in the UK sample, there were no differences in computer anxiety between the sexes but males were more positive in their attitudes towards computers than females. Interestingly, for the HK sample there were no sex differences in computer attitudes, but males had greater computer anxiety than females. This is the first sample where males have reported having more anxiety towards computers than females, even though the HK males reported more computer experience than the females. Interestingly, greater experience was related to increased anxiety among HK males whereas greater experience was related to less anxiety among UK females. Further analysis showed that HK males had more anxiety when *anticipating* using computers.

The unexpected findings of this study are similar to the findings of a study by Weil and Rosen (1995) who found that out of 23 countries, Japan was the only country out of the 23 that combined 'high technophobia with moderate experience' (p. 110). Brosnan & Lee (1998) suggest that perhaps the "Oriental cultures of HK and Japan share cultural factors that undermine the traditional association between experience and technophobia found in Western cultures" (p.575). In other words, it could be that some cultures differ in the extent to which they have masculinized technology. They suggest that some further research be carried out to investigate the role of cultural factors upon the sex differences in attitudes and anxiety towards technology. However, there may be problems with comparing different cultures if the hardware availability differs greatly between the countries, as found by Omar (1992) who compared the US with Kuwait.

Researchers have now begun to examine the role of psychological gender, a concept that originates from sex role identity theory (Bem, 1974). The theory purports that individuals have varying levels of psychological masculinity and femininity, those (males and females) higher in masculinity are more likely to engage in masculine technology related behaviour (Bem, 1993). Those who are not gender-stereotyped are less likely to engage in behaviours that are stereotyped in their culture. High masculinity has been associated with more positive attitudes in females, and with confidence in completing a computer science course in both males and females (Oggletree & Williams, 1990). Colley, Gale & Harris (1994) found that males had lower computer anxiety, higher confidence and greater liking for computers than females and when the effects for prior experience and gender stereotyping were removed, no significant sex differences remained. Thus, it would seem that "computer anxiety is not a culture-free construct" (Weil & Rosen, 1995).

2.8.3 Technophobia

"Technostress[7] is a modern disease of adaption caused by an inability to cope with the new computer technologies in a healthy manner" (Brod, 1984).

Technology is increasing in the modern world and consequently, it is becoming ever more difficult for people to avoid using technology in everyday life. However, there are individuals who go to great lengths to avoid using computers and other computer-based technologies because they are anxious about using them and/or hold negative attitudes towards them. These individuals who have a negative attitudinal response to technology have been named as *technophobes* or *computerphobes*. Although this may not be a phobia in a classic sense, some individuals have reported physical responses typical of phobias such as heart palpitations, nausea, dizziness and high blood pressure. For others, they may feel uncomfortable using technology and will avoid using it where possible but if they have to use it, they may adopt strategies to relieve some of their anxiety.

It is estimated that technophobia is experienced by one quarter to one third of the population in the industrial world (Brosnan & Davidson, 1994). In a survey conducted by Wienburg & Fuerust (1984), 25% of respondents suffered from mild technophobia, of whom, 5% were classed as severely technophobic, that is, experiencing the physical symptoms associated with phobic reactions such as nausea and dizziness. Other studies have produced consistent results, finding that the proportion of technophobes varied very little, with one quarter to one third of the sample being technophobic (Lightbody & Durndell, 1994). In a sample of college students, as much as 50% of the sample were technophobic (Rosen & Maguire, 1990).

[7] The terms technostress and technophobia are used interchangeably. See Glossary for a definition.

Rosen and Weil (1990) state that computer anxiety is not just about current interactions with computers or computer-related technology but also future interactions. Individuals may have specific negative cognitions, or self-critical internal dialogues, during actual computer interaction and when contemplating future interaction. Thus, computer anxiety is the "fear of impending interaction with a computer that is disproportionate to the actual threat presented by the computer" (Howard, 1986). Computer anxiety refers to irrational fears towards computers such as hostility; apprehension; intimidation; worries about being embarrassed or looking stupid and worries about damaging equipment. Computer anxiety does not include rational fears such as job displacement. Weil, Rosen & Sears (1987) suggested that there are 3 types of computerphobes (i) uncomfortable users are people who experience mild anxiety when using computers, (ii) cognitive computerphobes have a negative internal dialogue, saying things such as "everybody else knows how to work this computer but I don't" and, "if I touch it, I'll break it" and, (iii) anxious computerphobes who experience the physical symptoms associated with an acute anxiety disorder.

The author has spoken to an individual who could be classed as an uncomfortable user. This 65-year-old man would only go to an ATM (cash machine) at 7:00 am on a Sunday morning when he could be sure other people would not be using the machine. When questioned, he admitted that using an ATM made him feel 'uncomfortable' and this mild anxiety was exacerbated if others were waiting in a queue behind him. An ATM uses simple text menus as its interaction style, it does not require users to remember difficult operations and the feedback is immediate, indicating whether the user has gone to the right menu. Indeed, the ATM interface is excellent for novice users but this could be part of the problem. If a technology is thought to be easy to use then expectation is high of users' ability to operate the device. When this is combined with the time pressures that such a technology imposes, the user is expected to operate the system both fast and effectively so that the next person can use it. Similarly, some people may avoid other public terminals on the same basis.

2.8.3.1 Technophobia and the design of technology

"The same technology that simplifies life by providing more functions in each device also complicates life by making the device harder to learn, harder to use. This is the paradox of technology" (Norman, 1990, p31).

Norman (1995) describes how technology is often designed with the intention to make life easier for individuals but as complexities are gradually added, users begin to find the technology more difficult and frustrating to use and it no longer makes life easier. Norman refers to this as the *paradox of technology*. One example he gives is that of a digital watch which has many more functions than the original analogue version. For example, a digital watch may have a calculator, alarms, stop watch, facilities to check different time zones, date and so on, thus making it far more complicated than a watch that just tells the time. Since it is only possible to fit a certain amount of buttons on a multifunctional digital watch, this means that each button needs to have more than one function assigned to it and there is no longer "one-to-one matching" between function and control. We can also see this in other technologies such as computers and mobile phones. Problems for usability arise when there are more functions than the number of controls required for operating the device. The solution to providing the user with a device that is multifunctional but remains easy to learn and use, depends upon the application of good design principles.

Norman suggests that people experience anxiety towards technology because computers and computer-based technologies are becoming increasingly more complex and difficult to use. Where technology is driven by technologists and not driven by users this will inevitable lead to poor design and poor usability. Norman emphasises the importance of focusing on the user and involving the user throughout the development of technology.

Vincente and Williams (1988) proposed a model that the main purpose of design should be to eliminate the mismatch between user capabilities and task demands. A mismatch occurs when a computer task extends beyond the capabilities of the user. Egon and Gomez (1985) also argued that the skills of the user should be mapped to the requirements of the task. Thus, the involvement of users in the design process is essential. In the cases where users have not been involved this often leads to reluctance to using the device (Newman, 1989).

2.9 User-centred design

2.9.1 General features of user-centred design

User-centred design means that potential users are involved in every stage of the design process, ensuring that as far as possible, the design meets the needs of users. It is essential that users be identified in terms of their characteristics, the tasks that they will be performing with the technology and the context(s) or environment(s) in which they will be using the technology. Involving users throughout the design process is possible if the design process is iterative. A number of approaches (e.g. the waterfall design lifecycle) have been put forward aimed at making users central to the design process. This should begin with a user requirements analysis whereby the needs and requirements of the user are identified by interviews, focus groups and observation. Designs are then evaluated for their usability. Bennet (1984) identified four components of usability:

- Learnability or *ease of learning* of the system
- Throughput or *ease of use* of the system
- *Flexibility* of the system to adapt to changes in task and environment
- *Attitude* i.e. the positive attitudes of users to the system

Therefore usability is concerned with making sure the system is easy to learn and easy to use, and that the system is flexible to changing tasks and environments as well as being concerned with the users' attitude towards the system.

Petrie (1997) states, "the development process is a balance between the technological possibilities and the users' needs" (p. 11). User-centred design, participatory design and usability engineering (Dix, Finlay, Abowd, & Beale, 1993; Nielsen, 1993; Norman, 1986; Schuler & Namioka, 1993) propound a number of different methodologies for eliciting and gathering user requirements. A prototype can be developed based on the user requirements and initial design decisions, which is then observed in use and evaluated with potential users. The evaluation studies allow the developers to establish the usability of the technology and to establish whether it meets the requirements and capabilities of the intended users. The results from such studies inform the design decisions for further prototypes and bring to light any additional user requirements. This design cycle is iterative, meaning that further prototypes can be developed and evaluated.

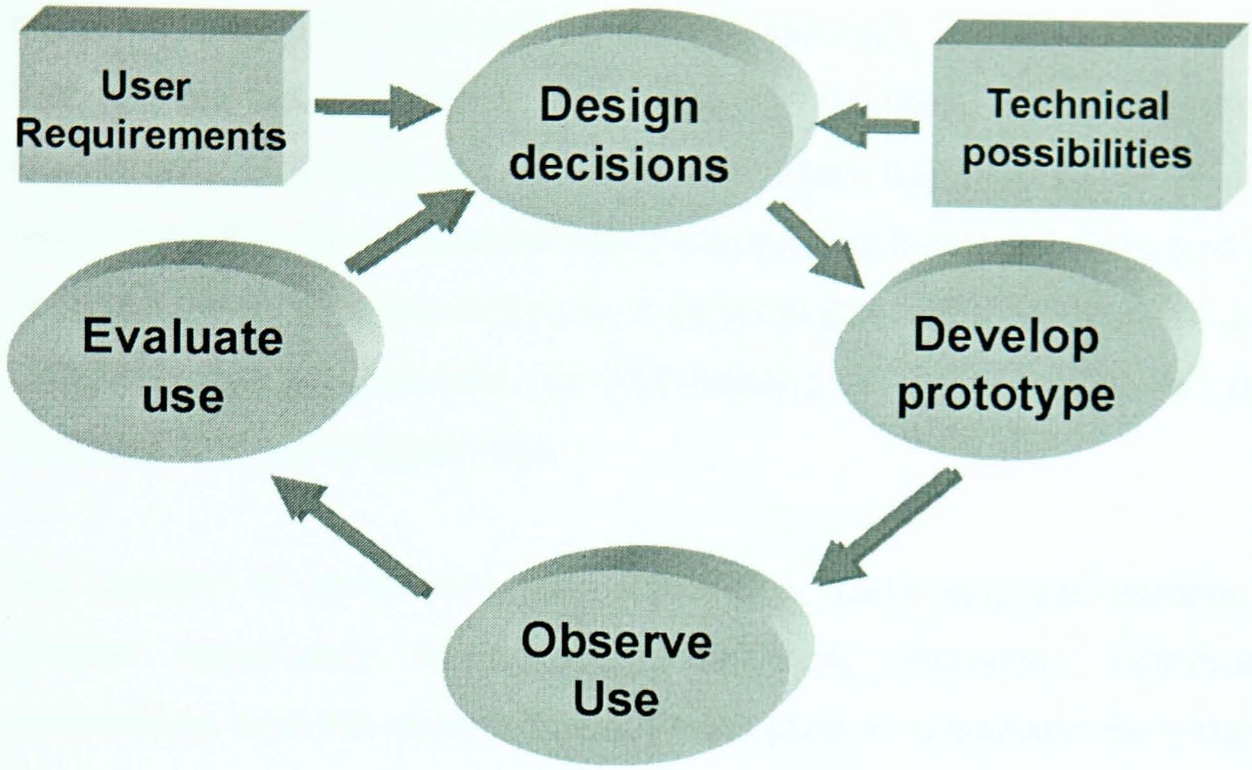


Figure 2.10 Iterative design cycle (Petrie, Johnson, Michel & Jansson, 1994)

Figure 2.10 illustrates the iterative process of user-centred design. The design decisions are initially influenced by the requirements of the user as well as the technical possibilities that are available. As prototypes are developed and evaluated by users, the results of evaluations can inform the design decisions. This cycle is necessary to ensure that the design of technology meets the needs of all users, but it can be particularly important for those user groups with special needs, such as the disabled and elderly.

2.9.2 Accessibility and 'universal design'

"Providing accessibility means removing barriers that prevent people with disabilities from participating in substantial life activities, including the use of services, products, and information" (Bergman & Johnson, 1995).

In other words, *accessibility* is about ensuring that disabled people have equal opportunity to use and obtain the services, products and information that are readily available to their able-bodied peers. One example where accessibility has been incorporated into public buildings is the provision of ramps and lifts, so wheelchair users can access these buildings and use the services within. Another example of accessibility is the provision of sub-titles with television programmes, so that hearing impaired people can read the dialogue of many programmes.

The advent of computers has provided visually impaired people with a greater opportunity to access information, increased communication possibilities and job opportunities. Information in electronic form has many advantages for visually impaired people. For instance, electronic processing allows the visually impaired user to store large amounts of information, as well as making this information more manageable and useable. Information can also be scanned into the computer from other sources, searching for information can be quick and communication possibilities are increased using the Internet. Furthermore, electronic information is used by both visually impaired and sighted people, and has enabled improved communication possibilities between them.

However, since the introduction of graphical user interfaces (GUIs), computers have become more difficult for visually impaired people to access (Petrie and Gill, 1993). Initially, computers operated using the DOS operating system or similar command line systems, allowed visually impaired people to access the information fairly easily using speech synthesisers, screen readers and electronic braille. GUIs have made computers more usable for sighted people because the user can directly manipulate the pictorial representations (icons) on the screen with the mouse pointer. For example, if a user wishes to delete a file they can drag that file, with the help of the pointer, across the desktop and place it into the trash can with ease and speed. This of course requires a certain level of vision and hand-eye coordination and therefore means that visually impaired people are unable to exploit the advantages of GUIs. Assistive technology (software or hardware) has been designed to help overcome the problems that GUIs pose to visually impaired computer users (Petrie, O'Neill & Colwell, 2002). Although assistive technology has made GUIs more accessible, assistive technology still has difficulty enabling access to certain types of information such as poorly designed web pages (Petrie, O'Neill & Colwell, 2002).

There are many examples where accessibility is poor for some disabled people, for instance, public transport is still largely inaccessible to wheelchair users and other mobility impaired people. However, in many instances improving access for disabled people can also be advantageous for able-bodied people. For example, curb ramps common on street corners was initially introduced for wheelchair access but now benefit people with pushchairs and elderly people with shopping trolleys. Another example is the speech messages heard when a lift arrives at the next floor, this was initially designed to help visually impaired people, but this auditory signal also alerts sighted people. This lead to the term "universal design" (Vanderheiden, 1990) usually referred to in Europe as "Design for All" (Stephanidis, et al., 1998), which means that special design for disabled people can in fact have benefits for everyone. Increasingly, assistive technologies are being designed and developed to enable elders to regain or sustain their functioning. A good example of this is the development of the PAM-AID walking aid, which intends to provide frail visually impaired elders with increased independent mobility. Although initially developed for elderly visually impaired people, the PAM-AID walking aid has shown potential to be a very effective rehabilitation aid for people of all ages with different disabling illnesses that impair mobility e.g. those with Parkinson's disease, Multiple Sclerosis and Cerebral Palsy to name but a few. Woodhuysen (1993) calls for transgenerational design, which is where the design for older people also meets the needs of younger people. A good example is the BT large button telephone, which was specifically designed for elderly people but proved to be a successful product for consumers of all ages.

2.10 Summary

This chapter has presented some of the research that has been conducted in each of the fields relevant to the research in this thesis. The demographic picture given by the statistics shows that the population of Europe and other Western societies, is one of an ageing society. People are living longer due to improved health and hygiene and advances in modern medicine. Since the likelihood of disability increases with age, it is also expected that the numbers of disabled people will also increase. Furthermore, there has been a decline in the numbers of working adults and younger people, which has prompted some speculators to suggest that there is a demographic crisis, whereby society may not be able to provide the financial and human resources needed to support the dependent groups within the population.

Consequently, technological innovations are being developed to help improve the quality of life for many elderly people by assisting them in everyday tasks, or by enabling them better communication with others. Such innovations should also increase the independence of elderly people thus relieving the pressure on limited human and financial resources. One such innovative technology is the PAM-AID robotic walking aid, which was developed to enable frail visually impaired elders to maintain independent mobility, whilst also relieving some of the burden upon their carers. However, the studies conducted with elderly people to establish their requirements for the device and to evaluate its usability, highlighted an inconsistency among their attitudes that suggested that they would not accept or use PAM-AID.

One of the main problems with technological aids designed for the elderly is that they are often not accepted or used by this user group. Research has shown that between 50% and 60% of elderly people will discard, not use or under-utilise the assistive devices that they are given, and that the use of technological aids decreases with increasing age. It is apparent that, the attitudes and perceptions of elders towards technology, must be taken into account when designing and developing new technology for this user group, in order to maximise the potential of acceptance and use.

This chapter has proposed that measuring attitudes to technology can improve design and lead to more useable technological innovations. This not only applies to elderly and disabled users but to all user groups. Attitudes can be measured using psychometric scales, which enable a valid and reliable measurement of attitudes. Currently, there are no scales available that can be applicable to different types of technology. The Technology Acceptance Model was designed specifically for software and computers, and is not applicable to technologies such as PAM-AID.

Although there is a plethora of scales measuring people's attitudes and anxiety towards computers, these are not suitable for measuring other types of technology and many of these scales have only been validated with student populations. The wealth of research that has been generated using computer attitude/anxiety scales, has demonstrated that scales of this type can be useful for identifying the differences between different groups, such as the differences between age groups and the sexes. The research indicates that in general, older people have more anxiety and more negative attitudes toward computers than younger people do. However, it seems that the way that computers are introduced to elders and the training that they receive can influence their attitudes, making them more positive and less anxious. Research has also shown that females tend to have more negative attitudes and anxiety towards computers than males, but the evidence is growing in support for the theory that this is as a result of cultural factors. So far, there appears to be no research investigating the effect of sex and age upon attitudes towards other types of technology and so the ATS could also be used to build this body of research.

The current research involves the development of the ATS, a scale that could be applicable to different types of technology, and for different user populations. Therefore, this chapter has also outlined the process of developing a psychometric scale for measuring attitudes, and the number of different stages that were followed during the development of the ATS. The most important aspect of scale construction is ensuring that the scale is reliable and valid. Reliability is an important criterion of any scale, and there are two types relevant to psychometric scales, (i) test-retest reliability and (ii) internal consistency reliability. However, reliability does not imply validity, and one must demonstrate that a scale is valid by providing adequate evidence. There are many different types of validity, some of which were detailed in this chapter, but not all are relevant for attitude scales. It is important for the scale developer to conduct studies to show that the scale measures what it claims to measure, often a problematic task that relies on the judgement of the scale developer.

The ATS is a scale that could be used to measure the attitudes and anxiety of all users towards all types of technology. Norman (1995) links technophobia and negative attitudes with poor design and poor usability. He proposes that people experience anxiety with technology because computer-based technologies are becoming increasingly more complex and difficult to use. This often results from the design of technology being driven by technologists and not driven by user requirements. Thus the design of technology must be user-centred.

The process of user-centred design is illustrated in the model of the iterative design cycle (Petrie, Johnson, Michel & Jansson, 1994) and this process is particularly important when the user group has specific needs, such as the elderly and disabled. Since user-centred design is a process that attempts to match the requirements of the user, with the functional specification, one would hope that users would be more likely to accept and use a technology that has been developed and tailored to their needs. However, this is not always the case and as stated above, many useful technologies are not being used or adopted by elders, even though they would clearly benefit from using such devices. It is important to understand why technology is not used or accepted by users. Attitude theory purports that one's intention to use is an indicator of actual use, and so attitudes and perceptions of users are important variables to consider when designing technology, and when introducing technology to users. Indeed, measuring attitudes of potential users should be an integral part of the user-centred design process, so that developers can predict the future use of and acceptance of technology by certain user groups.

Chapter 3

Establishing the user requirements for PAM-AID

3.1 Introduction

This chapter reports on the initial user requirements interviews conducted with 38 frail and elderly people and 12 professional carers of elders.

The overall aims of the study were three-fold:

(i) To increase our knowledge of the people that may use PAM-AID, that is, to find out the advantages and disadvantages of the walking aid(s) that elders currently use, to establish their current levels of mobility; to see the type of residence that elders live in and hence the environments in which PAM-AID would be used.

(ii) To establish the requirements of this user group with regards a walking aid such as PAM-AID, that is, how would they like to operate it and what feedback they would like regarding their environment.

(iii) To make tentative investigations regarding users' attitudes towards PAM-AID.

During the interviews, participants were told that there could be a number of possible input and output methods for PAM-AID and they were asked to give their opinions regarding these interface options:

- Voice input
- Input switches
- Speech output
- Non-speech sound output
- Two modes of operation (automatic, manual)

Apart from the elicitation of user requirements, these interviews also investigated whether carers thought that users would be embarrassed about certain features of PAM-AID, particularly as *embarrassment* may hinder future use of technology and technology acceptance by elders in public places (Gitlin et al., 1996).

The results from this study were used to inform the design and development of the first PAM-AID prototype. Also, the study included some tentative investigative questions to establish whether potential users of PAM-AID thought that it was a useful idea and whether they would like to use the walking aid.

3.2 Method

3.2.1 Participants

3.2.1.1 Elders

38 elderly participants took part in this study, 25 females and 13 males. The unequal gender balance in this sample is due to the availability of men and women for this study. However, this sample is generally reflective of the unequal women to men ratio in the elderly population. For instance, in the UK, women have a higher life expectancy then men. Women can live for an average 79.7 years whereas men live for an average 74.4 years (Help the Aged, 1991). Participants' ages ranged between 68 and 92 years of age,

giving a mean age of 81.76 years. 18 participants were partially sighted, 13 blind and seven sighted.

Twenty-four of the participants lived in residential homes for the elderly, where they lived with the 24-hour supervision of professional carers. Five residential homes took part in this study.

Two participants lived in sheltered accommodation with an on-call warden, where each resident lived in a small private flat. One sheltered accommodation took part in this study.

Twelve participants lived in their own homes, receiving home help and social support.

All participants in this study were classified as frail because they were unable to walk without a walking aid. Table 3.1 shows participants' primary walking aid although participants may occasionally use another type of walking aid. The table also shows that all participants used fixed rails within their home for support and guidance. Twelve participants used a Zimmer frame as their primary walking aid, 10 participants used a frame with wheels and two used a frame without wheels.

15 participants used a walking stick as their primary walking aid, three of which used two walking sticks. One participant had the constant support and guidance from his wife. Nine participants used navigational aids such as the long cane and symbol cane.

Table 3.1 Primary mobility aids used by participants (n = 38)

Primary mobility aid	Blind	Partially sighted	Sighted
Frame with wheels	-	10	3
Frame without wheels	-	2	-
Walking stick (1)	3	6	3
Walking sticks (2)	-	-	3
Guide/symbol cane and other support (fixed rails or carer)	9	-	-
Human guide/support only	1	-	-
No walking aid	-	-	-
Fixed rails	13	18	7
Total	13	18	7

3.2.1.2 Carers

Interviews were conducted with 12 professional carers of frail and elderly people at their place of work, nine of the carers were female and three were male. Their ages ranged between 35 and 70 years of age, giving a mean age of 55.2 years.

Interviews were conducted in the UK and Ireland The 12 participants that took part in this study worked as Carers in residential homes for elderly visually impaired people, where residents received 24-hour supervision. These participants worked a combination of day and night shifts on any day of the week. Four participants had managerial and supervisory responsibilities as well as their duties caring for residents, and four had nursing qualifications.

The two remaining participants who took part in this study worked for the National Council for the Blind of Ireland (NCBI), one being a social worker and the other a counsellor for elderly visually impaired people. Their place of work was the NCBI but they visited visually impaired people living in residential homes. Even though their roles differed from those participants who worked in residential homes, these two participants were still involved in the caring profession and had valuable experience working with elderly visually impaired people.

3.2.2 Measures

An interview schedule *(Appendix E)* of questions was developed for the user requirements study, in order to elicit their requirements for the PAM-AID walking aid. The interview schedule for elders had additional sections to specifically address elders' existing mobility aids and levels of mobility. However, sections (iii) and (iv) remained the same as that used with the carers.

The interview schedule consisted of a total of 51 questions, which were grouped under the following sections:

(i) Current Mobility/Support Aids

(ii) Current Level of Mobility
- Within the home/place of residence
- Outside of the home/place of residence

(iii) User Requirements for PAM-AID *(same as carers)*
- Input
- Output
- Physical design/structure
- Mode of operation
- Level of technology acceptance

(iv) Participant's Personal Data

To maximise information elicitation, the interview schedule included open-ended questions to facilitate a discussion between interviewer and participants. Some questions required participants to give a rating on a 5-point Likert item.

3.2.3 Procedure

All interviews were conducted on an individual basis, in a quiet room free from any distractions. These rooms were in the elders' own place of residence or carers' place of work.

First, the interviewer read a brief description of the PAM-AID walking aid to the participant. Using simple everyday language, the description explained the basic functionality of PAM-AID e.g. the two modes of operation, ability to detect obstacles and the use of speech output. The description was followed by one of two scenarios to place the PAM-AID device into an identifiable context for participants.

Total interview time lasted between 40 to 50 minutes each, including the time to read the description and scenarios. Participants were reassured that the interviews would be completely confidential. The interviewer recorded participants' ratings and tape-recorded the interviews to allow for more detailed notes to be taken at a later stage.

3.3 Results and discussion

The interviews with potential end users and carers of elderly people have yielded a wealth of information regarding the user requirements for the PAM-AID walking aid (O'Neill, Petrie, Lacey, Katevas, Karlson, Engelbrektsson, Gallagher, Hunter, & Zoldan, 1998). The study gathered information regarding certain characteristics of this user group i.e. their current use of mobility aids (including positive and negative aspects of the aid); their current level of mobility within and outside of the home and any worries they have about their current level mobility. Furthermore, the comprehensive interview schedule ensured that user requirements were elicited regarding all aspects of PAM-AID. That is, regarding method of input; method of output; physical design; mode of operation; and level of technology acceptance.

A number of questions on the interview schedule required participants to give a rating on a 5-point rating item (see below) and gathered mean ratings (M) from participants and these are reported in this section together with the standard deviations and any comments given by participants. Throughout the results section the elders' mean ratings are given prominence but carers' ratings are also reported for comparative purposes.

5-point rating item used

1	2	3	4	5
Very Low	Fairly Low	Moderate	Fairly High	Very High

3.3.1 Methodological issues

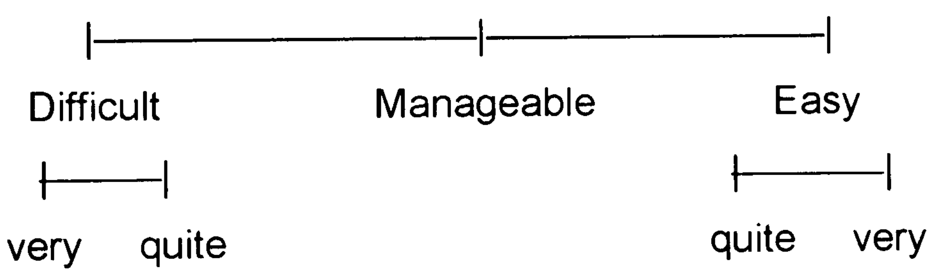
Although this study produced useful and informative data, a number of methodological issues arose that should be noted, particularly as these would have an impact upon future studies with elderly participants. In order to gather useful opinions and ratings from participants, the researcher needed to get across to them the concept of the PAM-AID walking aid. Since there was no prototype to show them, the researcher decided that a scenario-based methodology would help to provide participants build up a mental model of the device and the context in which they would use it. For some participants this did help them to understand certain aspects of the walking aid but for others, the scenario method was insufficient in helping them to build a mental model of the PAM-AID walking aid. The main difficulties were that the elderly participants' experience and knowledge of technology was extremely limited and in some cases non-existent. Furthermore, the PAM-AID walking aid is an innovative device and there were no comparative devices for participants to draw upon. In many cases, a Wizard of Oz technique is employed (Preece, Rogers, Sharp, Benyon, Holland & Carey, 1994) whereby the system or device can be tested before it is actually built. This is where the user is presented with a system or device that appears to be working but in actual fact, a human (the Wizard) is controlling the system unbeknown to the user. This was a particularly difficult thing to do with PAM-AID, as it was a unique device that included highly sophisticated robotics and sensors and a mock-up version was just not possible. Therefore, the first evaluation study (reported in Chapter 4) would be particularly important, since it would be the first time that potential users could experience the functionality of PAM-AID first hand.

Furthermore, during the study, a number of problems were highlighted regarding the use of 5-point rating scales with elderly people. It became apparent that the elderly participants (both sighted and visually impaired) had little or no experience of rating scales and the researcher had to explain how rating scales worked. Due to limited experience, elders may have difficulty visualising scales, particularly so if they are both elderly and visually impaired, since it is difficult to show these individuals what a scale looks like. It was also apparent that scales can be quite difficult to verbalise in an interview and cognitive overload may occur when visually impaired elders are given five-response choices to remember. The author has been involved in many research projects over the past 6 years involving visually impaired participants of all ages and from her experience, rating scales are not a problem for most visually impaired people. Therefore, the author is quite sure that the problem in the current study was due to the fact that the participants were very elderly and inexperienced of rating scales and not specifically due to their visual impairment.

Taking into account the above reservations, and in attempt to capture the sensitivity that 5-point rating scales give, a new approach should be taken to simplify the scales and questions for participants with limited experience with scales.

The interviewer can ask the participant a question and then give them a choice of only three responses e.g. "Did you find that **difficult**, **manageable**, or **easy**". This is in effect like giving the participant a 3-point rating scale. If participants give extreme ends of the scale (i.e. difficult or easy), the interviewer would then try to establish more sensitivity of the original response e.g. if the participant has said "difficult" then the researcher would probe "is that **quite difficult** or **very difficult**? ".

Hence, the 5-point rating scales in the questionnaire were two-tiered, like so:



This two-tiered approach would provide the data that would be obtained from a 5-point rating scale whilst reducing the cognitive overload that 5 choices would give to some individuals. This approach was then used in later studies presented in this thesis and published in a paper (O'Neill et al., 1998).

3.3.2 Overall analysis

Initially, some overall analysis was conducted to see if there were any differences between the subgroups of participants. It was important to see if there were any significant differences between blind, partially sighted and sighted participants (vision) or whether there were any significant differences between males and females (sex) in terms of their ratings. If so, further analysis would need to be conducted to see how the groups differed as this would impact upon decisions made about the interface design. Indeed, any differences could mean that several interfaces might need to be developed, each being tailored to the needs of different user groups.

The data was analysed using repeated measures General Linear Model (GLM). **Question** was the within-subjects factor, which had 19 levels (questions 9; 12; 19; 23; 24; 25; 26; 27; 28; 30; 31; 32; 37; 38; 39; 40; 47; 49 and 50). The between subjects factors were **sex** (male and female) and **vision** (blind, partially sighted and sighted).

Explanatory variables		**Levels**	
Sex	Female	Male	
Vision	Blind	Partially Sighted	Sighted

There were no significant differences between the participant sub groups relating to their ratings, therefore mean ratings and standard deviations are given in the following section for all participants.

3.3.4 User requirements for the PAM-AID mobility aid

Participants were interviewed to establish their requirements for the initial development of the PAM-AID device. These interview questions were designed to elicit user requirements regarding method of input, method of output, mode of operation and the physical design of the PAM-AID device.

3.3.4.1 Input methods

Participants were explained that one possible method for operating PAM-AID is that of voice input. They were asked if they would use a walking aid that required them to operate it by voice input (Q24). Elders gave a fairly moderate mean rating for voice input (M = **3.21**) indicating that may use voice input. For those who were not in favour of this form of input, they remarked that it would make them feel *"embarrassed", "nervous"* and *"idiotic".* They would get *"confused with other sounds".*

However, for those who were very happy to use voice input, they stated that it would be *"interesting"* and they would like to use anything that gave them *"independence".*

Participants were asked whether they would mind operating the walking aid by speaking to it in the privacy of their own home (Q25), to establish whether potential use of voice input depended on social embarrassment. Elders gave fairly moderate mean rating for using voice input within the privacy of the home ($\underline{M}$ = **3.57**).

Participants were asked whether they would use voice input in a public place, again to establish whether potential use of voice input depended on social embarrassment. Elders gave a moderate mean rating for using voice input in a public place ($\underline{M}$ = **3.22**). The mean rating for using voice input in a public place was lower than that given for using voice input in a private place, meaning that they would mind more. Although the difference was minimal, it does indicate that elders' preference for this form of input is influenced by the factor of social embarrassment and this should be considered in the design of PAM-AID.

As an alternative to voice input, participants were explained that switches operated by fingers and/or thumbs could be used for input purposes. Participants were asked whether they would like to operate switches with their fingers as an input method. Elders gave a moderately high mean rating for finger switches ($\underline{M}$ =**3.79**), receiving a higher rating than the voice input option. Some participants commented that the switches would have to be *"easy to identify"; "easy to find"* and *"easy to manipulate like buttons on a radio"*. Therefore, consideration would need to be made regarding where the switches were placed and should be tactile so that visually impaired individuals can locate and identify them easily.

Participants were asked whether they would like thumb-operated switches as an input method. Elders gave a moderate mean rating for using thumb switches (M = **3.34**). This was lower than the finger switches and the voice input.

Table 3.2 Mean ratings for questions relating to input methods (n=38)

Question	**M**	**SD**
Q25 (voice input in private)	3.57	1.61
Q26 (voice input in public)	3.22	1.83
Q27 (switch input)	3.79	1.26
Q28 (thumb switch)	3.34	1.36

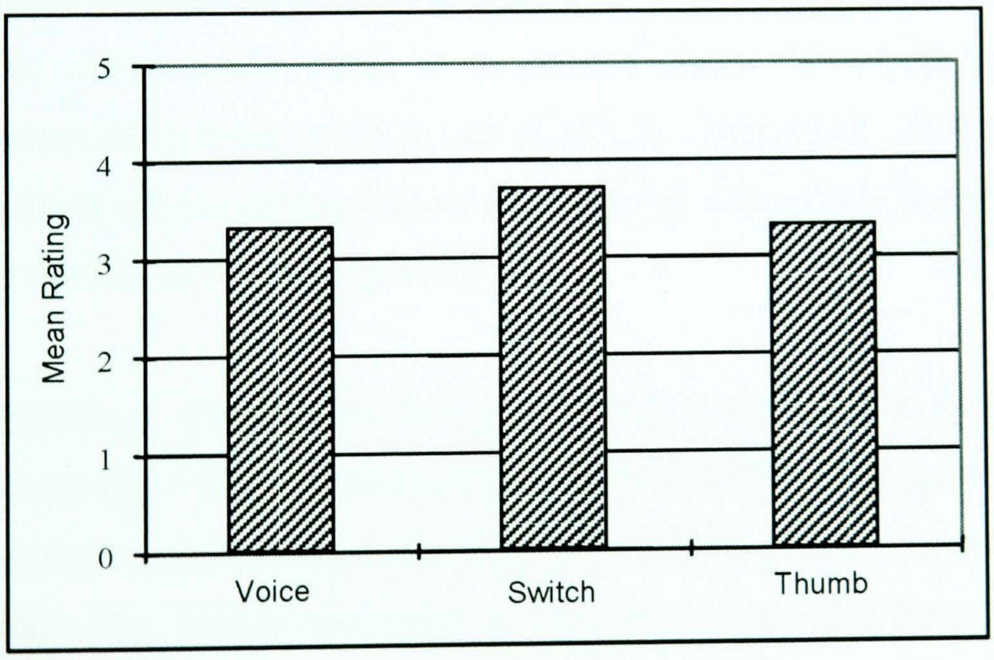


Figure 3.1 Mean ratings for possible input channels

There was some division among carers regarding voice input, with some carers suggesting that voice input would be an intuitive method for users, *"communication through speech is how we function, therefore this machine is keeping up the pattern of life"*. However, other carers were concerned that voice input may be ineffective in a noisy environment. This last point is an

important one, the implementation of voice input would depend on whether it is practical in a residential home setting, where there are many other environmental sounds which may effect the efficiency of voice input.
The carers were also asked whether they thought users would be embarrassed to use voice input. Carers felt that users would not be very embarrassed with using voice input, giving a mean rating of **4.3** (1=very embarrassed, 5=not at all embarrassed), *"if the visually impaired persons had training and the walking aid was really useful to the user, then it would not be embarrassing".* In general, carers felt that if PAM-AID improved the users' quality of life then this would over-ride any embarrassment.

To qualify this further, carers were asked to give ratings as to whether users would mind using a walking aid with voice input in (a) in public and (b) in a private place. An example of a public place given was a hospital or even the living room shared by residents in the residential home, and an example of a private place given was a resident's flat or room. Interestingly, carers' ratings for using voice input in a private place remained fairly high (M = **4.7**) supporting their original rating above. Therefore, carers believed that users would not be embarrassed about using voice input in settings where they had a certain amount of privacy.

However, their mean rating for using voice input in a more public place was lower (M = **3.1**), showing that carers did think that users are more likely to be embarrassed using voice input in a public place. Although several carers felt that this embarrassment would gradually decrease over time once the walking aid became an established part of the residential home.

Table 3.3 Mean ratings for voice input (n = 12)

Voice input	M	
Using voice input	3.2	Neutral
Embarrassed using voice input	4.3	Fairly high
Using voice input in private	4.7	Very high
Using voice input in public	3.1	Neutral

A comparison was made between the ratings of the elders and carers. Since the raw data from the previous study was lost, the carers' means were used as a test value in a one-sample t-test. Table 3.4 below gives the carers and the elders' means and the results of the one sample t-test.

Table 3.4 Comparison of carers and elders ratings of input methods (n=50)

Question	Elders' M	Carers' M	Difference in ratings (t-test)
Q25 (voice input in private)	3.57	4.7	t = -4.28 p = 0.00
Q26 (voice input in public)	3.22	3.1	-
Q27 (switch input)	3.79	4.1	-
Q28 (thumb switch)	3.34	4.0	t = -2.97 p = 0.005

Table 3.4 shows that carers gave a significantly higher mean rating for question 25 (M = **4.7**, SD = **1.61**) than elders (M = **3.57**), (t (36) = -4.28, p = .000). This means that carers were more positive in their ratings as they thought that elders would not mind using voice input in private. Elders' significantly lower mean rating suggests that they would mind using voice input in private. The results show that both elders and carers were in

agreement regarding the use of voice input in public and regarding the use of switch input.

Furthermore, carers gave a significantly higher mean rating (M = **4.0,** SD = **1.36**) than elders (M = **3.34**), (t (37) = -2.97, p = .005) regarding question 28, which indicates that elders were not as positive as carers regarding thumb switches.

3.3.4.2 Output methods

Participants were explained that information about their environment and the status of the walking aid could be given to them via speech output. They were asked whether they thought this information via speech output would be useful. Participants gave a moderate mean rating for using speech output information (M = **3.47**, SD = **1.72**) indicating that they thought that this would be moderately useful *(see Table 3.5).*

Table 3.5 Mean ratings for questions relating to output methods (n= 38)

Question	M	SD
Q30 (speech output useful)	3.47	1.72
Q31 (mind speech output?)	3.68	1.61
Q32 (mind in public?)	3.63	1.78
Q37 (sounds)	3.39	1.35
Q38 (sounds useful?)	3.03	1.64
Q39 (hear sounds)	3.42	1.57
Q40 (conspicuous?)	2.03	1.55

Participants were asked whether they would mind using a walking aid that spoke information to them. Participants gave a moderately high mean rating for using speech output (M = **3.68**, SD = **1.61**) meaning that they wouldn't mind a walking aid that spoke information to them.

Participants suggested different kinds of information that was thought to be useful:

- obstacles in pathway
- steps and stairs (especially down)
- identify rooms
- direction of turns

Participants were asked whether they would mind using a walking aid that spoke information to them in a public place. Participants gave a slightly lower mean rating for using speech output in a public environment ($\underline{M}$ = **3.39**, SD = **1.35**).

Participants were asked whether they would mind using a walking aid that gave information via sounds, participants gave a moderate mean rating ($\underline{M}$ = **3.39**, SD = 1.35). When participants were asked whether they it would be useful if the non-speech sounds gave them information, they gave a lower mean rating ($\underline{M}$ = **3.03**, SD = 1.64). Therefore, participants thought that the information via speech output would be more useful than the information via sounds.

Participants were asked whether they would be able to hear the non-speech sounds. This was to establish whether hearing difficulties or other extraneous sounds in their environment would interfere with their ability to hear sounds. Participants gave a fairly moderate mean rating for ability to hear the non-speech sounds ($\underline{M}$ = **3.42**, SD =1.57). Figure 3.2 shows the mean ratings for use of speech and non-speech sounds.

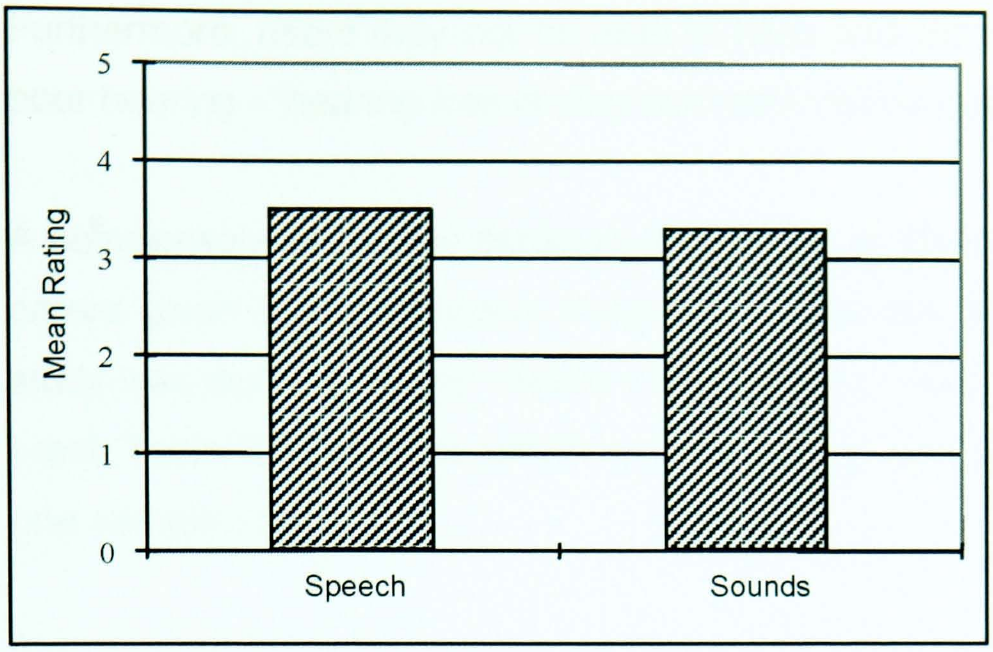


Figure 3.2 Mean ratings for the use of speech and non-speech sound output

Carers were asked if users would mind using a walking aid with speech output in privacy and gave a high mean rating ($\underline{M}$ = **4.8**). This indicates that carers believe users would not mind at all using speech output in privacy *(see Table 3.3 & Figure 3.2)*. However, their ratings were lower for using speech output in a public place ($\underline{M}$ = **3.8**) and they suggested that users would feel a bit more embarrassed in front of others. All carers thought that users would want the choice to turn off the speech output, even if it was only on occasion. Furthermore, all carers stated that users would like to be able to change the volume of the speech output, mainly due to their different levels of hearing. One carer said that *"it would be useful [to change the volume] due to changing situations, as audibility will depend on things like the number of people in a room, the size of the room and so on"*.

One carer, who gave a particularly low rating, was worried that the sounds would worry and confuse users. Another carer was concerned that the sounds would be *"too much for the elderly to take on board"* but mentioned that the sounds may be useful for warning or indicating certain things to the carers e.g. non-speech sounds to indicate that the battery was running low.

Furthermore, users may not be able to hear and identify the sounds due to poor hearing - *"hearing loss is very common as one gets older".*

A comparison was made between the ratings of the elders and those of the carers given in the previous study. Since the raw data from the previous study was lost, the carers' means were used as a test value in a one-sample t-test. Table 3.6 gives the carers' and the elders' means and the results of the one sample t-test.

Table 3.6 Mean ratings for questions relating to output methods (n= 50)

Question	Elders' M	Carers' M	Difference in ratings (t-test)
Q30 (speech output)	3.47	4.50	t= -3.67 p= 0.001
Q31 (mind speech output?)	3.68	4.80	t = -4.265 p = 0.00
Q32 (mind in public?)	3.63	3.80	-
Q37 (sounds)	3.39	3.10	-
Q39 (hear sounds)	3.42	2.60	t = 3.22 p = 0.003
Q40 (conspicuous?)	2.03	2.40	-

Table 3.6 shows that carers gave a significantly higher mean rating (M = **4.5**, SD = **1.72**) for question 30 than elders (M = **3.47**), (t (37) = -3.68, p = .001). This means that carers thought that speech output would be more useful than the elders did. There was also a significant difference between carers' and elders' mean ratings for question 31, whereby carers were significantly more positive than elders in their ratings.

There were no differences between carer and elder ratings regarding the use of speech output in public, the use of sounds, or feeling conspicuous.

However, there was a significant difference between elders' and carers' ratings regarding whether elders would be able to hear the sounds. The carers did not think that elders would be able to hear the sounds whereas elders thought that would be able to hear the sounds.

3.3.4.3 Mode of operation

Participants were explained the two modes of operating PAM-AID that were being proposed *(i)* automatic and *(ii)* manual. It was explained that the automatic mode gently guides them and they would feel a gentle pull as they walked with the aid. The manual mode on the other hand, requires them to push and direct the walking aid themselves. 34% of participants said they would prefer to push PAM-AID (manual mode) and when asked why, some participants suggested the following:

- *"My arms are quite strong enough"*
- *"I'd just rather push it"*
- *"I think it will be better for me"*

26% of participants said that if they used PAM-AID, they would operate it using either mode. One participant thought that the guiding option was a particularly good idea, because it would encourage those who cannot push a frame to walk independently. The remaining participants were unsure at this stage and it was clear that they needed a tangible demonstration of the two modes of operation.

Participants were asked whether they would mind the walking aid gently pulling them along (i.e. the automatic mode of operation). Participants gave a fairly low mean rating ($\underline{M}$ = **2.45**) indicating that they would mind the gentle pull of the walking aid. Therefore it is very important that the modes of operation are altered to users' preferences.

Table 3.7 Mean ratings for questions relating to mode of operation (n=38)

Question	M	SD
Q47 (automatic mode)	2.45	1.41

A comparison was made between the carers' and the elders' ratings. A one-sample t-test showed that carers (M = **3.7**) gave a significantly higher mean rating than elders (M = **2.45**, SD =**1.41**), (t (37) = -5.48, p = .000). *(see Table 3.8).* This suggests that elders were more concerned about the automatic mode of operation than the carers had anticipated.

Table 3.8 Mean ratings for questions relating to mode of operation (n=50)

Question	Elders' M	Carers' M	Difference in ratings (t-test)
Q47 (automatic mode)	2.45	3.7	t = -5.48 p = .000

3.3.4.4 Opinions of participants

At this stage, only tentative investigations into the attitudes of potential users towards PAM-AID were made. Participants were asked how useful they thought the walking aid would be and participants gave a very high mean rating (M = **4.45**) indicating that they thought the walking aid would be very useful. This is even more outstanding considering that throughout this results section, the mean ratings have all been moderate. Clearly, there was strong positive opinion regarding the usefulness of PAM-AID.

Participants were asked whether they would be interested in using the walking aid. Participants gave a fairly high mean rating (M = **3.74**) indicating that they would be interested in using the walking aid. However, this was lower than expected and this shows that although elders think this piece of technology is very useful, this does not automatically mean that they will use it *(see Table 3.9 and Figure 3.3).*

Table 3.9 Mean ratings for questions relating to technology acceptance (n = 38)

Question	M	SD
Q49 (useful for elders)	4.45	1.03
Q50 (are you interested?)	3.74	1.62

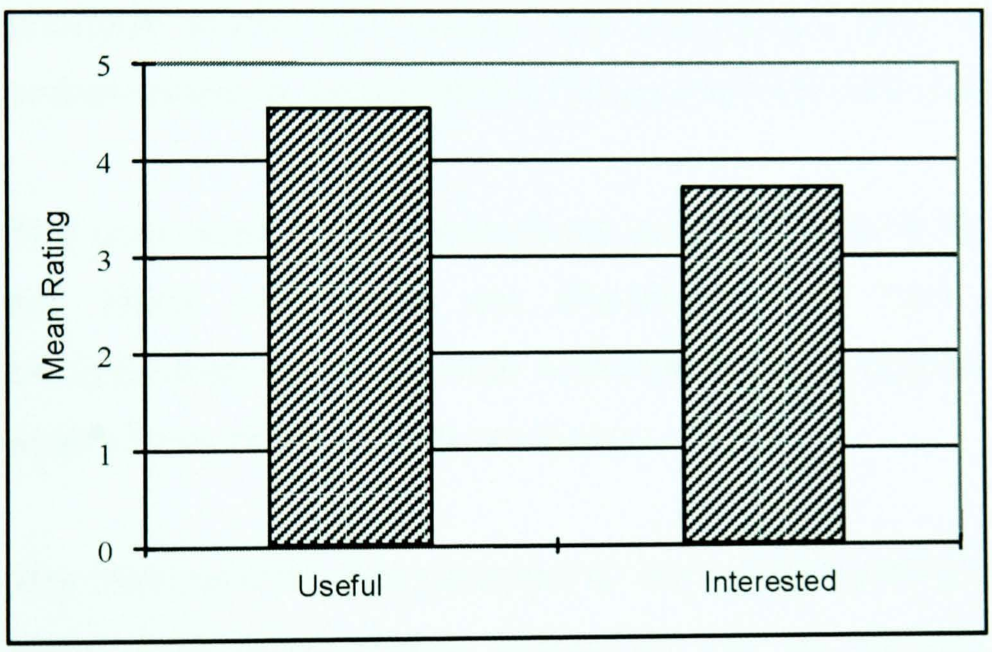


Figure 3.3: Mean ratings for technology acceptance

Carers were asked if they thought residents in their place of work would be interested in using PAM-AID. Carers rated that overall users would be very interested in using PAM-AID, as they feel that some of their residents are *"very pioneering"* and like to try anything new. However, they did point out that some potential users may not accept PAM-AID or may be resistant to using PAM-AID. Carers suggested that PAM-AID would need to be introduced in a very informed way to 'resistant users', i.e. explaining the benefits of the new device. This may improve acceptability of the new walking aid to those users who may be a little wary of PAM-AID. One carer commented that, *"perhaps it will be easier for the next generation who have experience of technology".*

3.4 Summary

The three main aims of the current study were (i) to investigate the advantages and disadvantages of elders' current walking aids that they use inside and outside the home as well as their current levels of mobility, (ii) to gather the user requirements for PAM-AID and (iii) to make tentative investigations regarding elders' attitudes towards using PAM-AID, since the previous study with carers had highlighted that some elders may feel embarrassed of, or resistant to using the PAM-AID walking aid.

The user requirements interviews identified a need for the PAM-AID walking aid. Many participants are dissatisfied with their existing walking aids because they do not provide sufficient physical support and visually impaired elders have difficulty with navigation.

The main worries that participants had when walking around their home was losing their balance and falling, as well as bumping into obstacles. It is paramount that the PAM-AID walking aid must be designed so that it provides robust and sturdy support for users and that it helps them to avoid bumping into obstacles. PAM-AID will include infrared sensors that will detect obstacles around the device and will safely guide users around the obstacles or it will halt the walking aid in the event of impending danger.

The results from this study were used to inform the design and development of the first PAM-AID prototype. During the interviews, participants were given a number of possible input and output methods for PAM-AID and they were asked to give their opinions regarding voice input, switch input and auditory output.

The use of voice input was a novel idea to participants and a few of them were interested in using it because it sounded fun and interesting. For these few participants, it did not matter if the device was different from their current aids as long as it gave them the independence they wished to maintain or regain. Overall, the use of voice input received only moderate ratings. This may be because none of the participants had come across voice input before and they were unsure whether they would like it or not. It may also be because some participants said that they would feel embarrassed using voice input, particularly in a public place and appeared to be more reluctant to using this method.

Comparisons between carers' and elders' ratings from the first and second user requirements studies, showed that carers thought elders would not mind using voice input in private situations. Elders' gave a significantly lower mean rating, which suggests that they may mind using voice input in private settings. Therefore, the carers underestimated elders' opinion regarding the use of voice input in private. Interestingly, the results showed that both elders and carers were in agreement regarding the use of voice input in public. That is, both groups thought that voice input may be more embarrassing when using it in front of others.

Overall, participants were fairly keen on the method of operating PAM-AID with finger switches as long as they would be easy to find and operate. Their ratings were also in agreement with those of carers in the previous study. Participants said that these switches should be well placed for them to reach.

The mean rating given by elders for the thumb switches was not as high as the rating for finger switches. Carers had rated the thumb switches significantly higher than elders and this may be because some elders thought is would be difficult operating switches with their thumbs.

In general, participants liked the idea of speech messages as long as they gave them useful information about their environment e.g. about obstacles in the way. Some potential problems were noted with auditory output. Some participants thought that the auditory output could be obscured by other environmental noises in their home e.g. the noise from the TV or the noise from the dining room of their residential home. Furthermore, some participants said that they would feel embarrassed walking with an aid that made a noise and said that there should be the option to alter the volume or turn off the auditory output altogether.

On comparison of carers' and elders' ratings, carers gave a significantly higher mean rating for the usefulness of speech output than elders. Thus carers thought that the speech output would be more useful than the elders. Also, carers thought that elders would not mind using a walking aid with speech output. However, elders' ratings were significantly lower when they were asked if they minded using the speech output. Therefore, the carers underestimated how elders' may feel using an aid with speech output.

There was no difference between carer and elder ratings regarding the use of sounds, although there was a significant difference between elders' and carers' ratings regarding whether elders would be able to hear the sounds. The carers did not think that elders would be able to hear the sounds whereas elders thought that would be able to.

Participants were also asked about their preferences for the physical design of PAM-AID to find out what facilities they would like the aid to have. For example, participants said they would like handles to support both arms but it would be useful if the walking aid could be directed by one arm for those with paralysis or arthritis. Some participants would like the option of a seat, an alarm and a clip-on shopping basket. All current walking frame users said that the 'U'-shaped design of their frames was good because it not only made the frame sturdy, but they could step into the U-curve of the frame and easily reach items from shelves and cupboards. Thus, the design of the PAM-AID walking aid should draw upon the advantages of existing Zimmer frame and rollator design. Above all, this study did highlight the need for providing a range of choice in terms of the design, to suit the differing needs and preferences of users within different environments.

In addition, participants were asked their opinion regarding the two modes of operation (i) automatic and (ii) manual. This was a difficult concept to get across to participants, as they were unsure about the wheels being motorised and moving automatically, as participants thought this would mean that they would not be in control of the device. They were worried about the gentle pull of the aid and this is something that will need to be tested in an evaluation of the first prototype so participants can base their opinions on actual experience of the modes.

This study highlighted some methodological issues. The elders had limited or no experience with rating scales and consequently, the author has proposed an alternative method of simplifying the 5-point rating scale. A two-tiered approach to the 5-point rating scale will be used in the next evaluation studies to help simplify the scale for elders. Another difficulty was attempting to gather elders' opinions about an innovative piece of technology without being able to demonstrate the device. This can be a problem with user requirements studies conducted with people of any age and particularly with individuals who have a limited experience of technology. It is often difficult for participants to build a mental model of the proposed device.

Apart from gathering the user requirements for PAM-AID, this study highlighted that some elders may be reluctant to change from their existing walking aids to PAM-AID, even though PAM-AID may improve their level of independent mobility. Social embarrassment was clearly an important issue and should be followed up in further studies. If elders are embarrassed of using PAM-AID then they are less likely to accept or use PAM-AID.

Participants clearly thought that the PAM-AID walking aid would be a very useful device for elders, however, some were cautious about using it themselves. This may be partly due to the fact that at this stage, there was not a prototype to demonstrate to participants and they did not have anything tangible to relate to. The issue of whether PAM-AID would be accepted by or used by elders was the most interesting issue that emerged from this study. The attitudes of elders will be followed up in future evaluation studies since this is vital to the acceptance of this walking aid.

The results from this study informed the design of the first PAM-AID prototype (see Appendix C for functionality) and gave valuable information about the potential user group. The main requirements that were identified were:

- Speed of the motorised wheels should remain constant
- The aid should be U-shaped like the conventional Zimmer frame so that it is easy for elders to reach shelves
- PAM-AID must provide sturdy physical support and prevent users from bumping into obstacles
- Voice input will not be implemented in the first prototype due to the mixed opinion of participants and due to the technical possibilities at that time.
- Speech messages will be included to tell users about obstacles and other important environmental information
- Non-speech sounds will be implemented to give warning information
- Allow users to turn down and turn off the volume of the auditory output
- Both finger and thumb switches will be implemented for evaluation by users
- Make switches easy to reach and identify
- Implement both modes of operation for users to evaluate

The following studies (reported in Chapter 4), detail the evaluation of the first and second prototypes. The evaluations were an important opportunity to take PAM-AID to those individuals who had taken part in the current study, so that they would be part of the on-going user-centred approach that the project was committed to following.

Chapter 4

Evaluating the PAM-AID prototypes with elders

4.1 Introduction

4.1.1 Aims of the evaluation

User-centred design was integral to the PAM-AID project, ensuring that as far as possible, the design of the walking aid would meet the needs of users. The previous chapter detailed the user requirements studies conducted to identify a set of user requirements for the PAM-AID walking aid. The results of these two studies informed the design of the first PAM-AID prototype, which was then to be evaluated by potential users as part of the iterative design process. Two evaluation studies were conducted to (i) evaluate the usability of the user interface with elders and (ii) pursue the attitudes of elders towards the technological walking aid. The two evaluations formed an overall iterative evaluation period, whereby the results from the preceding evaluation influenced the investigations of the following evaluation. For instance, any major usability or technical problems observed in the first evaluation were rectified for the second evaluation.

Figure 4.1 shows the first PAM-AID prototype used in the first round of evaluations. The functionality of the first PAM-AID prototype is given in Appendix C.

Figure 4.1 First PAM-AID prototype being evaluated by a visually impaired participant

Figure 4.2 shows the second PAM-AID prototype used in the second round of evaluations. The functionality of the second PAM-AID prototype is given in Appendix D.

Figure 4.2 Second PAM-AID prototype

4.1.1.1 *Evaluating the usability of the interface*

This evaluation was designed to investigate the usability of the user interface and more specifically, to address the following aspects:

- Quality of motion
- Ease of Use
- Satisfaction
- Safety
- Usability of instrumental handles & finger switches
- Configuration of the switches/handles
- Non-speech sounds & speech messages
- User control over feedback

4.1.1.2 Measuring elders' attitudes to PAM-AID

The user requirements studies highlighted that elders may be reluctant to change from their existing walking aid to PAM-AID, even though they thought that PAM-AID was a useful walking aid for other frail elders. Overall, there was a discrepancy in their attitudes and therefore it was important to measure elders' attitudes to the first prototype to see if these attitudes persist. Furthermore, measuring their attitudes may indicate whether elders will accept and use PAM-AID and whether their attitudes will change *over time* (i.e. in future evaluations). We would expect that users' attitudes would become more positive as design improvements are made.

Usability questionnaires are often designed to gather users' subjective ratings regarding different aspects of the technology of interest. However, such ratings only give an indication of attitudes and cannot be taken as valid and reliable measures of attitudes. In order to achieve a reliable and valid measure of attitudes towards PAM-AID, a psychometric scale should be used that is applicable to that technology. The summated scores will give an indication where users' attitudes fall on a quantitative measurement continuum. However, the only existing scales currently available, measure attitudes to computers/information technology (IT) and were not applicable to PAM-AID.

For this study, the Technology Acceptance Model (TAM, Davis, 1986) was used to make tentative investigations into users' attitudes to PAM-AID. It is acknowledged that it does have limited value, but it was used to provide some insight into attitudes that may be useful for the development of PAM-AID. Of course, this has highlighted the need for a more applicable attitude measure to be developed.

4.2 Method

4.2.1 Design

The first evaluation had a between-subjects design where participants were randomly placed into two groups *(see Table 4.4),* whereby one group experienced one input/output combination (instrumental handles and speech output) and the other group experienced another input/output combination (switches and non-speech sounds output). However, P5 was the exception in that he was physically able to complete more than one task and therefore experienced both input/output combinations. Both groups experienced the automatic and manual modes of operation.

However, the second evaluation had a within-subjects design whereby all participants completed the same evaluation procedure. Each participant received a short briefing and basic training about some of the functionality of PAM-AID. This was followed by an evaluation procedure whereby participants were required to walk with the PAM-AID walking aid from one end of a corridor (approximately 30 metres in length) to the other end and back again, during which they answered questions from the evaluation questionnaire *(see Appendix E).* The researcher also noted observations.

4.2.2 Participants

Eight participants took part in this study, five females and three males. Participants' ages ranged between 76 and 90 years of age, giving a mean age of 85 years. All participants were visually impaired, five were blind and three partially sighted.

All participants lived in residential homes for visually impaired elderly persons. Two residential homes took part in this study.

Six participants had a hearing impairment and had to rely on a hearing aid. Furthermore, six of the participants had additional disabilities that affected their ability to walk effectively with a walking frame. The most prevalent disabling illness was arthritis, affecting half of all participants. Arthritis affected most participants in their arms, legs, and hands but for one participant, arthritis affected her neck and head.

One participant had difficulty walking because both of his knees were plastic. Another participant had an artificial right leg and no toes on his left foot that resulted in poor mobility.

One participant reported suffering from epileptic seizures brought on by cancer of the pituitary gland and another reported suffering from a severe nervous complaint which caused her to shake uncontrollably.

All eight participants in this study were classified as frail because they were unable to walk without a walking aid. However, their levels of mobility did vary, four out of the eight participants were very frail as they needed to support themselves with both hands and needed to support their whole body weight at all times. The remaining four participants were able to walk with only one hand supported e.g. by using a walking a stick.

Sixteen participants took part in this study, 7 men and 9 women, whose ages ranged between 55 to 94 years of age, giving a mean age of 77.12 years. All participants were visually impaired and on the Irish blind register, 10 were blind and six had some residual vision (partially sighted).

Participants lived in one of two residential homes for visually impaired persons, which participated in this study. None of the participants used a hearing aid, however, four participants did state that they had difficulty with their hearing.

Of the 16 participants, six had arthritis, one had a ringing in the ears, one suffered from depression and nervousness when presented with new tasks, and one had hip problems.

The current level of mobility of participants was observed and recorded, taking into account participants' pace of walking and use of a support aid or cane *(Table 4.1).* All participants used the fixed wall rails for support and/or guidance but some participants also used other aids in conjunction with the rails.

Table 4.1 Primary Mobility Aids (n=16)

Primary Mobility Aids	Blind	Partially sighted
Support/walking stick (1 only)	3	3
Walking frame without wheels	-	3
Rails only	7	-

4.2.3 Measures

4.2.3.1 Tasks A and B for evaluation study 1

The participants' in this study were unable to walk very far so it was necessary for ethical reasons, to make sure that the walking time for each participant was kept to a minimum. Hence, the evaluation procedure was planned on the basis that walking time would be no more than 10 minutes for each participant, unless they specified otherwise. This meant that participants were not able to experience both modes of operation, both methods of input and both methods of output. Therefore, the functionality of

PAM-AID was divided into two combinations of input and output and participants were assigned to only one of the combinations - Task A or B *(Appendix F and Table 4.2)*. However, P5 was the exception. He was originally assigned to Task A, but after completion, he was able to continue walking and complete Task B.

Table 4.2 Participants assigned to tasks A and B

A Instrumental Handles/Speech	**B = Blind PS = Partially sighted**	**B Switches/Sounds**	**BD = Blind PS = Partially sighted**
Auto & Manual		Auto & Manual	
P2	PS	P1	PS
P5	BD	P3	BD
P6	PS	P4	BD
P7	BD	P5	PS
		P8	BD

4.2.3.2 Evaluation study 2

During the first evaluation, there was limited time with the participants and they were unable to walk for more than 10 minutes. This meant that only some of the functionality was evaluated by some of the participants and clearly this was a limitation of the study. For the second evaluation, it was possible to spend more time in the residential home where the participants lived and this meant that each participant could evaluate all the functionality and therefore no separate tasks were set.

4.2.3.3 Evaluation questionnaires

Questionnaire for evaluation study 1

An evaluation questionnaire *(Appendix G)* was designed to establish the usability and utility of the first PAM-AID prototype. The questionnaire included a personal data section and a further four sections consisting of a total of 29 questions. The questionnaire comprised some multiple-choice items, some questions with 5-point rating scales, and some open-ended questions.

Questionnaire for evaluation study 2

An evaluation questionnaire was developed *(Appendix H)* to address the usability of PAM-AID. The questionnaire comprised of a personal data section of eight questions and a further six parts including 22 questions.

For certain questions, participants were asked to give responses on a 5 point rating scale, where 1 = a very low score and 5 = a very high score.

Five-point rating scale:

Unfavourable | Favourable

1	2	3	4	5
Very Low	Fairly Low	Moderate	Fairly High	Very High

During the user requirements study, a number of problems were highlighted regarding the use of 5-point rating scales with elderly visually impaired people. It became apparent that;

- elderly people have little or no experience of rating scales
- scales work effectively because of their visual nature and visually impaired people may have difficulty visualising scales
- scales are difficult to verbalize in an interview
- cognitive overload is likely to occur when elderly visually impaired people are given five response choices.

Taking into account the above reservations, and in attempt to capture the sensitivity that 5-point rating scales give, the two-tiered approach was taken:

Difficult		Manageable		Easy	
very	quite			quite	very

4.2.3.4 Technology acceptance

As no appropriate attitude measure existed, the evaluation questionnaire included five technology acceptance questions, which were based upon the constructs in the Technology Acceptance Model (Davis, 1986). This model is based on The Theory of Reasoned Action (Ajzen & Fishbein, 1980) and holds that two attitudinal constructs - **perceived ease of use** and **perceived usefulness** can predict technology acceptance (Davis, 1989). As this theory has been developed regarding information technology, it is only suitable for tentative investigations into the acceptance of a technology such as PAM-AID. However, two separate questions were included to establish whether elders thought PAM-AID was useful for (i) them and (ii) other frail and elderly visually impaired people. These questions were used to see if elders gave different ratings for themselves and for other frail and elderly visually impaired people.

4.2.4 Procedure

The evaluations were conducted in the participants' place of residence. Initially, each participant was given a brief introduction to the PAM-AID walking aid and some of its basic functionality. Each participant received a short briefing and basic training about the functionality of PAM-AID. In evaluation 1, participants completed either Tasks A or B whereby they walked with PAM-AID and experienced either input-output method combination. In evaluation 2, all participants walked with the second prototype using all functionality, the order of functionality experienced was counterbalanced. All participants walked first with PAM-AID using the automatic mode because this mode allows users to get used to walking with PAM-AID before learning the input methods. After familiarising themselves with PAM-AID, participants then walked using the manual mode, whereby they operated the input switches to move PAM-AID in different directions. Throughout the walk, participants encountered obstacles such as chairs and coffee tables that were placed in their usual layout around the living rooms of the residential home. Therefore, participants experienced the obstacle detection and wall-following capabilities of the walking aid. The researcher noted any observations and a debriefing was given to participants to complete the evaluation procedure.

After walking with PAM-AID, participants were seated and asked a number of questions from the evaluation questionnaire. At the end of the interview, participants were thanked for their participation.

4.3 Results of the evaluation of prototype 1

Throughout this section, mean ratings (M) and standard deviations (SD) are reported that were based on 5-point rating scales, where 1 = a low rating and 5 = a high rating (except the 4-point rating scale relating to safety). Where the mean ratings are based on only 4 or 5 participants, the minimum and maximum ratings have been given to show the range (R). The results include participants' comments and observations noted during the evaluations. A number of recommendations have been made regarding (i) design and development issues and (ii) areas to investigate in future evaluations. In some cases, the recommendations may appear to conflict because primarily, these recommendations have been made to facilitate discussion between technical and human factors researchers involved in the PAM-AID Project. Furthermore, any suggested design changes that may be implemented will be subject to future evaluations.

4.3.1 Input methods (manual mode)

4.3.1.1 Instrumental handles during the manual mode

Overall, 4 participants found the instrumental handles manageable to operate (M = **3.0**, SD = **1.0**, R = **2-4**). It was observed that the instrumental handles were fairly supportive for participants when they wanted to walk forwards. Indeed, as participants leant on both handles they found this comfortable and intuitive for walking forwards. Furthermore, participants found that the pushing down of the right handle to turn right and the left handle to turn left was very intuitive and easy to remember. Despite this, a number of usability problems were observed.

- Participants were particularly frail and demonstrated great difficulty when attempting to turn. Participants found it difficult to lift the handles, either when attempting to turn or when attempting to reverse.

- One participant had great difficulty lifting the handles to reverse due to a weak left arm (it had been fractured). She did ask whether the handles could be more flexible so that she could lift them easier. However, this participant demonstrated that for someone who has weak upper limbs, the lifting action required to reverse, is near impossible. Even for those who had stronger arms and who found the handles easier to lift, it may be possible that repetitive strain could occur. Another participant suggested that it would be more natural to pull the handles back towards them than to lift them upwards.

Overall, it was apparent that for someone who is extremely frail, these handles proved inoperable. Other participants also found the lifting motion difficult when they attempted to turn or reverse. Two main problems were observed; (i) for those who were particularly frail, they were unable to lift the handles at all and therefore could not turn or reverse, and (ii) all participants experienced the difficulty of their body-weight not being supported when turning or reversing.

Recommendations:

® The design of the instrumental handles caused problems for frail participants when trying to walk. Participants were unable to lift the handles when needing to reverse and turn. Design changes need to be made for further evaluation.

4.3.1.2 Switches on handles during the manual mode

Overall, 5 participants found the switches quite easy to operate ($\underline{M}$ = **4.0**, $\underline{SD}$ = **0.81**, $\underline{R}$ = **3-5**). Two participants found the functions of the switches were quite easy to remember and thought that they were easy to operate. One of them was observed to operate the switches very effectively and did not need any assistance from the researcher when walking with PAM-AID. Overall, participants thought it intuitive to press a switch on the right handle to turn right and a switch on the left handle to turn left. However, one participant did suggest that handles similar to those on a bicycle would be easier to operate than the switches.

The two participants who rated the switches as manageable appeared to operate the switches more efficiently over time. One participant said she had found them difficult to operate initially but once she had become familiar with the switches they were more manageable.

The switches were often quite difficult for participants to find. One partially sighted participant could just about visually discriminate between the switches but with some difficulty. As she was partially sighted, she could discriminate between the green and black switches in terms of their degree of shading. Although, this was still was not satisfactory because she had to peer closely at the switches in order to discriminate between them.

Two participants found the positioning of the switches difficult to reach and therefore uncomfortable. In general, participants found that reaching for the switches put a strain on their hands particularly for those who suffered from arthritis. One such participant said that her thumbs still hurt for some time after she had stopped using PAM-AID.

Overall, participants remarked that the switches were difficult to hold down all of the time. One participant said that his thumbs felt strained by having to hold the switches down and generally felt that his hands were under strain the whole time. This participant also suggested that the switches should be larger. Another participant found pressing down the switches difficult and tiring because of a nervous complaint that caused her hands to be shaky.

It was observed that some participants needed both hands for support and did not want to move their hands to reach for the switches because this caused them to be unsteady. It was evident that very frail participants were unable to move their hands when being supported by the frame.

Recommendations:

® It is not necessary for participants to press two switches to go forwards and another two switches to reverse. Reduce the number of switches to provide a simpler interface and for those who have only one able hand.

® Keep the current configuration of the switches i.e. press the switch on right handle to turn right and switch on the left handle to turn left.

® Re-position switches so participants do not have to move their hands in order to reach them. Switches need to be positioned approximately where fingers and thumbs would be resting. If switches are positioned near to fingers, participants may find it easier to hold down switches.

® Make switches more touch sensitive, because holding down switches was particularly difficult for those with arthritis and may cause repetitive strain injury.

® A safety mechanism may be needed to secure against participants accidentally pressing the switches. This needs to be investigated.

® Make switches easy to distinguish from each other for the visually impaired user. The switches should be larger; be distinct shapes (e.g. Δ, O); have tactile markings (e.g. Moon); have large print markings; use distinctive colours/shading (e.g. light vs. dark).

® Are switches necessary for turning left and right? Bicycle handles could be a more intuitive alternative and this could be investigated during the next evaluation study. Switches could remain for reversing and forwards.

4.3.1.3 A comparison of the two input methods

Overall, the instrumental handles received lower ratings than the switches in terms of ease of use *(Table 4.3, Figure 4.3).*

Table 4.3 Mean ratings for two input methods (n=8)

	M	SD	R
Instrumental handles	3.0	1.0	2-4
Switches	4.0	0.81	3-5

That is, the instrumental handles were rated as manageable to operate and the switches were rated as quite easy to operate. Some usability problems were noted with both types of input and need to be rectified for the next evaluation to improve their usability.

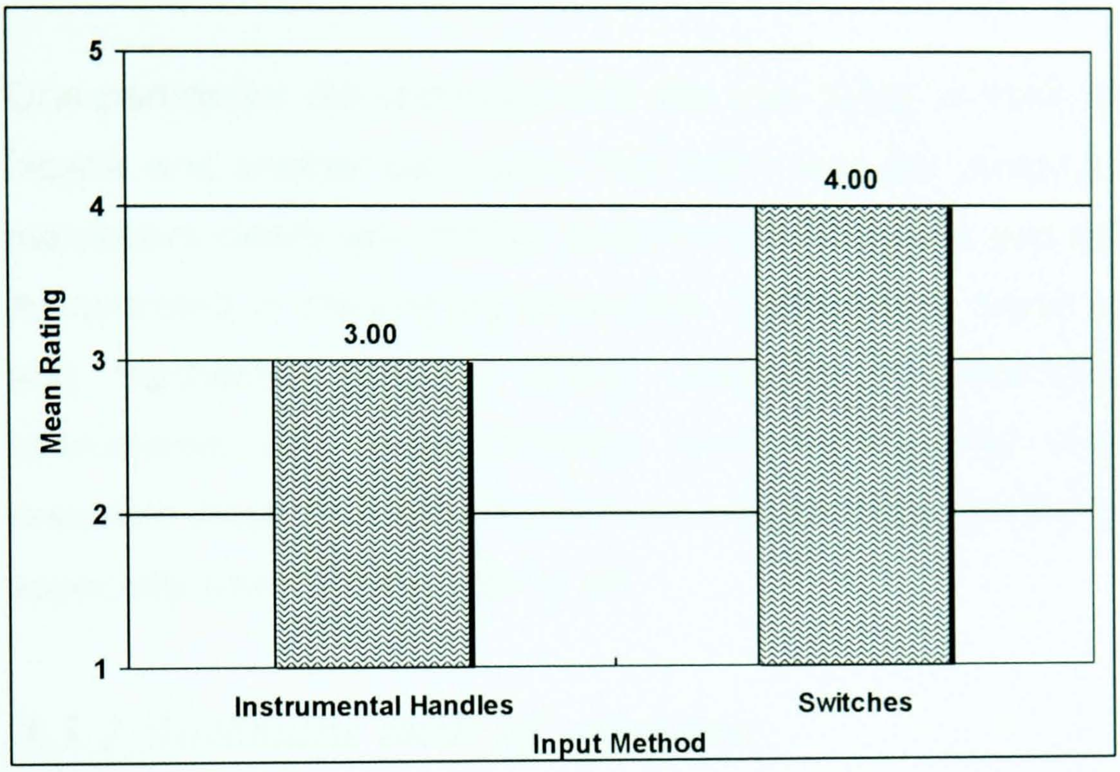


Figure 4.3 Mean ratings for ease of use for both methods of input

Operating the right handle for turning right and the left handle for turning left was very intuitive for participants. Although this was intuitive, participants did display some difficulty in the practical operation of both types of handle when turning. The instrumental handles were problematic because participants had to release one handle and lean on the other to turn. Of course, this meant that their physical support was reduced and participants' body-weight was unbalanced. This defeats the purpose of PAM-AID. The switches on the other hand, produced another difficulty. It was more time consuming for participants to find the exact switch needed and they found it tiresome and strenuous continuously holding the switch down.

When reversing, the instrumental handles caused problems for frail participants because (a) they could not easily lift the handles and (b) they were not being supported whilst lifting the handles. The switches too caused difficulty for participants when reversing. Again, it took longer for participants to find and discriminate the switches and there was the difficulty of continuously holding down two switches.

One participant did comment that she was trying to think of the aid like a bicycle and another participant said that it was like pushing a pram. These metaphors clearly are familiar ones for elderly people and perhaps could be incorporated in the training procedure. Furthermore, these metaphors have also highlighted possible design solutions. For example, perhaps the instrumental and switch handles could be replaced with handles that resemble those on a bicycle, as these may be more intuitive to elderly people especially when turning right or left.

4.3.2 Automatic mode of operation

4.3.2.1 Usability of the handles during the automatic mode

Initially, all eight participants experienced walking with the automatic mode of operation, because this mode is the simplest mode for learning to walk with PAM-AID. The automatic mode does not require any operation of the input methods, so even though some participants used the instrumental handles and some used the handles with switches during this mode, the experience should have been the same across all participants. However, this clearly was not the case.

Participants who used the instrumental handles during the automatic mode were confused because the handles moved giving them the impression that they were operating the aid in some way. Participants would move the handles and ask the researcher why PAM-AID wasn't moving in the direction they were telling it to go. It soon became obvious that the instrumental handles should be static or locked during automatic mode use.

However, the participants who used the static handles with switches were able to distinguish the automatic mode from the manual mode. Participants clearly understood that they did not have to operate the switches during this mode and that they should only hold onto the handles for support.

4.3.2.2 Auditory output during the automatic mode

Another important observation was noted. Throughout the automatic mode, participants heard speech or non-speech sound output. Those participants who heard command confirmation speech messages found them confusing for several reasons. First, participants thought that the messages were telling them what to do, so if they heard "turn right", they attempted to turn to the right. This was even more confusing during the automatic mode because they knew that they did not have to direct PAM-AID at all. At times, participants also seemed to be overwhelmed by the number of messages that they were given. Auditory information should be kept to a minimum; otherwise the information appears to be redundant.

Those participants that heard non-speech sounds only heard a command confirmation sound when reversing. As reversing is a less frequent operation, they did not hear this sound too often which seemed to be more acceptable to participants. Most participants liked the reversing sound, whereas some did find it a little loud and embarrassing.

Recommendations:

® The automatic mode is a good introduction to PAM-AID for new users and for training purposes, this mode should be experienced first until novice users feel confident enough to use the manual mode

® Prevent the instrumental handles from moving when participants walk with the automatic mode

® Command confirmation sounds and messages serve no purpose in this mode and should be switched off to prevent confusion

® Command confirmation could be kept for reversing because this operation is always manual and used fairly infrequently

® Sounds and messages for obstacle detection serve a useful purpose in informing users about their environment

4.3.3 Overall usability of the output methods

4.3.3.1 Speech messages

Overall, participants did not find the speech messages to be very useful (M = **2.5**, SD=**1.29,** R=**1-4**). Although one participant remarked that the messages were reassuring and made him feel safe, on the whole, participants thought that the speech messages would be more useful if they gave information about what they should do next, rather than confirming what they have just done.

Furthermore, participants said they would prefer to be able to change the volume of the speech messages. One participant remarked that they wanted to be able to change the volume so that they could over-ride noise from the environment. Also, participants wanted the option of being able to turn off the speech messages. One participant explained that she would like to be able to turn the messages off because she sometimes suffered from migraines. In general, participants remarked that the speech messages were understandable, but the number and length of the messages should be kept to a minimum.

Recommendations:

® Remove command confirmation messages and replace with speech messages to help users make informed choices about what to do next

® Have an option to turn off speech messages

® Have the option to change the volume of the speech messages

® Further investigations are required to find the optimum number and length of messages

4.3.3.2 Non-speech sounds

Overall, participants did not find the sounds very useful ($\underline{M}$ = **2.0**, $\underline{SD}$ =**1.22**, $\underline{R}$=**1-4**). Four out of five participants could hear the non-speech sounds whilst walking with the aid. After the task, only two participants managed to remember the reversing sound but they did not remember the obstacle detection sound. One participant commented that the number of sounds would have to be limited because *"you don't want too much noise"*. He also thought they sounded *"over the top"* and stated that he would like to be able to turn them off or turn them down depending on the situation he was in. He felt that only two or three sounds would be enough but he added that overall, he would prefer speech messages instead of sounds. Two other participants also felt that there should be fewer sounds and the volume should be changeable.

Three participants did not remember the sounds or what they were for and this was reflected in the overall mean rating from all 5 participants ($\underline{M}$ = **2.4**, SD = **1.67,** R=**1-5**), showing that the meanings of sounds were quite difficult to remember.

In general, participants thought that the sounds would not be very useful and this was reflected in their comments. One participant who couldn't remember the sounds, admitted that her memory was generally quite poor, but also said she did not understand the purpose of the sounds.

Interestingly, two participants commented that they would prefer speech messages instead of sounds because they would be more understandable and easier to notice in the home. One participant said that sounds would be difficult to listen to because there are already lots of sounds within the home and that *"a message would be more readily understood"*. He also commented that he had been in a lift (elevator) recently, which gave information via speech messages that he found very useful. This participant also mentioned that messages would be more useful if they gave instructions *"I think they should tell you what to do next"* but a message should be given once and not be repetitive.

Recommendations:

® Sounds should be kept to a minimum, perhaps only two, but this warrants further investigation.

® Obstacle detection sounds were quite repetitive. Generally, this made the sounds meaningless and participants started to ignore them.

® A sound could be kept for reverse because it is more unusual. Overall, participants liked this sound when it was pointed out to them.

® Participants tended to ignore the sounds and should therefore not be used for things that are important e.g. obstacle detection. Perhaps sounds should be used for things that happen on occasion and are not safety-critical e.g. a sound indicating that the battery needs re-charging.

® It appears that participants tend to be more attentive to speech messages.

4.3.3.3 A comparison of speech & sounds

Overall, speech messages received slightly higher ratings than the non-speech sounds for usefulness *(Table 4.4, Figure 4.4).*

Table 4.4 Mean ratings for usefulness of two output methods (n=8)

	M	SD	R
Speech messages	2.5	1.29	1 - 4
Non speech sounds	2.0	1.22	1 - 4

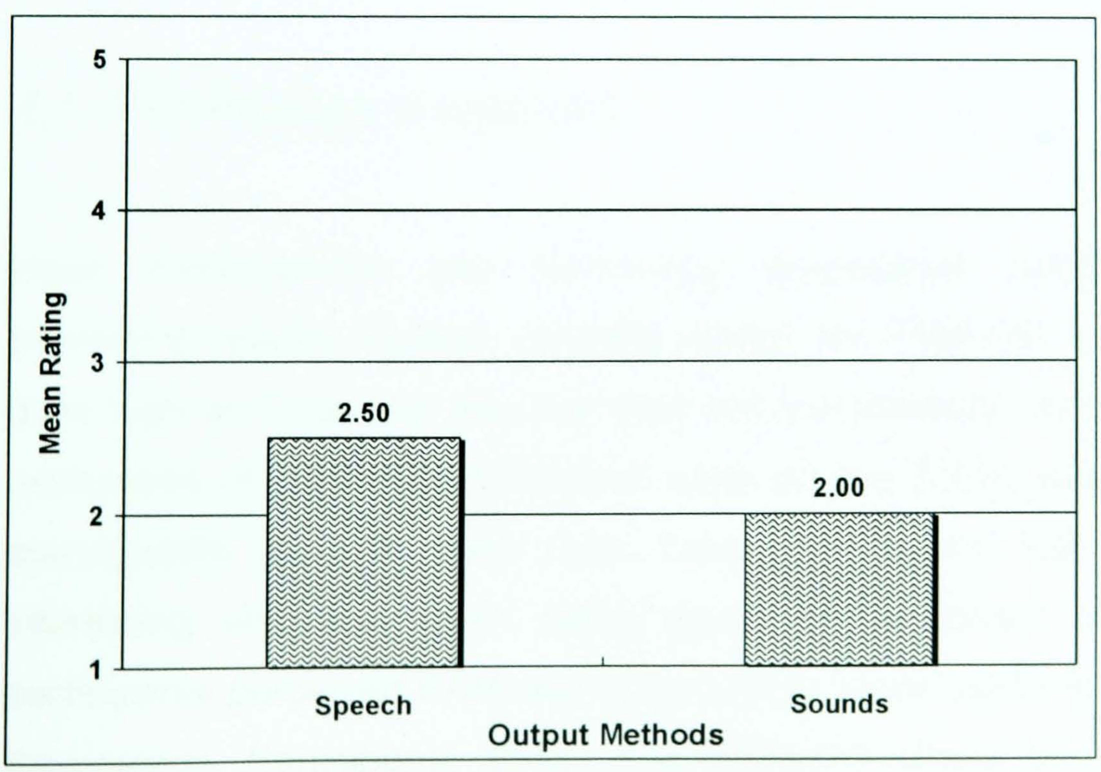


Figure 4.4 Mean ratings for usefulness of two output methods

Speech messages were more useful for giving participants certain information, such as obstacle detection information and environmental information of this sort should be available in either mode of operation. However, the command confirmation messages were not at all useful and were often confusing to participants. The speech messages would be more useful if they told participants what to do next rather than telling them what they had just done. Of course, instructional messages would only serve a purpose during the manual mode and should not be included in the automatic mode.

It was apparent that the number and length of the messages and sounds should be kept to a minimum. Indeed, any more than the number used in this evaluation may cause cognitive overload.

The non-speech sound for reversing was useful and most participants could remember this sound. However, participants could not remember the other sound (for obstacle detection), perhaps showing that sounds are quite difficult for participants to remember and are not always that informative.

4.3.4 Technology acceptance

Initial investigations into technology acceptance have shown some interesting results. Overall, usability ratings for PAM-AID were moderate to quite high and this was also the case with participants' ratings for perceived usefulness of PAM-AID. Perceived ease of use (PEU) was rated between manageable to quite easy *(see Table 4.5, Figure 4.5)*. Perhaps more interesting was the mean rating given for perceived usefulness. Most participants perceived PAM-AID to be slightly more useful for others than for themselves. Participants stated that PAM-AID would be only moderately useful for them (PU Self) but quite useful for other visually impaired people (PU Others).

Table 4.5 Technology acceptance (n=8)

	M	SD	R
PEU	3.5	1.06	2 - 5
PU Self	3.0	1.41	1 - 5
PU Others	4.25	0.71	3 - 5

When asked to explain, most participants said that they were happy with their existing means of support whilst walking around their home e.g. walking stick, attachments on walls, furniture and personal assistance from carers. Participants commented that physical interaction with their environment (such as holding onto furniture) not only allows them to support themselves physically, but also provides them with feedback as to where they are in the environment. Even though participants' attitudes to PAM-AID were fairly positive, they were not ready to accept PAM-AID as a walking aid for themselves, but at this time they could see the benefits of PAM-AID for frail visually impaired people. This demonstrated that individuals' attitudes can be complex and although they may give high usability ratings, these may be unreliable predictors of future acceptance and use of the technology. Thus a more reliable form of measurement would be needed and one which is a reliable predictor of future behaviour.

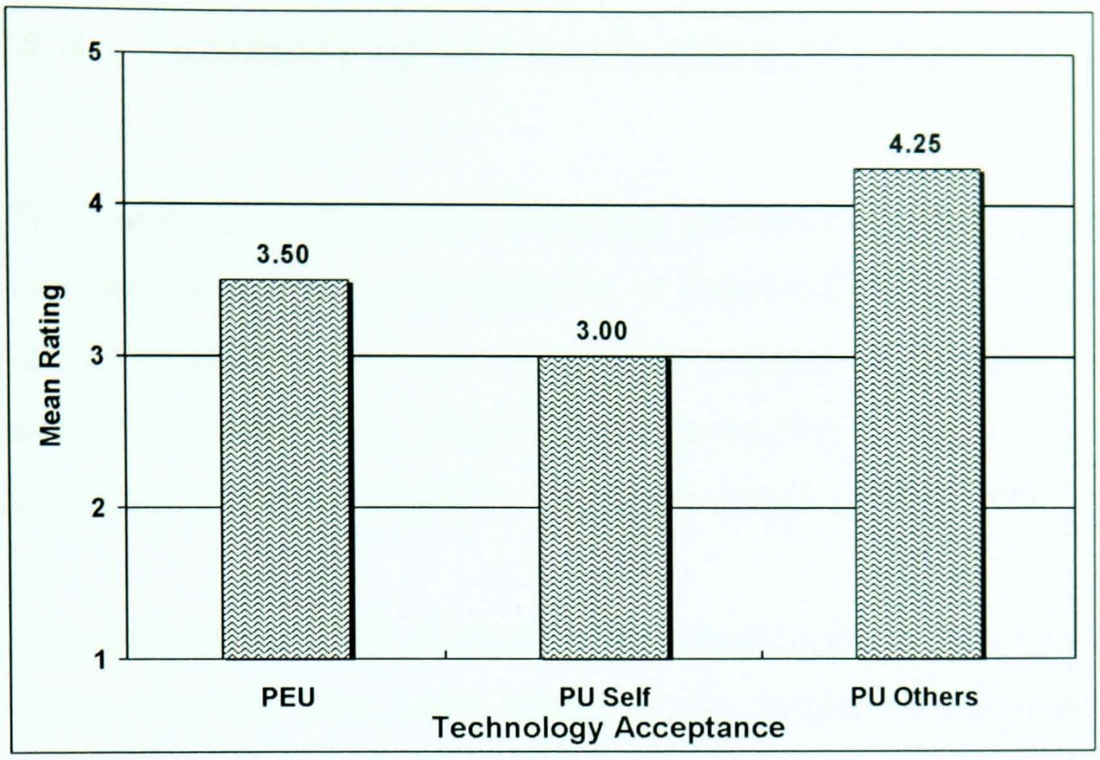


Figure 4.5 Mean ratings for perceived ease of use and perceived usefulness

The results from the technology acceptance questions are not taken to be valid or reliable measurements of attitudes. However, these questions do highlight a discrepancy in elders' views concerning their use of PAM-AID. Although elders were positive in their attitudes towards PAMAID, there was a clear resistance to using the technology. Indeed, this demonstrates an inconsistency between elders' attitudes and behaviour. The results do suggest that this is an area that should be investigated more thoroughly, particularly if elders are to accept and use PAM-AID.

Recommendations:

® Attitudes to PAM-AID should to be measured during future evaluations of PAM-AID

® Develop a scale that would accurately measure people's attitudes to PAM-AID and similar technologies

4.4 Summary of the evaluation of prototype 1

This evaluation of the first prototype provided a wealth of information for the iterative design and development of PAM-AID. The most informative aspect of this evaluation was the initial observations of potential end users walking with PAM-AID. The results have provided a basis on which to make intelligent design changes for the next version of PAM-AID.

The automatic mode proved to be a good introduction to PAM-AID for new users and this has been noted for the future development of the training programme. Furthermore, this mode proved to be most suitable for those participants who were particularly nervous of operating the aid. The handles with switches were more appropriate for the automatic mode because they were static, whereas the instrumental handles remained moveable and gave participants the impression that they were operating the aid in some way. Therefore, handles should become static during the automatic mode to prevent this confusion.

Some other difficulties were observed during the automatic mode. For example, participants thought the command confirmation sounds and messages were actually telling them what to do next, even though the researcher kept reassuring participants that they were not operating the aid during this mode. Also, it was confusing to participants that during the automatic mode, they had to operate PAM-AID manually in order to reverse.

Overall, participants rated the switches as easier to operate than the instrumental handles. Observations showed that there were some serious usability problems for participants using the instrumental handles. Even though participants found the configuration for turning intuitive, the practical task of turning was fairly difficult because the instrumental handles were not supportive to frail participants during turning. Participants also had difficulty with the switches because they were very difficult to keep pressed down, especially for those with arthritis.

The instrumental handles were not very supportive for participants when reversing and some alternatives have been suggested. When using the switch handles, pressing two switches to move forwards or to reverse, meant additional and unnecessary complexity. Fewer switches would make these handles easier to operate and less confusing to participants. Furthermore, the switches need to be positioned closer to participants' thumbs/fingers, they need to be easier to press and easier for the visually impaired user to discriminate between them e.g. make them larger and tactile.

One participant did comment that she tried to think of the handles like those on a bicycle. Perhaps bicycle handles would solve some of the difficulties that participants had when turning, but this clearly warrants further investigation. Also, a bicycle metaphor may be useful during user training of PAM-AID, because this is a metaphor familiar to most elderly people.

The speech messages for command confirmation proved not very useful, and perhaps more useful messages would indicate to participants what they should do next. The obstacle detection messages were quite useful and participants were often more attentive to these messages. Participants should be given the option to turn off speech messages and change their volume depending on the situation they are in.

It was observed that non-speech sounds should be kept to a minimum, perhaps a maximum of two sounds only. Too many sounds tend to become meaningless and are often ignored by participants. If non-speech sounds are to be used, further research needs to look at their most efficient application.

Fortunately, participants felt quite safe when walking with PAM-AID, and found the quality of motion to be sturdy and supportive. Several safety measures were incorporated for this evaluation to ensure maximum safety for participants. However, these safety measures need to be made more practical for the 'real world', where participants may be walking with PAM-AID in the absence of researchers and carers.

Interestingly, preliminary investigations into technology acceptance have shown that participants perceive PAM-AID to be only moderately useful to themselves, but quite useful for other frail visually impaired elders. This is consistent with the findings in the user requirements study where the participants thought that PAM-AID was useful for others but they would not use it themselves. It seems that many participants are resistant to changing their walking aid and at this early stage, cannot see the potential benefits of PAM-AID. We would expect these perceived usefulness mean ratings to increase in future evaluations, moving in-line with the improving design and efficiency of PAM-AID.

Furthermore, participants rated PAM-AID as manageable to quite easy to use. As PAM-AID is developed in an iterative manner according to evaluation results, it is expected that this overall mean rating will increase throughout the project. Following the principles of user-centred design, the results from this study provided valuable information for the next design iteration. The second PAM-AID prototype (see Appendix D for functionality) was developed based upon the initial set of user requirements and upon the results of this first evaluation study.

Elders' attitudes were investigated during this study and an unexpected discrepancy between their attitudes and behaviour emerged. Although elders were positive about the technological walking aid, many of them said that they would <u>not</u> use it, even though they would clearly benefit from using PAM-AID. Interestingly, elders thought the aid would be useful for other frail visually impaired elders who had equivalent mobility problems and this reflects what other researchers have found (Bynum & Rogers, 1987; DeWitt 1991). Clearly, elders' attitudes towards technology are complex and should be explored but since this discrepancy exists, their attitudes should be measured using a valid and reliable scale.

4.5 Results of the evaluation of prototype 2

The data gathered during the evaluation of the second prototype are reported in this section. Throughout this section, mean ratings (M) are reported on 5-point rating scales, where 1 = a low rating and 5 = a high rating (except the 4-point rating scale used relating safety). The results include the participants' comments and the researcher's observations from the evaluations. A number of recommendations have been made regarding (i) design and development issues and (ii) areas to investigate in future evaluations.

4.5.1 Input methods (manual mode only)

4.5.1.1 Handles with switches

The switches on the handles were improved based on the findings of the previous evaluation in terms of positioning and configuration, and were made more distinguishable by shape and colour.

Fifteen participants thought the switches were well positioned and very easy to find. The partially sighted participants were able to distinguish between the different switches due to the use of colour identifying different switches.

Overall, participants found the switches quite easy to use ($\underline{M}$ = **4.3**, $\underline{SD}$ = **1.06**). It was observed that whilst the handles supported participants, they could also easily operate the switches with their thumbs. However, one participant did tend to press down on the switches unintentionally when holding onto the handles. Two participants with arthritis did have some difficulty pressing the switches and their thumbs became tired and painful and may not be an appropriate input method for those with arthritis - *'I had a bit of problem holding down the switches constantly while walking".*

The majority of participants found the switches quite easy to learn (M =**4.4**, SD = **1.14**). However, one participant found them difficult to learn, and said that they would require constant reminding about how to operate the walking aid. Another participant said they needed more time with PAM-AID and more practice – *"it was difficult at the start but in the end easy".*

Participants also found the configuration of the switches intuitive and easy to remember (M = **4.3**, SD = **1.06**) *"absolutely spot-on, I think a child could operate it"* and *"I could remember all immediately".* One participant found it was easy to remember forwards and backwards, but needed prompting for the left and right directions. It was interesting to notice that those participants who had been car drivers before the loss of their vision, operated the walking aid with efficiency. Indeed, participants often used driving metaphors when walking with aid, for example, the left and right switches were compared to the indicators in a car. Furthermore, as participants became more familiar with the walking aid, performance improved.

Table 4.6 Mean ratings for switch input (n=16)

Switches	M	SD
Ease of use	4.3	1.06
Ease of learning	4.4	1.14
Ease of remembering	4.3	1.06

Two participants commented that they disliked operating the walking aid with the switches but the remaining 14 stated that they liked the switches – *"I* *enjoyed operating it - it is like operating my radio tape recorder"* and *"easy to just press them".*

One participant was concerned that *"it would be easy to put your thumb on the square one by mistake for the round one".* Another participant was worried about having to press down on the switches all the time *"my thumb might get tired".*

One participant made the suggestion that the walking aid could incorporate a pre-set route. The individual could just hold on to the walking aid for support and the walking aid would guide the user on a pre-set route and return to the starting point with no input from the user.

Recommendations:

® Retain the option of switch input for those users that would prefer this method of operating PAM-AID.

® Keep the configuration and positioning of the switches as they are easy to remember and easy to use.

® An alternative input method must be provided for those users who cannot use or do not like to use the input switches.

4.5.1.2 Voice input

Participants were introduced to the idea of voice input as a method of operating PAM-AID. Six liked the idea of using voice input *"it would be even better than switches".* Six participants disliked the idea, three were not sure and one participant preferred the switches to operate PAM-AID.

Overall, participants were not sure whether they would find it embarrassing speaking to PAM-AID (M = **3.78**, SD = **1.06**). Opinions differed among participants, for example, whereas one participant was *"not bothered about what people think"*, another commented that they *"would be worried that people would think I was talking to myself"*. One participant felt that it could be hazardous under some conditions - *"in a crowded situation it would be more dangerous than embarrassing"*. Another participant decided that it would be bewildering – *"it would confuse me altogether"*.

Recommendations:

® An evaluation should be carried out to investigate whether voice input is a viable input option within a residential home setting and to establish user reaction to voice input.

4.5.2 Bicycle handlebar design

Overall, participants found that the bicycle handlebar was supportive – *"very supportive, just like a bicycle"*. For this evaluation, it was decided that the handlebar should not move (i) to test whether the handlebar design was supportive enough and (ii) to avoid confusing participants during the automatic mode, as the previous instrumental handle design had caused confusion during the previous evaluation. However, 12 participants commented that they would like the bicycle handlebar to move so that they could direct PAM-AID to the left and right instead of using the switches - *"I would prefer moving bicycle handles, and did wonder why it was necessary to have the switches at all, it would be more natural to turn the handles like a bicycle"*. Although some participants found the switches were fun to use, they did say that *"moving the [bicycle] handles would simplify it"*.

Recommendations:

® Moveable bicycle handles should be implemented and evaluated by participants.

4.5.3 Automatic and manual modes of operation

Participants had the opportunity to operate the walking aid with the automatic and manual modes, and were asked after the practical trials which mode was preferred. Six opted for automatic - *"I preferred it when it was going itself"*, whereas six preferred the manual mode – *"I would like to press the switches and choose what I want to do"*. Four participants had no preference.

Recommendations:

® Both modes of operation should be retained so that users have a choice between the modes.

4.5.4 Speed & quality of motion

Eight participants found the speed of PAM-AID too slow and the other eight found the speed about right. Nine participants stated they would like to be able to change the speed of the PAM-AID walking aid – *"sometimes you may want it to go slower if lots of people are around and other times you may want to walk faster"*. Five participants commented that PAM-AID should be set at just one speed that was right for the individual.

PAM-AID reversed at the same speed as it moved forwards. All participants found the speed too fast when reversing. The backward motion of the walking aid tended to catch participants off balance. Walking backwards for most participants was very disconcerting and their balance was not as stable as when they were walking forwards. A mobility trainer of visually impaired people was consulted for her opinion and she explained that when visually impaired people are given mobility training, they are made aware of the dangers when walking. Visually impaired people are taught never to walk backwards as they are placing their feet into 'unknown territory' and this is unsafe. When walking forwards they are able to use a navigational aid to establish whether the area is safe or not before stepping into it. Therefore, if a visually impaired person needs to move backwards, they are taught to 'turn on-the-spot' as this is much safer.

Fifteen participants described the movement of the PAM-AID walking aid along the corridor as smooth - *"lovely and smooth"* and *"little bit jerky when starting, smooth when going"*.

Recommendations:

® Some design modifications need to be made so users can turn on the spot.

® The speed of PAM-AID needs to be altered according to the user's preferred walking speed. This needs more investigation.

4.5.5 Efficiency of PAM-AID

Participants felt the walking aid was an efficient walking aid (M = **4.2**, SD = **1.06**). Positive comments made were *"it would be a wonderful help, it would give people confidence"* and *"it was very supportive, as I have balance problems normally"*.

4.5.6 Technology acceptance

As in the previous evaluation, some tentative investigations were made into the attitudes of elders towards PAM-AID. Since no applicable measurement tool was available, some questions were drawn from the two constructs identified in the Technology Acceptance Model (Davis, 1986): perceived ease of use and perceived usefulness. These questions were the same as those used in the first evaluation so that comparisons could be made between the two studies. As noted before, these are not taken to be valid or reliable measurements of attitudes but they have provided a basis for questioning elders about their attitudes to PAM-AID and have shown some interesting results.

Perceived ease of use (PEU) was rated as fairly high (M = **3.8**, SD = **1.33**) but participants did give suggestions for how the usability of PAM-AID could be improved. This included making the bicycle handlebar move instead of using the switches and also to find a solution to the problem of reversing.

When asked whether participants felt that the PAM-AID would be useful to them personally (PEU Self), participants gave the walking aid a fairly low mean rating meaning that they thought that PAM-AID was not very useful to them (M = **2.6**, SD = **1.31**) – *"I'm too old to learn a new skill"*. Although participants thought that PAM-AID would be quite useful for other frail, visually impaired elders (PEU Others) (M = **4.0**, SD = **0.63**) – *"very useful for blind people" (see Table 6.4).*

Table 4.7 Technology acceptance

Technology acceptance	M Evaluation First prototype (n = 38)	M Evaluation Second prototype (n = 16)
PEU	3.5	3.8
PEU Self	3.0	2.6
PEU Others	4.3	4.0

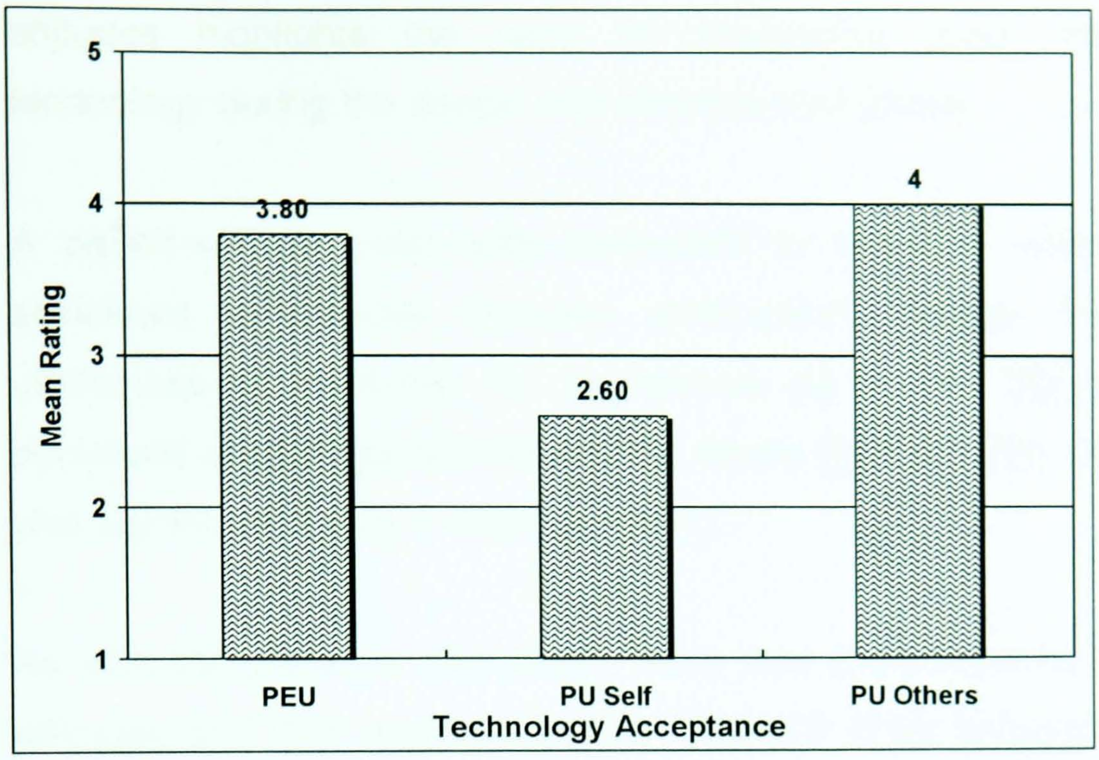


Figure 4.6 Perceived ease of use, perceived usefulness for self & others

Comparisons could be made between the mean ratings of the first evaluation with the second. An independent samples t-test showed that there were no significant differences between the ratings given by participants in the first evaluation and the participants given in the second evaluation. Therefore, participants' ratings were consistent across the two evaluations.

There was a small increase in participants' ratings regarding the ease of use of PAM-AID between the two prototypes. This is not unexpected since the iterative design process aims to improve usability, of which *ease of use* is a key component (Nielsen, 1993). Interestingly, there was a small decrease in the mean rating given by participants regarding the usefulness of PAM-AID to one self. Even though design improvements had been made to the PAM-AID prototype to increase usability and to meet the needs of users, this drop in their mean rating may be indicative of a reluctance to accept PAM-AID as a useful assistive technology. However, participants still perceive PAM-AID to be useful to other frail, visually impaired people, suggesting that they (i) do not think they have a need for a device like PAM-AID and/or (ii) they are resisting any change from their existing walking aids. This paradox in attitudes highlights the need for measuring users' attitudes towards technology during the design and development phase.

A paired-sample t-test was conducted to establish whether there were significant differences between participants' ratings for (i) perceived usefulness of PAM-AID for themselves ($\underline{M}$ = **2.6**, $\underline{SD}$ = **1.31**) and (ii) perceived usefulness of PAM-AID for others ($\underline{M}$ = **4.0**, $\underline{SD}$ = **0.63**). The result was significant ($\underline{t}$ (15) = -4.04, $\underline{p}$ = .001).

As with the previous evaluation, there was a discrepancy between elders' attitudes and their intention to use PAM-AID (their behaviour), showing the complexity of the attitude-behaviour relation. It is important to measure individuals' attitudes towards technology to inform the design of more acceptable technology. Although Davis' TAM was not very suitable for measuring elders' attitudes to PAM-AID during this study and showed that there is a need for a valid and reliable measure applicable to technologies such as PAM-AID.

Recommendations:

® Develop a valid and reliable scale for measuring attitudes to PAM-AID and other technologies since the Technology Acceptance Model is not very applicable to PAM-AID.

4.6 *Summary of the evaluation of prototype 2*

The second evaluation of the improved PAM-AID prototype with frail elderly visually impaired people yielded some interesting information. The design of the input switches were improved in line with the recommendations given by participants in the first evaluation of the prototype, and it was one aim of this evaluation to test the usability of the design changes made to the switches.

The input switches were well received by participants, and in general, they found them very easy to remember and learn and very easy to use. However, the switches were difficult to use for those participants who had arthritis in their hands and another method of input would suit these users better. There are two possible alternatives to the switches for those participants who were unable to operate or did not like the switches: moveable handles or voice input.

The handlebar design had been changed to a bicycle handlebar since the previous evaluation. It was decided that for this prototype the handles should not move for two reasons (i) to test whether the new handlebar design was supportive enough for frail elders and (ii) to avoid the confusion that participants had experienced with the instrumental handles in the previous study. However, many of the participants commented that they would like the handles to move to the left and right like a conventional bicycle handlebar, as this would be easier than using the switches. Since many of the participants had ridden a bicycle when they were younger, moveable handlebars would be intuitive to these participants. Although, the bicycle handlebar may also be intuitive to those elders who had never ridden a bicycle. The handlebar had shown that it was very supportive of participants whilst walking unlike the instrumental handles and so moveable handles could be implemented in the next prototype for evaluation. However, these handles should only move in the manual mode and become locked during the automatic mode, so that users do not get confused and think that they are directing the aid in the automatic mode.

Although voice input was not implemented for this evaluation mainly due to technical difficulties, participants were introduced to this as a possible alternative to switch input. As in the user requirements study, there was a mixed response from participants. Although some participants thought this might be a fun way to operate PAM-AID, many of them said they would find it embarrassing talking out loud to their walking aid. Some participants were concerned that it would not be a practical method in a noisy nursing home. Some further investigation is needed to find whether voice input has any use for this user group and to discover the technical problems posed with using voice input in a fairly noisy environment such as a residential home.

This evaluation showed that the automatic and the manual modes of operation provided users with a choice regarding the operation of PAM-AID. As with the previous evaluation, the automatic mode proved to be a good introduction to PAM-AID because it required little operation from the user, and for more confident participants, the manual mode could be used to direct PAM-AID.

One interesting observation made during this evaluation was that PAM-AID was not able to meet the needs of participants when they wanted to turn around. Participants had to reverse and walk backwards which is not safe for frail visually impaired people. Mobility training for visually impaired people encourages them to 'turn on the spot', as this is far safer than stepping backwards into an area that they cannot see. For example, the person may step backwards and there may be an obstacle behind them or a dangerous drop such a flight of stairs. Therefore, the PAM-AID technical specification would need to be altered so that the wheels on PAM-AID can swivel allowing users to turn on the spot.

Overall, the pre-set speed of PAM-AID did not meet the requirements of most participants. Some participants found the speed to be too slow and others found the speed to be about right. This is a problem that needs to be rectified. Some solutions to this problem have been proposed such as programming PAM-AID to move at different user's preferred walking speeds. However, most people like to vary their walking speed depending on the situation and so this solution may not be a very practical one. Another solution would be to remove the motors that drive the wheels of PAM-AID, so users can control the speed. Motors would still be retained to control the steering of the walking aid so that the user is guided safely around obstacles.

Participants' attitudes to PAM-AID were addressed during this evaluation using the same questions that were used in the previous evaluation so that comparisons could be made. Participants in the current study rated PAM-AID as fairly easy to use. The results showed an increase in the mean ratings given for ease of use and quite useful for other frail visually impaired people. However, participants did not think that PAM-AID would be very useful for them personally as they gave a fairly low rating. This is consistent with the response from participants in the first evaluation study. Their ratings for others were very different when they had to rate for themselves. This gives an indication that although elders can see the benefits of PAM-AID as a walking aid for people with similar mobility problems to themselves, they may still be resistant to adopting this technology. Therefore, it is important to understand the complexity of elders' attitudes towards PAM-AID, so that methods can be employed to promote more positive attitudes and acceptance among elders.

The limitations of TAM for measuring elders' attitudes towards PAM-AID have been noted and a new measure of attitudes to technology is needed. It would have been useful to measure participants' attitudes to PAM-AID during both of the evaluations conducted, not only so that participants' attitudes could be measured in parallel with the iterative design changes, but also to gain an indication of potential future usage of PAM-AID.

This study has highlighted the need for a scale that measures users' attitudes to technology and in particular a scale that can be used with user groups that have special requirements such as those participants who took part in this study. Consequently, the author embarked upon developing an attitude scale that would measure users' attitudes towards technologies with the intention that it would be used in further studies during the PAM-AID Project. Further PAM-AID prototypes were developed and tested with users before becoming a commercial device (see Chapter 8) although these are not reported in this thesis. Since the research in this first part of the thesis identified the need for a psychometric scale for measuring attitudes to technology, the research reported in the second half of this thesis, details the development of the Attitude to Technology Scale.

Chapter 5

The development of the Attitudes to Technology Scale

5.1 Introduction

The previous research within this thesis has focused on the establishment of the user requirements and the subsequent evaluations of the PAM-AID walking aid. The elderly participants who evaluated PAM-AID had fairly limited experience of technology and they displayed varying attitudes towards the PAM-AID walking aid. A scale for measuring people's attitudes to technology was needed so that the attitudes of this group could be measured throughout the design and development phase of PAM-AID. However, such a scale did not exist. A scale for measuring attitudes to technologies such as PAM-AID would be useful for a number of reasons.

- This age group has limited experience of technology and it would be informative to accurately measure their attitudes. This information would inform how the technology should be introduced to the user group as well as inform the level of training needed.

- As the design of PAM-AID was improved throughout the iterative design life cycle in accordance with the requirements of potential users, we would also expected users' attitudes to become more positive with each design iteration. If attitudes do not increase (positively) then this would indicate the need for further investigation into the requirements of users.

- It would be interesting to see if usability is correlated with attitudes i.e. if users perceive a piece of technology to be highly usable, is this reflected by users' positive attitudes to the technology?

- A scale measuring attitudes may also predict future use of and acceptance of the technology by users.

The PAM-AID project highlighted a need for a scale that could measure potential users' attitudes to technology. Many subjective measures are used in HCI research are unvalidated and their relationship to technology usage is unknown. As a consequence, the second half of this PhD research programme has involved the development of a scale to measure people's attitudes to technology, with the intention that this scale could be used during evaluation procedures. The idea for such a scale came to fruition during the PAM-AID project with elderly users as the project highlighted the need to measure users' attitudes of <u>all</u> ages during the development of technology. Not only would the attitudes of users of any age be of interest from a human factors point of view but also if the scale was developed to measure attitudes of people of all ages, then comparative analysis could be made across age groups for different technologies. Such a scale could provide rich information during evaluations and enhance the design of the technology.

This chapter details the development of a summated scale that can measure attitudes to technology of people of any age. The Attitudes to Technology Scale (ATS) is a universal scale that can be applied to different technologies. The scale has been designed so that the scale administrator can simply input the name of the technology into the space provided for each scale item. Subsequent chapters describe tests for the validity and reliability of the ATS across different technologies and samples.

5.1.1 Stages of scale construction

Before embarking on the development of a scale that measures attitudes to technology, the author reviewed the literature of existing scales that measure attitudes to computers (see section 2.7). This provided an overview of the process of scale development of a number of published scales that purport to be valid and reliable measures of computer attitudes and anxieties. The development of these scales has involved the scale developers creating an initial item pool from past literature and not from expert consultation or exploratory research such as focus groups. For instance, Davis (2001) generated his 14 items for the TAM from past literature before conducting pre-test interviews to establish the semantic content of the items. Dambrot et al., (1985) derived the items for the CATT from previous research and observations about people's attitudes toward computers. The scale was then given to a sample of individuals for scoring and following this, a high internal reliability coefficient was obtained (.84). Content validity for the CATT was obtained by correlating the new scale with an established scale (Fennema-Sherman Math Anxiety Scale, 1976). Further evidence for validity was given from studies correlating the CATT with other valid and reliable measures. Of course, the results of these studies very much depends on the development quality of the comparison scales. Many of these scales have formed the basis of the body of research investigating attitudes and anxieties to computer technology. If there is any doubt over the validity and reliability of these scales then a large proportion of research must be questioned.

However, Raub (1981) developed the initial item pool of the Attitudes Towards Computers Scale (ATC) by interviewing individuals for whom the scale was designed for, as well reviewing the relevant literature. Conducting interviews in conjunction with a literature review enhanced the quality of the initial item pool. The ATCUS (Popovitch, Hyde & Zakrajsek, 1987) established an item pool from previous literature and a pilot survey. Following these examples, the initial item pool developed for the ATS not only involve a review of the literature but also included a consultation with experts.

The development of the ATS has followed an iterative process whereby the development has followed 5 major stages *(Figure 5.1).* This chapter describes the work undertaken to fulfil the first four stages and the following two chapters will detail the final stage of validation. The approach taken in the development of the scale is an *inductive* one and is strongly recommended by Spector (1992). This means that the scale development process begins with a clearly defined construct from which hypotheses can be constructed for validation of the scale. This approach contrasts to the *deductive* approach taken by many scale developers, which involves administrating items to participants and then taking an exploratory approach to analysing the data. This usually takes the form of factor analysis but great caution must be taken since "almost any group of correlated items is bound to result in factors that can be given meaning" (Spector, page 13). Thus the inductive approach is recommended for scale development and this was the approach taken for the development of the ATS.

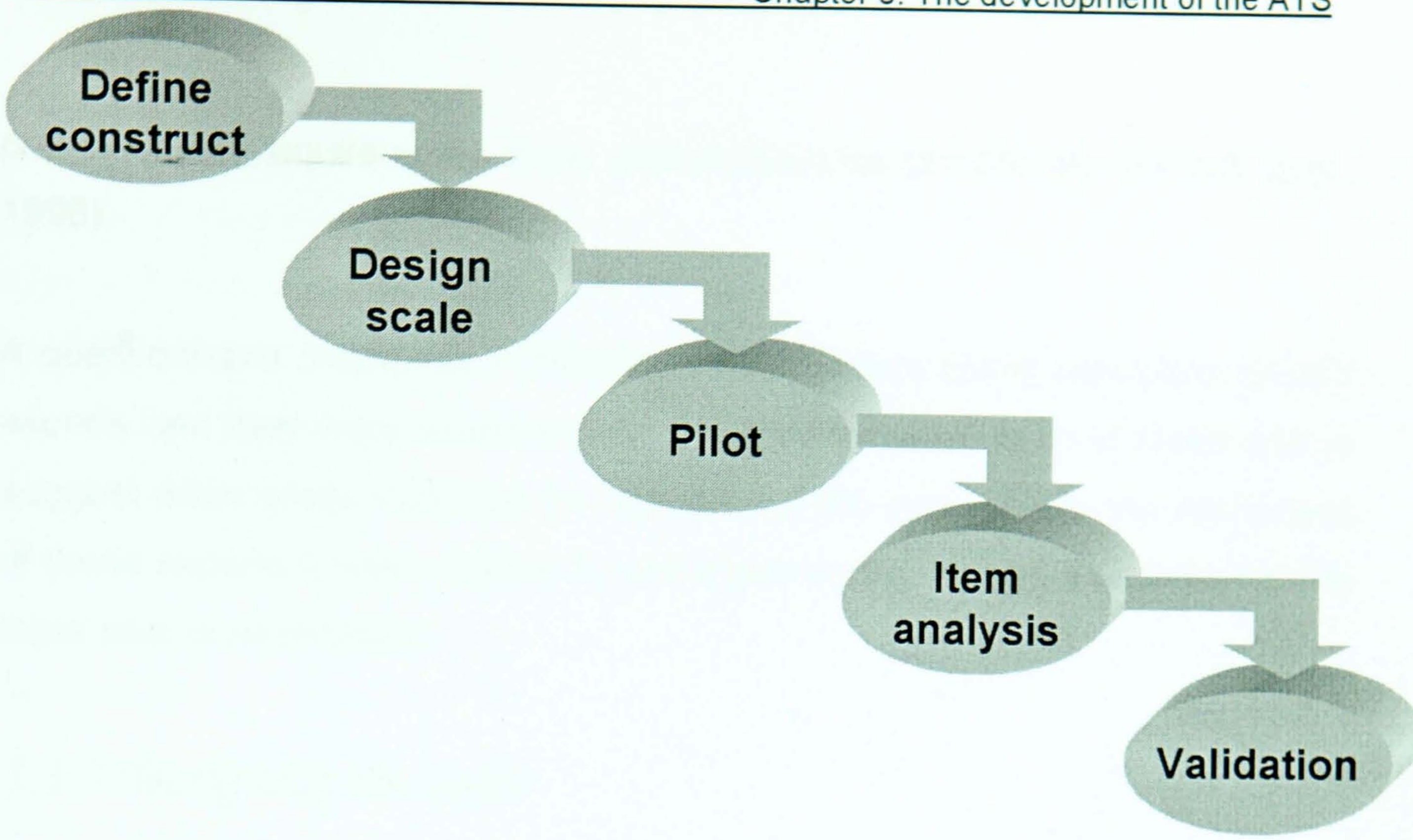


Figure 5.1 The 5 major stages of developing a summated rating scale (Spector, 1992)

5.1.2 Defining the construct

Initially, the construct of interest was defined; the new scale would measure people's attitudes to different types of technology. In order to precisely define the construct of interest and to ensure that good items for the scale would be produced, a number of content areas need to be generated. To generate these content areas, Golombok and Rust (1992) proposed that experts in the field of interest be consulted. Experts in the field of Human-Computer Interaction (HCI) were consulted to produce content areas. This ensures content validity from the outset of scale development (Kline, 1986). A literature review was conducted and a number of content areas were initially generated from usability research - Nielsen's 5 usability criteria were included (Nielsen, 1993) and technology acceptance research - Davis' two factors, perceived ease of use and perceived usefulness were included (Davis, 1986; Davis 1989). Furthermore, research into attitudes towards computers was included (Dambrot et al., 1985; Hollins, 1989; Nickell & Pinto, 1986; Popovitch et al., 1987), as well as other factors that had arisen in the previous user requirements study and evaluations of PAM-AID (O'Neill et al., 1998).

A questionnaire *(Appendix I)* detailing these content areas was given to HCI experts and they were asked to rate the importance of each of these and to suggest other areas that may be relevant for the scale. From the responses of these experts it was possible to turn these content areas into items for the initial pilot questionnaire.

5.1.3 Designing the scale

The summated rating scale was initially developed by Likert (1932) specifically for the assessment of attitudes. The four main characteristics of a summated rating scale are (i) the scale must consist of multiple items, (ii) each item must represent something that can vary quantitatively, such as attitudes which can vary from positive to negative (iii) each item should have no 'right answer' unlike a multiple choice test and (iv) each item must be a statement, so that respondents can rate the statement (Spector, 1992). The first version of the pilot questionnaire consisted of 43 items developed from the suggestions of the HCI experts. Items were carefully worded so that they were clear, concise, unambiguous and concrete. The instructions asked respondents to rate each of the statements using a 5-point Likert scale, where 1 = *strongly disagree*, 2 = *disagree*, 3 = *not sure*, 4 = *agree*, 5 = *strongly agree*. Respondents were asked to rate how much they agreed or disagreed with the item using the response choices available. A balanced number of positive and negative items were used to reduce the possibility of response bias.

5.1.4 Factor analysis

The first full administration of the questionnaire was given to 200 participants and their responses were subsequently analysed using factor analysis.

Factor analysis is a statistical procedure used in the process of scale development to reduce the number of items to a smaller number of underlying factors. These factors are derived from the analysis of the intercorrelations between items. Factors are formed when groups of items correlate with one another more strongly than they relate to other groups of items. If meaningful factors are found, these can be indicators of separate constructs or different aspects of a single heterogeneous construct. A note of caution is that the results of factor analysis are wholly dependant upon the number and quality of the items entered. Thus, it is recommended that great care be taken to ensure that items are based upon well-researched content areas and that items are well worded.

In the current study, a principal components factor analytic model was used, which produces one factor per item. It is then that the number of factors that best represents the items can be decided. This is usually based upon the inspection of the eigenvalues, which represents the relative proportion of variance accounted for by each factor. Where the items form several factors, each will have an eigenvalue of more than one and this indicates that it accounts for more variance than a single item.

Once the number of factors has been decided, the factors can be rotated to simplify the correlation matrix and produce factor loadings that are correlations between each original variable with each factor. A minimum of .30 to .35 is required for a variable to 'load' onto a factor.

5.1.5 Item analysis

In order to produce a scale suitable for validation, it is first necessary to run an item analysis. This enables the scale developer to assess the status of the scale before proceeding to the next stage. Item analysis requires a sample of about 100 to 200 respondents (Spector, 1992). For example, the initial sample for the Work Locus of Control Scale was 149 (Spector, 1989) and so the initial sample of the ATS was 200. An item analysis is used to identify the items that produce an internally consistent scale so that these could be retained and to find those items that are not internally consistent so that they can be eliminated. If a scale is internally consistent, then all the items intercorrelate and measure the same construct. If the items fail to correlate with each other then this implies that they do not measure the same underlying construct and would not contribute to a reliable summated rating scale. The item analysis was conducted on the data gathered from the pilot of the 43-item scale.

This chapter reports on the first four stages of the scale construction detailed above: defining the construct; designing the scale; piloting the questionnaire and conducting an item analysis. This study was conducted in two parts and is documented below.

5.2 Method

Part 1 of this study involved defining the construct for the scale and this was addressed by consulting experts in the field of HCI. Following this, the pilot questionnaire was designed. Part 2 of this study involved the next two stages of scale development, piloting the questionnaire and conducting the item analysis.

5.2.1 Part 1: Participants

15 participants took part in first part of this study, all of whom were experts in the field of Human-Computer-Interaction (HCI) with backgrounds in psychology and computer science, and at the time, were involved in the design, development and evaluation of systems (not just computers) (see Table 5.1). Nine of the participants were male and 6 were female. The mean age of participants was 39.2 years.

Table 5.1 Field of expertise of participants

Participant	Field of expertise
1	PhD student: HCI
2	PhD student: Psychology
3	Research psychologist: HCI
4	Professor : HCI
5	Research psychologist: HCI
6	Researcher: HCI & RT
7	Researcher: IT
8	Professor: HCI
9	Lecturer: Computing Science/HCI
10	Professor: Computing Science/HCI
11	Professor: Computing Science/HCI
12	Lecturer: Computing Science/HCI
13	Lecturer: Computing Science/HCI
14	Lecturer: Psychology
15	PhD: Psychology

5.2.2 Part 2: Participants

5.2.2.1 Sample size and selection

A sample of 200 participants participated in the second part of this study, 85 were male and 111 were female (4 did not specify). This size sample was chosen because a sample of between 100 and 200 is needed for item analysis (Spector, 1992). Furthermore, to obtain replicable factor analysis, sample sizes of about 200 are required (the minimum sample being 100) (Kline, 1986).

5.2.2.2 Participant characteristics

Participants were recruited via advertisements placed within the University of Hertfordshire, and they were also posted to other Universities within the UK for distribution. Questionnaires were also sent to different work organisations for distribution among the employees, so employees would have a variety of occupational backgrounds. Of the sample, 44% were students but 52% of participants were in jobs ranging from administrative occupations (e.g. receptionist) to manual jobs (e.g. factory operator, drivers, builders) to public services (e.g. librarians, teachers, police officers, social worker) to professions (e.g. surveyors, accountants, Directors). Only 4% were not in paid work, one participant was unemployed, 5 were retired and two were housewives.

The ages of the participants ranged between 14 years and 75 years of age, giving a mean age 34.4 years.

76% of the participants were British and the remaining 24% of participants came from 23 other countries around the world.

5.2.3 Design

5.2.3.1 Part 1: Defining the construct and designing the pilot questionnaire

Eleven content areas were generated from the literature (see Introduction). These content areas were presented as items on a questionnaire *(Appendix I)*, which was distributed among the HCI experts. Experts were asked to rate how much they agreed or disagreed with each of the statements and to suggest other areas that may be important when measuring people's attitudes to technology. The results provided a number of content areas, which were worded into 43 items for the initial pilot questionnaire.

5.2.3.2 Part 2: Pilot stage and item analysis stage

The 43-item pilot questionnaire was given to 200 people of varying ages and from varying occupations. The data were analysed using principal components factor analysis and item analysis.

5.2.4 Measures

5.2.4.1 Part 1: Questionnaire for experts

The questionnaire given to HCI experts included 11 items *(Appendix I)* and participants were asked to rate how much they agreed or disagreed with each statement (1 = *strongly disagree* to 5 = *strongly agree*). Participants were also asked to suggest other areas that may be important when measuring people's attitudes to technology.

5.2.4.2 Part 2: Pilot questionnaire

The response choice chosen for this scale was that of *agreement*, whereby the respondent indicates the extent to which they agree or disagree with each statement. A 5-point bipolar response scale was chosen, with *strongly disagree* at one extreme and *strongly agree* at the other extreme and with a neutral central point. A total score for the scale would therefore be calculated by adding the numbers associated each response i.e. 1 = *strongly disagree*, 2 = *disagree*, 3 = *neither*, 4 = *agree* and 5 = *strongly agree*. Negatively worded items were reverse scored.

The pilot questionnaire *(Appendix J)* was designed so that the name of any technology could be inserted into the items, making it a universal tool for measuring attitudes to technology.

For example: ________________ are efficient

The pilot questionnaire consisted of 3 sections:

(i) Nine items establishing participants' level of use of different types of technology
(ii) Six items establishing participants' use of the specific piece of technology under investigation
(iii) 43 items measuring attitudes to the specific piece of technology under investigation

Items were worded positively and negatively to avoid acquiescence bias, and a 5-point Likert scale was used (1 = *strongly disagree*, 5 = *strongly agree*).

5.2.5 Procedure

5.2.5.1 Part 1: Expert consultation and designing the scale

Questionnaires were sent to participants to complete in their own time. All 15 experts completed and returned the questionnaires. Mean ratings were calculated for each of the items as well as the percentages for responses on each of the 5-points on the scale.

Based on the consultation with experts, items could be written for the pilot.

Kline (1986) commented that "a test can be no better (but it can be worse) than its items", and so the following three guidelines were adhered to when the items were worded for the pilot scale (Spector, 1992).

1. *Each item should be unambiguous.* If an item can be interpreted in more than one way, then the participant will be confused and the item will be invalid.

2. ***Use both positively and negatively worded items.*** This reduces response bias such as acquiescence bias whereby participants tend to agree (or disagree) with all the items. These participants will have extreme scores, which will distort analysis conducted on the sample scores.

3. ***Avoid colloquialisms, expressions and jargon.*** Word items using plain language. Avoid using terms that are culturally specific, as people from different cultures may not understand the connotations. Avoid language that is time specific, that is, expressions that are understood now may not be understood in 10 years from now

5.2.5.2 Part 2: Pilot study

As the scale is intended to be used for any technology, the pilot study gathered data on three different types of technology used in three different domains (i) Microwaves (home-based technology); (ii) ATMs (public technology) and (iii) Computers (home-based & workplace). Therefore, each participant completed one large questionnaire that consisted of three copies of the ATS, each copy focusing on one of the three technologies listed above. The order of the three questionnaires was randomised. The data were analysed using principal components factor analysis and item analysis.

5.3 Results

5.3.1 Part 1: Expert consultation

The purpose of this part of the study was to verify the content areas that had been chosen from the literature with those experts in the field of HCI. Table 5.2 details the participants' ratings for each of the items from the questionnaire as well as the percentage of participants who responded to each of the responses on the 5-point scale. These responses helped to confirm whether the area was important enough to be included in the pilot scale.

Table 5.2 Participants' ratings and response percentages

Item	1 Strongly Disagree %	2 Disagree %	3 Neither %	4 Agree %	5 Strongly agree %	M
1. Perceived to be useful	-	-	-	40	60	4.6
2. Learning to use it, is easy	-	6		54	40	4.3
3. Rarely makes errors/goes wrong	-	10	10	53	27	3.9
4. It is perceived to be safe	-	20	20	33	27	3.6
5. It is efficient to use	-	7	7	60	26	4.1
6. It improves quality of life	-	-	7	80	13	4.1
7. It is easy to remember how to use	-	7	12	27	54	4.3
8. It is perceived to be easy to use	-	6	6	50	38	4.2
9. It is pleasant to use	-	-	27	40	33	4.1
10. It is aesthetically pleasing	-	7	42	49	-	3.5
11. It does not cause anxiety	-	7	20	60	13	3.8

Participants also suggested other possible areas to be included in the scale. Many participants suggested the same areas, which are listed below, with some of their comments.

1. It is important for a piece of technology to support the task for which it was intended.

"it is more efficient/easier to do a task with the technology than without it"

"perceived to support the task (also if it is perceived to support more than one task e.g. fax & answering machine, washer & dryer, fridge & freezer)"

"fulfils task I need help with or can't otherwise do"

2. People's attitudes to technology and their subsequent use of it is very dependent upon how fashionable it is, how well marketed it is and whether one's peers use it.

"Fashion, hype, image, other (important) people that have accepted it"

"having the technology gives you the owner/user prestige"

"street cred"

"publicity - seen on TV"

"other people, similar to myself (peer group) use it"

"Peer pressure, social pressure and market pressure"

3. People's attitudes are influenced by the cost of the technology and one's own subjective assessment of whether the technology is worth the investment.

"Value for money"

"Cost should be perceived as realistic for the task it performs. People may say they couldn't live without their microwave or VCR but would not necessarily be prepared to pay £1000s"

"saves money"

4. It is important if the technology comes with support materials such as a manual or online help system.

"If it has adequate instructions/training in how to use (simple and easy to understand). Could be summed up as provision of adequate training materials."

"Availability of external help (such as a help desk, hotline)"

"the device itself guides you through its use"

5. Technology should be rewarding in some way.

"it presents a rewarding challenge (e.g. chess, computer games)"

"provides a leisure facility"

6. For many people, technology is used because it is time saving and allows them to perform tasks quickly.

"saves time"

"They are faster than alternatives"

7. Another area that was suggested was safety.

"People still use technology that they do not perceive to be safe: mobile phones, photocopiers, nuclear reactors."

8. Sometimes people use a technology because it is the only option available or the best option available, but they may not have a very positive attitude towards it.

"Management tells you to use it"

"Alternatives are no longer supported/available"

"It may be the only option or best option available but may not fulfil the criteria"

These areas all informed the choice and wording of the items for the pilot scale.

5.3.2 Part 2: Pilot study

5.3.2.1 Factor analysis

200 questionnaires were completed for microwaves, 200 for ATMs and 200 for computers. Separate principal components factor analyses with varimax rotation were performed on the items for each of the individual technologies. Examination of the plotted values using Cattell's scree test (Cattell, 1966) suggested a clear 3-factor solution for each of the technologies, which accounted for **42%** of the total variance for Microwaves, **36%** for ATMs and **38%** of the total variance for computers. Factor 1 was labelled ***Confidence***

and contained a large number of negative attitude items relating to one's own confidence *(Table 5.3)*. Factor 2 was labelled ***Performance*** and contained items that relating to the performance of the technology *(Table 5.3)*. Factor 3 included items relating to fashion, image and peer usage and was labelled ***Fashion*** *(Table 5.4)*.

5.3.2.2 Scale reduction

Criteria were set to reduce the number of items in the scale. Items were retained if:

(i) they loaded onto a factor across 2 or 3 of the technologies because these items were applicable across different types of technologies and,
(ii) their factor loadings were .30 and above (Kline, 1986).

Table 5.3 Loadings of Factor 1 Items: *Confidence*

Item	Microwaves	ATMs	Computers
____________ make me nervous	.76	.75	.80
I have difficulty remembering how to use a ____________	.77	.73	.80
I feel anxious when using a _______	.71	.72	.76
I can confidently operate a ________	.73	.78	.75
When I use a _______ I am afraid I will break it	.51	.43	.69
Learning to use a _________ is easy	.73	.65	.67
I often need to refer to a manual for help	.74	.68	.66
____________ are rather difficult to use	.81	.67	.65
____________ are the best option for the job	-	.65	.59

Note that loadings < .30 are blank

Table 5.4 Loadings of Factor 2 Items: *Performance*

Item	Microwaves	ATMs	Computers
___________ are value for money	.64	.55	.69
___________ are efficient	.73	.60	.57
___________ have many useful features	.57	.42	.57
A _________ helps me to do a task effectively	.72	.48	.52
___________ are unreliable	.58	.48	.51
___________ are reliable	.65	.69	.50
___________ do not make life easier	.53	.56	.48
___________ are too expensive	.37	.34	.47
___________ are not any faster than alternatives	.52	.41	.31

Note that loadings < .30 are blank

Table 5.5 Loadings of Factor 3 Items: *Fashion*

Item	Microwaves	ATMs	Computers
Fashionable people use _________	.64	.62	.38
___________ are not fashionable items	.52	.40	.27
I have no choice but to use a _____	- .71	- .37	- .56
I could not manage without _______	.49	-	.67
Using a __________ is good for my image	.73	-	.37
A _________ helps me to do things I would otherwise not be able to do	.47	-	.53
I use a ________________ because lots of other people use one	.44	.66	-

Note that loadings < .30 are blank

5.3.2.3 Item analysis

In order to refine the scale further, an item analysis was conducted on the items within each subscale, to establish which items formed an internally consistent scale and which items needed to be eliminated. The item analysis provided the item-remainder coefficient for each item. Those items with high coefficients were retained i.e. those above .40 (DeVellis, 1991). The internal consistency was measured by Cronbach Alpha, which involved the comparison of the variance of the total scale score with the variances of the individual items. For a scale to demonstrate consistency, the alpha should be at least .70. Items with low coefficients were deleted and the new alpha checked. The subscales demonstrated that they had high internal consistency *(Table 5.7).*

Table 5.6 Cronbach Alphas calculated for each of the subscales

Subscale	Alpha
Performance Factor	.91
Confidence Factor	.85
Fashion Factor	.84

Once items had been selected for each subscale, an item analysis was conducted on all remaining items, to establish the level of internal consistency of the final scale. Alpha was calculated for the data collected for Microwaves, ATMs and Computers all of which maintained alphas of >.80 *(Table 5.8).*

Table 5.7 Cronbach Alphas calculated for the final 18-item scale

Technology	Alpha
Microwaves	.87
ATMs	.82
Computers	.81

The final scale consisted of 18 items *(see Appendix K)* and was named The Attitudes to Technology Scale (ATS).

5.4 Discussion

This chapter has detailed the first four stages of the development of the Attitudes to Technology Scale (ATS), which were carried out in this study. Part 1 of the study concentrated on defining the construct with the involvement of HCI experts to ensure construct validity of the pilot scale. Part 2 of the study involved the initial piloting of the scale with 200 participants, the reduction of the items using factor analysis and the item analysis, which provided an estimate of the scale's reliability.

Defining the construct for the ATS was a difficult task in that a scale measuring attitudes to different technologies has not been developed before. The relevant literature was the best starting point for this task but it was necessary to consult experts for verification of the chosen content areas and for further ideas for this scale. This was a fruitful exercise, in that it showed that there was agreement among experts for most of the content areas. The experts were chosen because of their knowledge covered the fields of technology, psychology and HCI. On reflection, it would have been worthwhile to consult people without any expertise in these areas to establish whether any other content areas would have emerged from users and non-users of technology. Focus groups with specific cohorts, such as the elderly, may have identified some particular areas related to elders' positive or negative attitudes to technology.

The experts provided additional comments that were also very useful, as they suggested areas that had not arisen from the review of the literature. For example, the suggestions of 'fashion/fashionability' and 'marketing' are all-important factors affecting people's attitudes towards technology and their acceptance of it. Indeed, the sharp increase in mobile phone sales in the UK

(40% of the UK population own a mobile phone, NOP, 2000) has been attributed to the fashion and status of owning and using mobile phones, the sales continue to rise despite the current controversial debate over possible health risks.

The results from the expert consultation informed the content areas for the pilot questionnaire and items were carefully worded. The questionnaire was piloted with 200 people; all completed three versions of the questionnaire, each version relating to a different technology. This meant that a large amount of data could be collected for three different types of technology (i) Microwaves (home-based technology), (ii) ATMs (public technology) and (iii) Computers (home-based & workplace). Factor analysis produced a clear 3-factor solution for each technology and these factors were subsequently named *Confidence*, *Performance* and *Fashion*. The scale was reduced based on two criteria: Items were removed if they did not load onto the same factor across two or three of the technologies and if their factor loadings were 0.3 or less.

The scale was refined even further using item analysis, identifying the items that formed an internally consistent scale and those items that needed to be removed. Those items with high coefficients were retained i.e. those above 0.4 (DeVellis, 1991). Each of the subscales demonstrated high internal consistency. Once items had been selected for each subscale, an item analysis was conducted on all remaining items, to establish the level of internal consistency of the final scale. The item analysis was conducted for the data collected for Microwaves, ATMs and Computers all of which maintained acceptable alphas of >.80. The final scale now consists of 18 items *(Appendix K)* and has been named The Attitudes to Technology Scale (ATS).

5.5 Summary

The Attitudes to Technology scale (ATS) is a novel concept in that it measures people's attitudes to different types of technology. Users of the ATS will be able to insert the name of the technology into the items making it a universally applicable scale. The development of the scale has followed a step-by-step process to produce a valid and reliable scale. Consulting experts meant that the scale items were generated from a valid foundation of relevant content areas. The piloting of the scale also enabled a factor analysis to be conducted, which identified 3 underlying meaningful factors and thus provided some initial evidence for the validity of the scale. An item analysis was conducted to establish the internal consistency of the scale and this should be monitored throughout development process.

Chapter 6

Establishing the construct validity & predictive power of the ATS

6.1 Introduction

Perhaps the most difficult aspect of scale construction is gaining evidence to show that the scale measures what it claims to measure. This strategy began at the very start of the development of the ATS. Experts were initially consulted to ensure that valid content areas were included in the initial pilot scale and the subsequent factor analysis demonstrated that the scale had some validity, since the items formed meaningful subscales (Chapter 5). It is however, necessary to conduct further studies to gather evidence for validity as the scale develops. This chapter continues the work that began in the previous chapter, gradually building the evidence of validity for the ATS, although this process must be an ongoing one and will continue beyond the confines of this research programme.

A study was conducted to gather evidence of construct validity by correlating the ATS with two other valid and reliable measures, one of which, was hypothesised to theoretically correlate with the ATS and one that would not. Cronbach and Meehl (1955) proposed that the variable measured by a scale or test should be viewed as a construct and so they introduced the concept of *construct validity*. To demonstrate construct validity, the scale developer must set a number of hypotheses based upon the research on the construct of interest. These hypotheses are then tested in a number of studies to establish if the results prove the hypotheses. Construct validity can include other forms of validity such as: Face validity, concurrent validity and predictive validity depending on the hypotheses being tested.

The study reported in this chapter also attempted to address whether the ATS could be used to predict individuals' *level of use* (usage) of a technology. If so, this may be a useful application of the scale. For example, designers and developers of new technology could use the ATS to gage the attitudes of potential users of a new technology whilst it is under development. Measuring potential users' attitudes could also give developers an indication of level of use and technology acceptance when undertaking usability studies.

Before this is detailed however, a small exercise is reported that was carried out to ascertain the face validity of the scale *(see section 6.1.1)*. The face validity or the appearance of a scale may appear obvious to the scale developer and as a consequence, it may be taken for granted that those for whom the scale is intended, will also be aware of its face validity. In other words, a scale is face valid if it appears to measure what it claims to measure to the respondents. This is an aspect of validity often viewed as trivial, but Kline (1986) suggests it is important for the motivation of participants. Simply asking participants whether the scale appears to be a good measure of the variable it is supposed to measure can assess face validity. This simple exercise is reported in the following section before the main study of this chapter.

6.1.1 Ascertaining the face validity of the ATS

In order to establish the face validity of the ATS and its subscales, ten participants were told that each of the items on the ATS fell into one of the three subscales: Confidence, Performance or Fashion. Participants were asked to judge which items belonged to which subscale to assess the face validity of each item. For this purpose, the ATS was adapted for the software **WORD**, which all participants were familiar with. Table 6.1 shows the percentage of participants who placed the item into one of the three categories, Performance, Confidence or Fashion.

Table 6.1 Percentage of participants who placed the item on each subscale

Item	Actual subscale	P %	C %	F %
1. WORD is efficient	P	90	10	-
2. WORD makes me nervous	C		100	-
3. WORD has many useful features	P	90	10	-
4. Fashionable people use WORD	F		10	90
5. I have difficulty remembering how to use WORD	C	20	70	10
6. WORD is reliable	P	90	10	-
7. I feel anxious when using WORD	C	-	100	-
8. WORD helps me to do a task effectively	P	80	20	
9. I can confidently operate a WORD	C	-	100	-
10. Learning to use WORD is easy	C	-	100	-
11. Using WORD is good for my image	F	-	-	100
12. I often need to refer to a help manual	C	20	80	-
13 WORD is rather difficult to use	C	30	70	-
14 WORD is the best option for the job	C	40	60	-
15. When I use WORD I am afraid I will break/crash it	C	20	80	-
16. WORD is value for money	P	100	-	-
17. Using WORD does not make life easier	P	100	-	-
18. I use a WORD because lots of people use it	F	-	-	100

(P = Performance; C = Confidence; F = Fashion)

Overall, the face validity of each of the items was very high, with most items being correctly placed (80-100% of the time). However, one item (14) was placed correctly under the subscale of Confidence only 60% of the time, and it was placed incorrectly 40% of the time under the subscale of Performance. Even so, item 14 was retained. Overall, this exercise has shown that the ATS appears to have very high face validity. The study reported below continues the work of establishing the validity of the ATS.

6.1.2 Establishing construct validity and predictive power of the ATS

The main study outlined in this chapter, began to gather evidence of construct validity by correlating the ATS with two other valid and reliable measures, one of which was hypothesised to theoretically correlate and one which was not hypothesised to correlate with the ATS. The ATS was adapted to measure people's attitudes to the Internet, a computer-related technology but one that could be viewed as a new technology in its own right. The two valid measures chosen for gathering evidence of construct validity were (i) The *Computer Attitudes Scale (CATT)* and (ii) The *State-Trait Anxiety Inventory (STAI)* trait scale only *(Y2 Form)*. These scales are outlined in more detail in section 6.2.3.

Firstly, it was hypothesised that there would be a high correlation between the CATT and the ATS. The ATS was applied to measure individuals' attitudes to the Internet during this study and since there was no comparable measure of attitudes to the Internet, a general computer attitude measure was used. Since the scoring systems are opposite on the CATT to the ATS, that is, a low score on the CATT indicates a positive attitude and a high score on the ATS indicates a positive attitude, then the ATS would negatively correlate with scores on the CATT.

Secondly, it was hypothesised that the Confidence and Performance subscales on the ATS would also correlate with the CATT, since these two subscales contain negative and positive items that are similar to those contained in the CATT. For instance, one item on the ATS Performance subscale is "The *Internet* helps me to do a task effectively" and another item on the ATS Confidence scale is "I feel anxious when using the *Internet*". On the CATT, comparable items are "I look forward to computers taking over certain routine tasks of my home and job" and "I feel very negative about computers in general". However, the Fashion scale on the ATS was quite unique and there were no comparable items from this scale with those on the CATT, therefore it was not expected that there would be a correlation between the ATS Fashion subscale and the CATT.

Thirdly, it was hypothesised that the STAI trait scale (measured by the STAI – Y2 Form) would not necessarily correlate with the ATS. This is because the STAI trait scale specifically measures individuals' predisposition to trait anxiety, whereas the ATS involves only some items that measure anxiety (on the Confidence subscale). The ATS is not an anxiety measure but a general attitude measure and includes items that do not just focus on anxiety. Hence, it was expected that the ATS and STAI scores would not correlate but if any correlation did occur between the two measures, it would only be of borderline significance.

Finally, the predictive power of the ATS was also to be examined to establish whether the ATS could be used to predict individuals' *level of use* of a technology. Analysis could be conducted to see if ATS scores could predict individuals' actual level of use of a technology.

Since this study would also generate a large amount of data regarding people's attitudes towards computers and the Internet, it was interesting to analyse the data in terms of sex and age differences. Although not the main aim of the study, it would be interesting to see whether age and sex were correlates of attitudes towards the Internet. Based on the review of the literature (Chapter 2), it was expected there could be significant differences between younger and older Internet users and between males and females in terms of their attitudes towards the Internet. In general, older individuals tend to have more negative attitudes towards computers than younger individuals and males tend to have more positive attitudes towards technology than females.

Finally, calculating the internal-consistency reliability gives an indication of how well the individual items of a scale, measure one underlying construct. This has been conducted in the previous chapter but even if a scale produces a high coefficient in the initial reliability analysis, it is important to replicate the analysis with subsequent samples (Spector, 1992). The coefficient alpha was calculated for ATS in Chapter 5 and it was shown to have high internal reliability consistency (>.80). Hence, a reliability analysis was conducted with the sample in the current study to establish the internal consistency of the ATS.

To summarise, the hypotheses of this study were:

H_1: There would be a significant correlation between the ATS and the CATT

H_2: There would be a significant correlation between the ATS Performance and Confidence subscales and the CATT

H_3: ATS scores can predict actual technology use

H_4: There would not be any correlation between the ATS and the STAI trait scale

H_5: Older participants would have significantly lower ATS scores than younger participants

H_6: Females would have significantly lower ATS scores than males

H_7: The ATS will have maintained its high level of internal consistency reliability

6.2 Method

6.2.1 Participants

Participants were opportunity sampled by advertising the study in the following ways:

- A poster was displayed on the Psychology Department notice-board at the University of Hertfordshire, to recruit Psychology and Cognitive Science students who are required to participate in research to gain course credits. Students were given a half-hour credit if they completed the on-line questionnaire for this study.

- Posters advertising the study were sent to a number of Universities across the UK, Europe, Australia and the USA, which were placed on notice boards to recruit participants.

- Announcements were placed on discussion lists specifically for people 50 years and above (e.g. University of the 3rd Age).

- Postings were placed on chat forums for people aged over 50 years (e.g. www.IDF50.com)

All 235 participants who took part in this study were computer users and users of the Internet. Of the 235 participants, 122 (51.9%) were male and 113 (48.1%) were female. The sample for this study consisted of nearly 50% of women. Previously, Internet users were predominantly male, but recent research has shown that the number of female Internet users is increasing year by year. The sample in the current study is consistent with a number of recent surveys, including a UK survey by ICM Research (2000) that found that 45% of those with Internet access are women and the 10th WWW user survey by the GVU (1998) that found that 52% of new users are female.

The age range of participants in this study was very broad with participants' ages ranging from 17 to 80 years, giving a mean age of 41.7 years. This is older than expected as the surveys mentioned above have found that the average age of Internet users is around 30 years of age.

Questionnaires were completed online from 21 countries around the world but the majority of respondents (70%) completed the questionnaire from the UK where the study was advertised more widely *(Table 6.2)*.

Table 6.2 Country of residence of participants who took in this study

Country	Frequency	Percent (%)
UK	167	71.1
USA	16	6.8
Australia	13	5.5
Brazil	12	5.2
New Zealand	5	2.2
Canada	4	1.7
South Africa	2	0.9
Israel	2	0.9
France	2	0.9
The Netherlands	1	0.4
Switzerland	1	0.4
Singapore	1	0.4
Saudi Arabia	1	0.4
Malaysia	1	0.4
Jordan	1	0.4
Japan	1	0.4
Hong Kong	1	0.4
Belgium	1	0.4
Ireland	1	0.4
Greece	1	0.4
Argentina	1	0.4
Total	235	100

50% of participants were in employment and these occupations ranged from professions (e.g. Civil engineers, lawyer, Doctor) to service industry jobs (e.g. market research, publishing) to the information technology field (e.g. IT manager, IT support) to public services (e.g. librarians, nurses).

For those not in paid work: 3.4% housewives, 21% retired, 3% unemployed, 23.4% students.

6.2.2 Design

The study had a 3-factor between-group quasi-experimental design, with one factor being **age group**, the second factor being **sex**, the third factor being **usage**. **Experience** was used as a covariate.

Table 6.3 Internet usage by sex and group

Internet Usage	Sex	Group 1 17- 40 years	Group 2 41 - 80 years	Total
Low	Male	11	20	31
	Female	22	20	42
		33	40	73
Medium	Male	16	24	40
	Female	13	10	23
		29	34	63
High	Male	33	18	51
	Female	23	25	48
		56	43	99

Experience as a covariate:

0.25	**0.5**	**1**	**2**	**3**	**4**
<3 mths	3-6 mths	6 mths-1yr	1-2 yrs	2-3 yrs	3-4 yrs

5	**6**	**7**	**8**	**9**
4-5 yrs	5-6 yrs	6-7 yrs	7-8 yrs	> 8 yrs

Table 6.4 Internet experience: frequency of participants

Experience	**Frequency**	**Percent**	**Cumulative Percent**
< 3 months	13	5.5	5.5
3-6 months	8	3.4	8.9
6 months - 1 year	21	8.9	17.9
1-2 years	32	13.6	31.5
2-3 years	53	22.6	54.0
3-4 years	38	16.2	70.2
4-5 years	25	10.6	80.9
5-6 years	21	8.9	89.8
6-7 years	7	3.0	92.8
7-8 years	8	3.4	96.2
> 8 years	9	3.8	100.0
Total	235	100.0	

6.2.3 Measures

The main focus for this study is the building of a profile of the validity and reliability of *The Attitudes to Technology Scale* (ATS). Two scales were chosen for comparative analysis with the ATS and the reasons for this were outlined in section 6.1.2. The *Computer Attitudes Scale* (CATT) (Dambrot, Watkins-Malek, Silling, Marshall & Garver, 1985) was chosen because it is a valid and reliable scale, which measures attitudes to computers. Therefore, some comparison can be made between this computer attitude scale and the ATS, which measures attitudes to the Internet for this study. The *State-Trait Anxiety Inventory* (STAI) (Spielberger, 1983) is a valid and reliable measure of anxiety, although for this study, the STAI-Y2 form was used to specifically measure trait anxiety. All three scales were combined to make one questionnaire that was given to participants *(Appendix J).*

6.2.3.1 The Attitudes to Technology Scale (ATS)

The ATS is a new scale under development to measure people's attitudes to different types of technology and establishing its construct validity is the main focus of this study. The ATS consists of 18 items and consists of three subscales namely, (i) **confidence** of one's ability to use the technology (ii) **performance** of the technology and (iii) **fashion** or peer usage of the technology.

6.2.3.2 The State-Trait Anxiety Inventory (Spielberger, 1983)

The STAI comprises of two self-report scales for measuring state and trait anxiety but only the Trait scale was used for this study. Each scale consists of 20 items each with a 4 point response scale, where 1 = 'almost never'; 2 = 'sometimes'; 3 = 'often' and 4 = 'almost always'. The T-Anxiety scale (STAI-Y2) is designed to assess whether a person has a predisposition to anxiety. In contrast to the S-scale, the T-Anxiety scale asks respondents to rate how they "generally feel". Items consisted of some statements such as "I have disturbing thoughts" and affirmative answers to such questions indicate a trait of anxiety proneness. A single total score is produced where a high score indicates a high level of trait anxiety.

In contrast, the S-Anxiety scale (STAI-Y1), which was not used for this study, consists of 20 statements that evaluate how respondents feel "right now, at this moment" to each of the statements, using the response scale provided. The S-Anxiety scale is used to measure state anxiety, which is a transitory anxiety state occurring at a given moment in time and can vary in level of intensity.

The STAI has the face validity of a measure of anxiety but this is not stated to respondents beforehand. Consulting Psychologists' Press[8] who own the copyright to the STAI gave their permission for the author to put the STAI (Y2 form) on the website for a limited period for this study.

Normative data *(Table 6.5)* are available for the T-Anxiety scale (STAI-Y2) to allow comparison of STAI scores obtained during this study. Although these norms are not based on representative or stratified samples, comparisons can be made with samples drawn from similar populations. The high school normative sample consisted of 424 tenth-grade students. The normative sample of college students consisted of 855 students enrolled in an introductory psychology course at the University of Florida. The data for the normative sample of working adults has been divided into three age groups.

[8] Consulting Psychologists' Press, California, http://www.mindgarden.com

Table 6.5 Means, standard deviations and alpha coefficients for working adults by sex and in three age groups

	High Sch students (15-16 years)		College students		Ages 19-39		Ages 40-49		Ages 50-59	
	M	F	M	F	M	F	M	F	M	F
	(202)	(222)	(324)	(531)	(446)	(210)	(559)	(135)	(382)	(382)
T-Anxiety										
M	40.17	40.97	38.30	40.40	35.55	36.15	35.05	35.03	33.86	31.79
SD	10.53	10.63	9.18	10.15	9.76	9.53	8.88	9.31	8.86	7.78
Alpha	0.90	0.90	0.90	0.91	0.92	0.92	0.91	0.92	0.96	0.89

Source: Spielberger (1983)

6.2.3.3 The Computer Attitudes Scale (CATT)

The CATT (Dambrot, Watkins-Malek, Silling, Marshall & Garver, 1985) consisted of 20 items, 9 positive statements and 11 negative statements about computers. The scale requires participants to rate the statements using a 5-point Likert scale, ranging from 1 = *strongly disagree* to 5 = *strongly agree*. The scores from individual items are added together to produce a summated CATT score, where a high score indicates that the participant has a negative attitude towards computers. There are no norms available for the CATT. The minimum summated score = 20 and maximum summated score = 100, giving a midpoint score of 60.

Dambrot et al., (1985) report that the CATT scale has an estimated internal consistency reliability (coefficient α) of .84. This scale was also chosen because the items had been published allowing the author freedom to use this scale on the Internet.

6.2.4 Procedure

As stated above, participants were recruited by advertising the study and website (www.NetInvestigations.net) in a number of ways. Participants voluntarily accessed the website, where they were given some initial information about the researcher and how long the questionnaire would take to complete. Participants were then required to follow a link to the questionnaire. Participants were assured that the information they would give would be treated in the strictest of confidence, all data would be used for the sole purpose of this study and any publication of the results would not identify any individuals.

The online questionnaire consisted of 3 questionnaires (i) the ATS (ii) the STAI and (iii) the CATT as well as a section requesting information about computer and Internet usage. Participants were asked how long they had used a computer and the Internet for, as well as current level of usage and frequency of use. A personal data section was also completed. Participants were given brief instructions and were asked to give responses to a series of statements by clicking on one of the response choices given. Once the questionnaire had been completed, it was submitted using the submit button. If any statement had not been responded to, then an automatic message would inform the participant that they needed to return to that particular statement. In the unlikely event that a participant may complete the questionnaire more than once, two measures were taken to monitor this. Participants were asked to give their email address so that they could be notified of the results of the study and their IP address was automatically recorded.

Once the results of the study had been analysed, the results were posted back onto the original website. Participants were notified that the results had been published on the website via an email.

6.3 Results

This section will begin with the descriptive statistics giving some background regarding the computer and Internet use of the sample. The analysis is then given regarding the two main aims of this study (i) establishing the construct validity and (ii) the predictive power of the ATS. The analysis is then given regarding the two sub-aims of this study. That is (i) the effect of age and sex in terms of attitudes towards the Internet and computers and (ii) the internal consistency of the ATS.

All inferential statistics were tested at the 95% confidence level.

6.3.1 Descriptive statistics

6.3.1.1 Hours per week spent on computer and the Internet

All participants were computer users who reported that they spend between 2 hours per week up to 84 hours per week, giving an average of 31 hours per week. This shows that people are spending considerable amounts of time each week using their computers. Table 6.6 gives the mean (M) and standard deviation (SD) for hours per week spent on a computer and using the Internet.

All participants were Internet users, but Internet use ranged from just 30 minutes a month up to 84 hours per week, giving a mean of 15 hours per week. So about half the time each week spent on a computer is spent using the Internet. In previous research on Internet addiction (Petrie & Gunn, 1998) it was found that non-addicts reported spending about 25 hours per week using the Internet, compared to addicts who reported spending 55 hours per week. Thus, the mean Internet usage of this sample indicated that they did not excessively use the Internet.

Table 6.6 Computer and Internet use in hours per week

	Computer use (hours per week)	Internet use (hours per week)
M	31.19	15.12
SD	20.61	16.89
Minimum	2.0	0.12
Maximum	84.0	84.0

6.3.1.2 Frequency of computer and Internet use

Computer use and Internet use was frequent, with most participants using their computer (90.2% of respondents) and the Internet (71.9% of respondents) on a daily basis *(Table 6.7).*

Table 6.7 Frequency of computer and Internet use (daily, weekly, monthly) (N=235)

	Daily basis	Weekly basis	Monthly basis
Computer use	212 (90.2%)	23 (0.8%)	0 (0%)
Internet use	169 (71.9%)	62 (26.4%)	4 (1.7%)

6.3.1.3 Use computer and the Internet for work, leisure or both

Participants were asked to state whether they used their computer for work, leisure or both. The majority of participants (74%) used their computer for both work and leisure *(Table 6.8).*

Table 6.8 Computer used for work, leisure or both

Computer used for:	n =235	Percent
work	16	6.8
leisure	45	19.1
both	174	74
Total	235	100

Furthermore, the majority of participants (72%) reported that they use the Internet for both work and leisure *(Table 6.9).*

Table 6.9 Internet used for work, leisure or both

Internet used for:	n =235	Percent
work	10	4.3
leisure	55	23.4
both	170	72.3
Total	235	100

6.3.2 Construct validity

The construct validity of the ATS was established during this study by testing the hypotheses set out in section 6.1.3. A two-tailed Peason's Correlation was conducted and Table 6.10 gives the inter-correlations between the 3 scales: ATS, CATT and STAI.

Table 6.10 Correlation matrix for the 3 scales (ATS, CATT & STAI) and the 3 ATS subscales (confidence, performance, fashion) (n =235)

	Confidence subscale	Performance subscale	Fashion subscale	STAI	CATT	ATS
Confidence subscale	-	-	-	-	-	-
Performance subscale	.31**	-	-	-	-	-
Fashion subscale	-.12	.01	-	-	-	-
STAI	-.12	-.07	.12	-	-	-
CATT	-.54**	-.42**	.03	.23**	-	-
ATS	.86**	.61**	.24**	-.09	-.57**	-

** Correlation is significant at the 0.01 level (2-tailed).

G*Power was used to calculate the correlation power of the scales.

There was a significant inverse correlation between the ATS and the CATT (r (233) = -.57, power = .9932, p= .01). High scores on the ATS represented a positive attitude to technology and high scores on the CATT represented a negative attitude to computers. A linear regression showed that the CATT predicted 33% of ATS scores (r^2 = .33, p= .005).

As expected, there was no significant correlation between the ATS and the STAI; however, the relationship was of borderline significance (r (233) = -.09, power = .9932, p = .01). There was a significant positive correlation between the CATT and the STAI (r (233) = .23, P= .01).

The analysis showed that there was a significant correlation between the performance subscale and the confidence subscale (r (233) = .31, power = .9932, p= .01). There was also a significant correlation between the CATT and both the ATS confidence subscale (r (233) = -.54, power = .9932, p= .01) and the performance subscale (r (233) = -.42, power = .9932, p= .01).

6.3.3 Effect of age and sex

6.3.3.1 Hours per week spent on the Internet (usage) by age group and sex

A 2-way ANOVA was conducted to find out if there were any significant differences between age group 1 and 2 and sex in time spent on the Internet. The results showed that there was a significant difference between the means for the factor Age group in terms of Internet usage (F (1,234) = 9.40, p= .002). The younger age group had significantly higher usage of the Internet than older group. There was also a significant interaction between age group and sex for Internet usage (F (1,234) = 7.95, p= .005). Thus the significant differences in usage between the older and younger age groups were due to the younger males significantly higher usage of the Internet than the older males (who were moderate users). Whereas there were no differences between young and older women who were moderate users.

No significant sex differences were found. The means and standard deviations for age groups 1 and 2 and sex are given in Table 6.11.

Table 6.11 Means and standard deviations for hours spent on the Internet by age groups and sex (n=235)

Sex	**Age Group** 1= 17-40 yrs **2 = 41-80 yrs**	**M**	**SD**	**N**
Males	Age Group 1	21.95	21.22	60
	Age Group 2	9.37	8.10	62
	Total	15.56	17.10	122
Females	Age Group 1	14.89	17.36	58
	Age Group 2	14.36	16.14	55
	Total	14.63	16.70	113
Total	Age Group 1	18.48	19.66	118
	Age Group 2	11.72	12.73	117
	Total	15.11	16.88	235

6.3.3.2 Effect of age and sex on experience

A MANOVA was conducted to investigate whether there were any significant differences between Age group and Sex in terms of their experience with the Internet and computers. The 2 DVs being the **experience of the Internet** and **experience of the computers** and the 2 EVs were Age group (older, younger) and Sex (males, females). There was a significant difference between the two age groups in terms of their Internet experience (F (1,234) = 3.99, p= .047) and their computer experience (F (1,234) = 4.65, p= .032). There was a significant difference between males and females in terms of their computer experience (F(1,234) = 5.39, p= .021). There were no other main effects. Table 6.12 below shows the means and standard deviations by sex and age group for computer and Internet experience.

Table 6.12 Means and standard deviations for Internet and computer experience by age group and sex

	Sex	Age group	M	SD	N
Internet experience	Males	Age group 1	3.97	1.84	60
		Age group 2	3.09	2.13	62
		Total	3.52	2.03	122
	Females	Age group 1	3.83	2.10	58
		Age group 2	3.56	2.65	55
		Total	3.70	2.38	113
	Total	Age group 1	3.90	1.96	118
		Age group 2	3.31	2.39	117
		Total	3.60	2.20	235
Computer experience	Males	Age group 1	7.55	2.24	60
		Age group 2	6.33	3.10	62
		Total	6.93	2.77	122
	Females	Age group 1	6.27	2.64	58
		Age group 2	5.94	2.99	55
		Total	6.11	2.81	113
	Total	Age group 1	6.92	2.52	118
		Age group 2	6.14	3.04	117
		Total	6.53	2.81	235

6.3.3.3 Effect of age and sex on time spent on computers and CATT scores

A 2-way ANOVA was conducted to find out if there were any significant differences between age group 1 and 2 in time spent on their computers. The results showed that there was a significant difference between the means for the factor Age group ($F(1,234) = 21.01$, $p = .0005$) and time spent on their computer *(see Table 6.13)*. There was a significant interaction between age group and sex ($F(1,234) = 6.71$, $p = .01$). Younger males spent significantly more time than older males on computers. No significant differences were found for sex.

Table 6.13 Means and standard deviations for hours spent on computers by age group and sex

Sex	Age Group 1= 17-40 yrs 2 = 41-80 yrs	M	SD	N
Males	Age Group 1	42.73	20.56	60
	Age Group 2	24.27	17.57	62
	Total	33.35	21.16	122
Females	Age Group 1	31.45	20.91	58
	Age Group 2	26.12	18.42	55
	Total	28.86	19.83	113
Total	Age Group 1	37.19	21.41	118
	Age Group 2	25.14	17.92	117
	Total	31.19	20.61	235

The CATT gives a summated score where a high score indicates that the participant has a negative attitude towards computers. There are no norms available for comparing the scores of this sample. However, the minimum summated score = 20 and maximum summated score = 100, giving a midpoint score of 60. The scores of the sample show that all participants regardless of sex and age group had fairly low CATT scores, which means that participants in this study were not anxious about computers.

A 2-way ANOVA was conducted to investigate whether there were any significant differences between Age group and Sex in terms of their CATT scores and attitudes to computers. The DV being the summated CATT scores and the 2 EVs were Age group (older, younger) and Sex (males, females). There were no significant main effects. Table 6.14 gives the means and standard deviations for CATT scores by age group and sex.

Table 6.14 Means and standard deviations for CATT scores by age group and sex

Sex	**Age Group** 1= 17-40 yrs **2 = 41-80 yrs**	M	SD	N
Males	Age Group 1	42.97	7.94	60
	Age Group 2	42.15	8.29	62
	Total	42.55	8.10	122
Females	Age Group 1	42.22	7.78	58
	Age Group 2	42.96	9.36	55
	Total	42.58	8.55	113
Total	Age Group 1	42.60	7.83	118
	Age Group 2	42.53	8.78	117
	Total	42.57	8.30	235

6.3.3.4 Effect of age and sex on STAI scores (trait anxiety)

A 2-way ANOVA was conducted to investigate whether there were any significant differences between Age group and Sex in terms of their STAI scores on the trait scale and predisposition to anxiety. The DV being the summated STAI scores and the 2 EVs were Age group (older, younger) and Sex (males, females). There was a significant difference between the two age groups in terms of their STAI scores ($F(1,234) = 11.45$, $p = .01$) and between males and females ($F(1,234) = 4.54$, $p = .05$). However, there were no interaction effects. Table 6.15 gives the means and standard deviations for STAI scores by age group and sex.

Table 6.15 Means and standard deviations for STAI scores by age group and sex

Sex	**Age Group** 1= 17-40 yrs **2 = 41-80 yrs**	**M**	**SD**	**N**	**norms**
Males	Age Group 1	44.02	9.85	60	35.55
	Age Group 2	37.76	10.39	62	34.45
Total males		40.84	10.56	122	35.00
Females	Age Group 1	39.34	9.37	58	36.15
	Age Group 2	37.04	9.02	55	33.41
Total females		38.22	9.23	113	34.78
Total	Age Group 1	41.72	9.86	118	35.85
	Age Group 2	37.42	9.73	117	33.93
	Total	39.58	10.01	235	34.89

Interestingly, the scores for trait anxiety in the sample were higher than the norms for both age groups and both sexes. Thus, the participants in this study had more of a predisposition to anxiety than the average person.

6.3.3.5 Effect of age and sex on ATS scores

A 2-way MANOVA was conducted to investigate whether there were any significant differences between Age group and Sex in terms of their ATS scores and the ATS subscales. The DVs being the summated ATS scores and 3 separate subscale scores and the 2 EVs were Age group (older, younger) and Sex (males, females). There was a significant difference between the two age groups in terms of their summated ATS scores (F (1,234) = 19.02, p= .0005) but there were no significant sex differences. Table 6.16 below shows the means (M) and standard deviations (SD) for both Age group and sex for ATS scores and the subscales.

Table 6.16 Means and standard deviations for ATS scores and subscales by age group and sex

	Sex	Age Group 1= 17-40 yrs; 2 = 41-80 yrs	M	SD	N
ATSTOT	Males	Age Group 1	74.63	6.24	60
	Females		75.28	7.84	58
	Total		74.95	7.05	118
	Males	Age Group 2	70.85	7.15	62
	Females		70.02	10.20	55
	Total		70.46	8.69	117
	Males	Total	72.71	6.96	122
	Females		72.72	9.40	113
	Total		72.71	8.21	235
Confidence subscale	Males	Age Group 1	33.99	3.96	60
	Females		33.68	4.72	58
	Total		33.83	4.34	118
	Males	Age Group 2	31.87	5.13	62
	Females		29.89	6.68	55
	Total		30.94	5.96	117
	Males	Total	32.91	4.70	122
	Females		31.84	6.04	113
	Total		32.39	5.40	235
Performance subscale	Males	Age Group 1	18.59	2.57	60
	Females		18.83	2.41	58
	Total		18.71	2.49	118
	Males	Age Group 2	18.65	2.90	62
	Females		18.95	3.04	55
	Total		18.79	2.96	117
	Males	Total	18.62	2.74	122
	Females		18.89	2.72	113
	Total		18.75	2.73	235
Fashion subscale	Males	Age Group 1	12.03	2.36	60
	Females		12.39	2.51	58
	Total		12.21	2.43	118
	Males	Age Group 2	11.25	2.66	62
	Females		12.43	2.26	55
	Total		11.81	2.54	117
	Males	Total	11.64	2.54	122
	Females		12.41	2.38	113
	Total		12.01	2.49	235

The results showed that there was a significant difference between the age group for the Confidence subscale (F (1,234) = 18.99, p= .0005). The younger age group had significantly higher scores on the Confidence subscale than the older age group.

There was a significant difference between males and females for the Fashion subscale (F (1,234) = 5.74, p= .017). Females had significantly higher scores on the Fashion subscale than males. There were no other significant main effects or interactions.

6.3.4 Are ATS scores predictors of usage?

A linear regression was conducted to investigate whether ATS scores could significantly predict level of Internet **usage**. The DV was usage (level of Internet use), which had 3 levels (low, medium, and high) and the explanatory variable (EV) was the summated score on the ATS.

ATS scores were found to be significant predictors of **usage** (adjusted r^2 = .76. F (1,234) = 19.21, p = .005).

6.3.5 Internal consistency

The internal consistency was measured by Cronbach Alpha that involved the comparison of the variance of the total scale score with the variances of the individual items. For a scale to demonstrate consistency, the alpha should be at least .70.

The item analysis gave a Cronbach alpha of **.78**.

6.4 Discussion

The main aims of this study were to establish some evidence of construct validity with the ATS and to investigate whether the ATS has predictive power, that is, can it predict usage of a given technology. Furthermore, the study had two sub-aims, which were to investigate whether there were age and sex differences with regards to attitudes to the Internet and to establish whether the ATS had maintained its high level of internal consistency reliability. A discussion of the analysis is given below. The hypotheses are listed again below.

H_1: There would be a significant correlation between the ATS and the CATT
H_2: There would be a significant correlation between the ATS Performance and Confidence subscales and the CATT
H_3: ATS scores can predict actual technology use
H_4: There would not be any correlation between the ATS and the STAI trait scale
H_5: Older participants would have significantly lower ATS scores than younger participants
H_6: Females would have significantly lower ATS scores than males
H_7: The ATS will have maintained its high level of internal consistency reliability

6.4.1 Face and construct validity

Initially, an exercise was carried out to assess the face validity of the ATS, as this is important for the motivation of participants. Often, the face validity of a scale can be obtained by simply asking participants if the scale appears to be a good measure of the variable it is supposed to measure. Therefore, a simple exercise was conducted whereby ten participants were asked to place each of the items from the ATS into one of the three subscales: Performance, Confidence or Fashion. The face validity of each of the items was very high, with most items being correctly placed (80-100% of the time). Overall, this exercise has shown that the ATS appears to have good face validity and this will be a good motivator for those completing the scale.

Following on from this, the current study began to collect evidence for the construct validity of the ATS. This was addressed by correlating the ATS with two other valid and reliable measures, and hypotheses were made regarding the expected intercorrelations between the three independent scales. For this study, the ATS was applied to measure users' attitudes to the Internet. Since there were no comparable scales that specifically measure attitudes to the Internet, a general computer attitude scale was chosen, since these are technologies of the same type. It was hypothesised that the ATS and the CATT would significantly correlate with each other. As expected, the correlation showed that the ATS and the CATT significantly correlated with each other. Therefore, participants who had positive attitudes towards computers also had positive attitudes towards the Internet and those who tended to have more negative attitudes towards computers also tended to have more negative attitudes towards the Internet. A linear regression showed that the CATT could predict 33% of ATS scores in relation to the Internet, which is approximately a third of the variance.

Furthermore, it was hypothesised that the Confidence and Performance subscales on the ATS would also correlate with the CATT, since these two subscales contain negative and positive items that are similar to those contained in the CATT. For instance, one item on the ATS Performance subscale is "The *Internet* helps me to do a task effectively" and another item on the ATS Confidence scale is "I feel anxious when using the *Internet*". On the CATT comparable items are "I look forward to computers taking over certain routine tasks of my home and job" and "I feel very negative about computers in general". However, the Fashion scale on the ATS was quite unique and there were no comparable items from this scale with those on the CATT, therefore it was not expected that there would be a correlation between the ATS Fashion subscale and the CATT. The results of the correlation analysis did show that there was a significant correlation between the Performance and Confidence subscales with the CATT and as expected, the Fashion subscale did not correlate with the CATT.

Testing the construct validity of a new scale can also involve testing hypotheses whereby no correlation is expected between the new scale and other reliable and valid scales. This study used the STAI trait scale as a test of construct validity and it was hypothesised that there would not be a correlation between the STAI trait scale and the ATS. This is because the STAI is a general measure of trait anxiety and the ATS contains only a few anxiety-related items (on the Confidence subscale). The results were as expected, there was no significant correlation between the ATS and STAI trait scale but the correlation was bordering on significance, probably due to the ATS containing some anxiety items.

6.4.2 Predictive power of the ATS

At the start of this chapter, it was proposed that a useful application of the ATS would be to use the scale for predicting individuals' future use of a technology. Indeed, this could be the most important application of the scale whereby ATS scores could be obtained from individuals and from these future use could be predicted. In order to investigate the predictive power of the ATS, participants were asked to report the hours they spent using the Internet and from this they were grouped as high, medium and low users of the Internet. A linear regression was conducted to see if ATS scores could predict Internet usage. The analysis showed that the ATS is a significant predictor of usage and the ATS has great potential as a predictive tool. For example, designers and developers of new technology could use the ATS not only to gage the attitudes of potential users of a new technology whilst it is under development, but also to predict future usage. Measuring potential users' attitudes could also give developers of technology an indication of level of use and technology acceptance when undertaking usability studies.

The predictive ability of the ATS would also be a significant tool for use in the commercial sector. For example, the telecommunications industry is currently interested in the potential market for 3rd generation (3G) mobile phones and services. The ATS could be given to existing mobile phone users (2.0 & 2.5G) and their attitudes modelled for market analysis. Market forecasts could be calculated regarding consumer appetite and acceptance of 3G technology and associated services.

Furthermore, in the case where technology is developed for groups with special needs such as the elderly, the ATS would be able to predict usage levels of these particular user groups. It would indicate whether the technology would be accepted and used by the user groups in the future. For example, if the ATS identified that an elderly user group will not accept and use a new assistive technology, this helps to identify an *acceptance gap*. Once an acceptance gap has been identified, a number of interventions can be made to close this gap, such as improvements to the design of the technology or by focusing on effective training programmes.

6.4.3 Summary effects of age

It was hypothesised that older participants would have lower ATS scores than younger participants. Analysis was conducted to establish whether there were any differences between older and younger participants in terms of their ATS scores and their attitudes to the Internet. The younger group had significantly higher ATS scores and therefore had more positive attitudes towards the Internet than the older group. Although the research has been mixed, some past research has found that younger people have more positive attitudes towards computers than older people (Laguna & Babcock, 1997; Loyd & Gressard, 1984). Interestingly, the younger age group had significantly higher usage of the Internet than older group. So as we might expect, those who are more positive in their attitudes towards the Internet are more likely to use the Internet. On closer inspection of the means, the significant differences in Internet usage between the older and younger age groups were mainly due to the fact that the younger males had significantly higher usage of the Internet than the older males (who were moderate users). There were no differences between younger and older women who were moderate users, so the differences in age group depended upon the high usage of young males.

Overall, those with greater experience of computers tend to have less anxiety towards them. The current study found that younger participants had significantly more experience of the Internet than older participants. It could be that the older group was not as positive towards the Internet because their experience was much lower than the younger group. Experience has been shown to be a correlate of computer attitudes and it is often a confounding variable in research investigating correlates of computer attitudes and computer anxiety. Research has shown that greater experience does not necessarily mean that attitudes will become more positive or reduce anxiety (Gilroy & Desai, 1986; McInerney et al., 1994). However, specially designed training programmes for the elderly have shown to help elders feel more at ease with technology (Adams & Thieben, 1991).

Interestingly, although the younger group spent significantly more time on computers than the older group, there were no significant differences between the two age groups in terms of computer attitudes. Thus, the differences in attitudes between older and younger participants in this study were specifically related to the Internet and not to computers. As stated above, previous research looking at computer attitudes and anxiety of different age groups has shown mixed results. Many past studies have failed to find any age differences in attitudes to computers (e.g. Gilroy & Desai, 1986; Massoud, 1991). Some researchers have proposed that older people may exhibit lower levels of computer anxiety because they are less inhibited and there is less pressure on them from society to be proficient at using computers, unlike younger computer users (Dyck & Smither, 1994).

Analysis of STAI trait scores showed that younger participants had higher trait scores than the older participants therefore, the younger group had higher levels of trait anxiety than the older group. This is not unexpected since STAI trait norms show that younger people tend to be higher in trait anxiety than older people. This is interesting when we compare the analysis of STAI trait scores with ATS scores. Even though younger participants have higher levels of trait anxiety than older participants, younger participants had more positive attitudes to the Internet than older participants. This suggests that trait anxiety and attitudes to the Internet are quite separate entities. Thus providing more support for the results of the correlation analysis, which showed that the ATS and the STAI did not correlate. This result also highlights that attitudes to the Internet are not correlated with trait anxiety. This suggests that those who have more negative attitudes to the Internet, are not necessarily higher in trait anxiety than those people with more positive attitudes to the Internet.

6.4.4 Summary effects of sex

It was hypothesised that males would have significantly higher ATS scores than females. The analysis of ATS scores showed that there were no significant differences between males and females and so there were no differences between male and female attitudes towards the Internet. Furthermore, there were no differences between males and females in hours spent on the Internet. This is interesting as recent research investigating the phenomenon of Internet addiction (Petrie & Gunn, 1998), found that in their self-selecting sample, 51% of the sample was female. Their study found that females scored higher than males on the Internet Use and Attitudes Scale (IUAS) and suggested that females were more likely to be "addicted" to the Internet. Also, a number of surveys have also found that the numbers of females using the Internet is steadily increasing. In a UK survey by ICM Research (2000), 45% of the Internet users surveyed were female. It is highly probable that the Internet has more appeal to females than any other computer application, and consequently, females are beginning to use computers more and particularly to access the Internet, compared to 5 or more years ago.

There were also no differences between males and females in their CATT scores and their attitudes towards computers. There were differences between males and females in terms of hours spent on computers. This contrasts with much of the previous research looking at sex differences and computer attitudes. Overall, past research has shown that females tend to have more negative attitudes than males towards computers (Gilroy & Desai, 1986; Massoud, 1991; Morrow, Prell & McEllroy, 1986, Raub 1981). However, more recently, researchers have suggested that these sex differences are not so much due to biological sex but are more dependent upon cultural factors (Brosnan & Lee, 1998) and an individual's level of masculinity or femininity (psychological gender). In other words, those males and females who are higher in masculinity, tend not to view computing to be a predominantly male activity and subsequently, are more likely to have positive attitudes towards computers and be less computer anxious.

Analysis of STAI scores showed that males had significantly higher levels of trait anxiety than females, which is particularly interesting because this is not consistent with existing norms. STAI norms show that women tend to have higher trait anxiety than males.

6.4.5 Internal consistency

During the development of a scale, it is recommended that the reliability of the scale be constantly assessed with new samples. As with previous studies, a reliability analysis was conducted to provide evidence for internal reliability of the scale. In the current study, the scale has a coefficient alpha of 0.78 and is maintaining an acceptable level of internal consistency.

6.5 Summary

This study has begun the process of obtaining evidence for the construct validity of the ATS. The ATS has good face validity and some evidence has been provided for the construct validity of the ATS. As expected, the ATS correlated with the CATT and more specifically, the ATS subscales of Performance and Confidence correlated with the CATT. Also, the ATS did not correlate with the STAI. This is only the beginning of the validity-establishing process and further studies would need to be conducted to address not only the construct validity of the ATS but also other forms of validity. It is important to conduct several studies reassessing the validity of a scale and this should be an ongoing process. Indeed, many computer attitude scales are subjected to validity testing by researchers other than the test developer. For example, the Computer Attitude Scale (CAS) originally developed by Nickell & Pinto (1986) has gone through extensive examination in terms of its reliability and validity by a number of other researchers (e.g. Rainer & Miller, 1995). The ATS will also need to go through further studies of validity beyond the publication of this research programme.

The internal consistency of a scale must also go through a similar level of continuous analysis, particularly as it is important to show that a scale is consistent over time. The previous study in this thesis showed that the ATS had a more than acceptable level of internal consistency and this current study also showed that the ATS has maintained that internal consistency. However, test-retest reliability is the other form of reliability that should also be addressed. This will involve giving the ATS to a group of individuals on two separate occasions to see if the ATS yields the same scores for the same group of people over time. This work is beyond the scope of this research programme but it will be conducted prior to publication of the ATS.

The results of this study have also shown that an individual's ATS score is a significant predictor of usage. Of course this should also be investigated in further studies with the ATS addressing other types of technology. In the following chapter, a study is given which analyses whether the ATS can predict mobile phone usage. In the current study, the results mean that the ATS could be a useful tool if used to predict users' level of use of a technology and their technology acceptance. An attitude measure that predicts future usage could be invaluable to designers and developers of technology for elderly people. This foresight will help to improve the design of technology for elders as well as highlight training needs, which may help to close the acceptance gap.

Chapter 7

Effect of age, sex and frequency of use on attitudes towards technology

7.1 Introduction

The previous study detailed in Chapter 6 produced more evidence for the validity and reliability of the ATS. In that study, the ATS was used to measure people's attitudes towards the Internet and computers, and some analysis was conducted to examine whether there were any sex and age differences. This produced some interesting results, particularly when relating them to previous research. There were significant differences between younger and older age groups but there were no significant differences between males and females. Since there was no research investigating the effect of age and sex on attitudes towards a range of technologies (other than computers), the author conducted two further studies to investigate the effect of age and sex on attitudes towards three other different types of technology.

Much of the past literature investigating age and sex differences in relation to attitudes to computers and computer anxiety (see Chapter 2) has been mixed. Many researchers have found that younger people have more positive attitudes towards computers and less computer anxiety than older people (Laguna & Babcock, 1997; Loyd & Gressard, 1984). Although, some researchers have found that the opposite is the case (e.g. Dyck & Smither, 1994). However, the age related research has been fairly limited, particularly in comparison to the large number of studies investigating sex related differences. The results of studies looking for differences between males and females regarding attitudes to computers has also been mixed but overall, males tend to have more positive attitudes towards computers and have less computer anxiety than females (Gilroy & Desai, 1986; Massoud, 1991; Morrow, Prell & McEllroy, 1986; Raub, 1981). However, in the previous study in this current research (Chapter 6) no differences were found between males and females regarding their attitudes to the Internet.

Two current studies (reported separately in this chapter) were conducted to see if differences between males and females and between age groups existed across three different technologies. It would be interesting to see if sex and age differences exist with specific types of technology. In the first study, individuals' attitudes towards microwaves and videocassette recorders (VCRs) were measured and in the latter study, individuals' attitudes to mobile phones were measured. The ATS was adapted for each technology to gather individuals' attitudes. Since the previous computer attitude research has given mixed results, the current hypotheses were based upon the findings of the previous study (Chapter 6). It was hypothesized that (i) younger people would have more positive attitudes towards the three types of technology than older people and (ii) that there would be no difference between males and females in terms of their attitudes towards the three types of technology.

Furthermore, it has been argued that the ATS would be a particularly useful tool if it could predict frequency of use of a technology, as this would indicate level of use and technology acceptance. Therefore, the second study has also investigated whether the ATS could predict frequency of use of mobile phones.

7.2 Study 1: The effect of age and sex on attitudes to microwaves and VCRs

This study was designed to investigate the hypotheses that younger people have more positive attitudes than older people regarding technology and that there are no differences between males and females attitudes towards technology. In this study two types of technology were chosen: microwaves and VCRs. The ATS was given to a number of people of varying ages to measure their attitudes towards these two different types of technology.

7.2.1 Method

7.2.1.1 Design

The study had a 2-factor between-groups design, with one factor being **age group** and the other factor being **sex**. Based on the distribution of ATS scores, participants were placed into 3 age groups (see Table 7.1).

Two hypotheses were addressed:

H_1: Younger people have more positive attitudes towards VCRs and microwaves than older people.

H_2: There are no differences between males and females attitudes towards VCRs and microwaves.

7.2.1.2 Participants

The ATS questionnaire was given to 114 participants, however, 15 of these questionnaires were rejected because they had not been completed properly.

Of the 99 participants who took part in this study, 44 were male and 36 were female. Participants' ages ranged from 15 years to 68 years of age, giving a mean age of 31 years.

Participants came from 5 different sources:

- Students at The University of Hertfordshire (21%)
- Civilian and police employees of Luton Police Station (20%)
- Employees of Time Computers in Bedford (26%)
- Members of the Cambridgeshire Over 60s Club (15%)
- Members of the Derby and Joan Club in Heath and Reach (18%)

Participants were of a variety of nationality and ethnic origin.

Table 7.1 shows the age and sex of the 99 participants who completed the ATS for microwaves and VCRs.

Table 7.1 Age and sex of participants who completed the ATS for microwaves and VCRs

	Age group 1 18-29 years	Age group 2 30-54 years	Age group 3 55-86 years	Total
Male	10	14	11	35
Female	14	24	26	64
Total	24	38	37	99

7.2.1.3 Materials

The 18-item ATS was adapted for this study so that two different technologies could be addressed VCRs and microwaves. Participants were asked to rate how much they agreed or disagreed with each of the 18 statements using a 5-point Likert scale (see below).

Strongly Disagree				Strongly Agree
☐	☐	☐	☐	☐
1	2	3	4	5

Participants were given the two versions of the ATS together with an introduction sheet and a personal data section *(see Appendix N).* The personal data section gathered information regarding participants' age, sex, and occupational status.

7.2.1.4 Procedure

Ninety-nine participants took part in this study. Each participant completed the ATS twice, once for each technology.

The introduction sheet explained to participants the general purpose of the study together with instructions as to how to complete the questionnaire. Participants were asked if they used each of the technologies, if they had not used them, then they could not continue filling in the questionnaires. Participants were thanked for their cooperation in the study and if they had any questions, the researcher answered these.

7.2.2 Results for study 1

The ATS summated scores can range between 18 and 90 with a mid-point of 36.

Participants were put into one of three age groups for the purpose of this analysis. The age groups were chosen on the fairly even distribution of participants' ATS scores in each age group.

Age group 1	Age group 2	Age group 3
18- 29 years	30 - 54 years	55 – 86 years

A multivariate analysis of variance (MANOVA) was conducted. There were 2 dependent variables (DV) and 2 explanatory variables (EV).

Variables		Levels
DV_1	Total ATS score for VCRs (TOTVCR)	
DV_2	Total ATS score for microwaves (TOTMIC)	
EV_1	Sex	Male, Female
EV_2	Age group	1, 2, 3

There was a significant main effect for age group on ATS scores for VCRs ($F_{2,98}$ = 3.16, p= .047). There were no significant interactions or other main effects.

Table 7.2 Mean ATS scores and standard deviations for VCRs and Microwaves by age group and sex

	Age Group	Sex	M	SD	N
VCR ATS scores	1	Male	67.10	8.18	10
		Female	67.50	8.04	14
		Total	67.33	7.92	24
	2	Male	62.78	8.55	14
		Female	61.79	7.68	24
		Total	62.15	7.92	38
	3	Male	62.72	6.42	11
		Female	60.96	10.58	26
		Total	61.48	9.48	37
	Total	Male	64.00	7.86	35
		Female	62.70	9.27	64
		Total	63.16	8.78	99
Microwave ATS scores	1	Male	67.60	8.27	10
		Female	71.50	5.18	14
		Total	69.87	6.77	24
	2	Male	65.71	5.60	14
		Female	64.87	7.66	24
		Total	65.18	6.91	38
	3	Male	68.18	7.90	11
		Female	64.65	8.61	26
		Total	65.70	8.45	37
	Total	Male	67.02	7.05	35
		Female	66.23	8.02	64
		Total	66.51	7.66	99

7.3 Study 2: The effect of age, sex and frequency of use on attitudes to mobile phones

This study was designed to investigate the hypotheses that younger people have more positive attitudes than older people regarding technology and there are no differences between males and females attitudes towards technology. The technology chosen for this study was mobile phones. The ATS was given to a number of people of varying ages to measure their attitudes towards mobile phones.

7.3.1 Method

7.3.1.1 Design

The study had a 3 factor between groups design, with one factor being **age group**, another factor being **sex** and the third factor being **frequency of use** (Table 7.3).

Hypotheses:

H_1: Younger participants would have more positive attitudes towards mobile phones than older participants.

H_2: There are no differences between males and females attitudes towards mobile phones.

H_3: Frequency of use is a predictor of ATS scores and attitudes towards mobile phones

7.3.1.2 Participants

80 participants took part in this study, 44 were male and 36 were female. Participants' ages ranged from 15 years to 68 years of age, giving a mean age of 31.3 years. Table 7.3 gives the numbers of males and females by age group and by frequency of use.

Table 7.3 Age group by sex by frequency of use

Frequency of use	Sex	Age group 1 (15-35 years)	Age group 2 (36-68 years)	Total
Daily	Male	18	6	24
	Female	11	4	15
	Total	29	10	39
Few times a week	Male	6	4	10
	Female	4	5	9
	Total	10	9	19
Few times month	Male	1	1	2
	Female	5	3	8
	Total	6	4	10
Rarely	Male	3	4	7
	Female	3	1	4
	Total	6	5	11
Never	Male	2	-	2
	Total	2	-	2
Total	Male	30	15	45
	Female	23	13	36
Total		53	28	81

7.3.1.3 Materials

The ATS was adapted for this study so that participants' attitudes towards mobile phones could be measured. Participants were asked to rate how much the agreed or disagreed with each of the 18 statements using a 5-point Likert scale (see below).

Strongly Disagree				Strongly Agree
☐	☐	☐	☐	☐
1	2	3	4	5

Participants were given the ATS together with an introduction sheet and a personal data section *(see Appendix N).* The personal data section gathered information regarding participants' age, sex, occupational status, frequency of use and experience of mobile phones.

7.3.1.4 Procedure

Each of the 81 participants in this study completed the ATS regarding mobile phones and the personal data section.

The introduction sheet explained to participants the general purpose of the study together with instructions as to how to complete the questionnaire. Participants were asked how long they had used a mobile phone for and how often they used it. Participants were thanked for their cooperation in the study and if they had any questions, the researcher answered these.

7.4.1 Results for study 2

This section will begin with the descriptive statistics giving some background regarding the mobile phone use of the sample. Some further analysis is provided that was conducted to establish (i) the age and sex effects on ATS and subscale scores and (ii) whether ATS scores can predict frequency of use. All inferential statistics were tested at the 95% confidence level.

The ATS summated scores can range between 18 and 90 with a mid-point of 36.

7.4.1.1 Descriptive statistics

All participants were either current mobile phone users or had used a mobile in the past. Experience was measured in terms of length of time that participants had used a mobile phone. Table 7.5 shows participants' experience of using a mobile phone. Most participants have been using a mobile phone for more than 1 year, with 41% of participants using a mobile for between 1 to 3 years and 37% having used a mobile for 3 or more years. The remaining 22% are fairly new users as they have been using a mobile for less than 1 year *(Table 7.4)*.

Table 7.4 Experience of using a mobile phone

Experience	**N**	%
Less than a year	18	22
1-3 years	33	41
3 or more years	30	37
Total	81	100

Most participants (48%) are high frequency users *(Table 7.5)* and use their mobile on a daily basis, whereas 24% of participants use their phone a few time a week, 12% use it a few times a month. Infrequent users who rarely use their mobile made up 13% of the sample with 3% never using their mobile.

Table 7.5 Frequency of use of mobile phones

Frequency of use	N	%
Daily	39	48
Few times a week	19	24
Few times a month	10	12
Rarely	11	13
Never	2	3
Total	81	100

7.4.1.2 Age and sex effects

Based on the distribution of ATS scores, participants were put into one of two age groups for the purpose of this analysis.

Age group 1	Age group 2
15- 35 years	36 - 68 years

Table 7.6 below shows the means (M) and standard deviations (SD) for Total ATS scores and subscales scores by age group and sex.

Table 7.6 Total ATS scores and subscale scores for mobile phones by age group and sex

	Age group	Sex	M	SD	N
Performance	1	Male	3.54	0.56	30
		Female	3.63	0.62	23
		Total	3.58	0.58	53
	2	Male	3.40	0.69	15
		Female	3.16	0.75	13
		Total	3.29	0.71	28
	Total	Male	3.49	0.60	45
		Female	3.46	0.69	36
		Total	3.48	0.64	81
Confidence	1	Male	4.22	0.63	30
		Female	3.67	0.77	23
		Total	3.98	0.74	53
	2	Male	3.36	1.02	15
		Female	3.59	0.94	13
		Total	3.47	0.97	28
	Total	Male	3.94	0.87	45
		Female	3.64	0.82	36
		Total	3.81	0.86	81
Fashion	1	Male	2.24	0.85	30
		Female	2.71	0.82	23
		Total	2.44	0.86	53
	2	Male	2.40	1.08	15
		Female	2.28	0.54	13
		Total	2.34	0.86	28
	Total	Male	2.29	0.92	45
		Female	2.55	0.75	36
		Total	2.41	0.86	81
ATS	1	Male	66.10	8.71	30
		Female	63.04	8.79	23
		Total	64.77	8.80	53
	2	Male	57.86	12.75	15
		Female	58.23	12.26	13
		Total	58.03	12.30	28
	Total	Male	63.35	10.82	45
		Female	61.30	10.28	36
		Total	62.44	10.57	81

A multivariate ANOVA was conducted, using the three subscales (Performance, Confidence and Fashion) and the total ATS scores as the DVs and Age group and sex as the EVs.

Variables		Levels
DV_1	Total ATS score for mobile phones	
DV_2	Performance	
DV_3	Confidence	
DV_4	Fashion	
EV_1	Sex	Male, Female
EV_2	Age group	1, 2

This analysis showed that there was a significant main effect for age group regarding total ATS scores, F (1,80) = 7.44, p = .008. The younger age group had significantly more positive attitudes to mobile phones than the older age group.

There was a significant main effect for age group regarding the subscale Performance, F (1,80) = 4.31, p = .041. The younger age group had significantly higher scores on the performance subscale than the older age group.

There was also a significant main effect for age group regarding the subscale Confidence, F (1,80) = 6.18, p = .015. The younger age group had significantly higher scores on the confidence subscale than the older age group.

Finally, the analysis showed that there was a significant interaction between age group and sex for the subscale Confidence, F (1,80) = 4.31, p = .041. Figure 7.1, below, shows that there was little difference in confidence between younger and older women, but that for older men, the mean confidence level was substantially lower than for younger men.

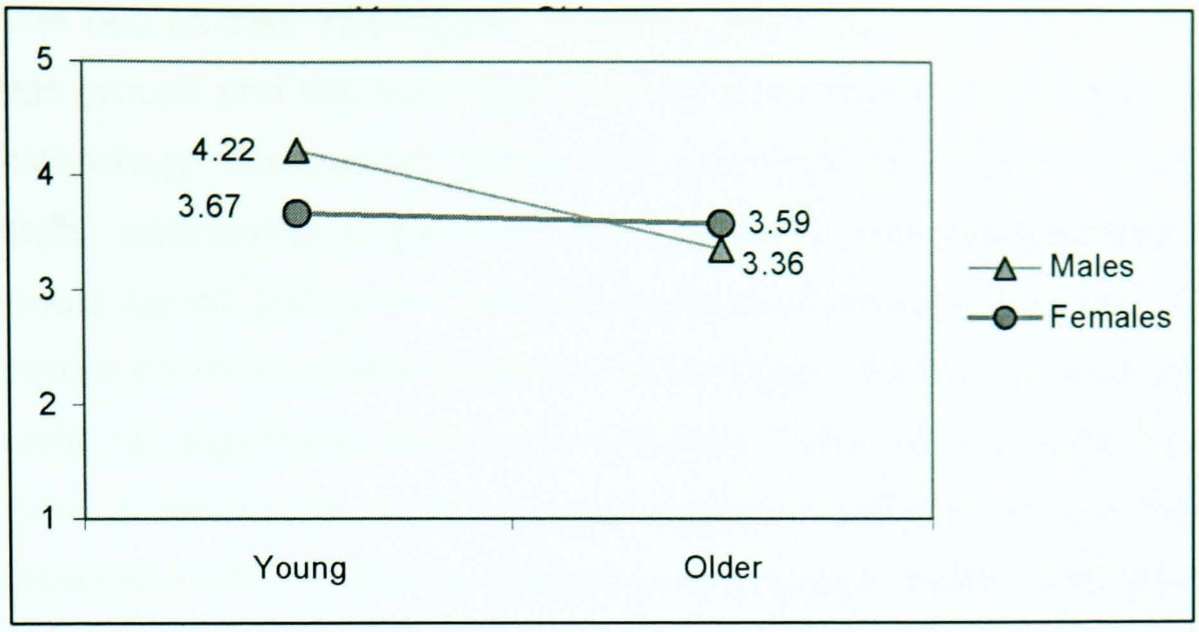


Figure 7.1 Interaction effect for age group and sex for the subscale Confidence

7.4.1.3 *Are ATS scores predictors of frequency of use?*

A linear regression was conducted to investigate whether ATS scores could significantly predict frequency of use. The DV was **frequency of use**, which had 5 levels (daily; few times a week; few times a month; rarely; never). And the exploratory variable (EV) was the summated score on the ATS.

ATS scores were found to be a significant predictor of **frequency of use** (adjusted $r^2 = 0.091$. $\underline{F}(1,79) = 9.06$, $\underline{p} = 0.004$).

7.5 *Discussion for studies 1 & 2*

This chapter has presented two studies investigating the hypotheses that (i) younger people have more positive attitudes than older people towards the three types of technology examined in this chapter and, (ii) that there would be no difference between males and females in terms of their attitudes towards the three types of technology. These hypotheses were based upon the results of the study reported in the previous chapter.

The two studies investigated whether there were any differences between age groups and sex with regards to attitudes towards three different types of technology: microwaves, VCRs and mobile phones. Based on the previous study addressing attitudes to the Internet, it was hypothesised that there would be no difference between males and females in terms of their ATS scores for three different types of technology. The results showed that there were no significant differences between males and females for all of the three technologies. It is possible that sex differences are beginning to disappear with regards to attitudes to technology. Indeed, the previous study found no sex differences in terms of computer attitudes (measured by the CATT) and attitudes to the Internet (measured by the ATS). Studies into Internet dependency have shown that increasingly, Internet users are female and they are using the Internet for longer times than males (Petrie & Gunn, 1998; ICM Research, 2000). Some researchers suggest that previous sex differences found with computers were due to cultural factors (Brosnan & Lee, 1998) and as certain types of technology are no longer seen to be masculine, attitude differences will begin to disappear. This may be particularly so for home-based technologies (e.g. microwaves) and for technologies whose usage has increased dramatically over the past 5-10 years (e.g. Internet) and technologies that have become highly desirable and fashionable items to use (e.g. mobile phones).

Furthermore, the results of the analysis showed there were significant differences between the age groups in terms of their ATS scores for VCRs and mobile phones. In study 1 the sample was divided into three age groups and it was found that younger people had significantly more positive attitudes towards VCRs than the two older groups. However, no significant differences were found between the three age groups for attitudes towards microwaves. In study 2, the sample was divided into two age groups and results showed that the younger age group had significantly more positive attitudes than the older age group towards mobile phones.

It may be that differences between age groups are very much dependant upon the type of technology. For instance, the microwave is a common household technology used by people of all ages and is a good example of a useable technology, that is, it has functions that are fairly easy to use and easy to learn. As Norman (1995) noted, technology is easy to learn and use when there is a "one-to-one matching" between the function and control. Problems for usability arise when there are more functions than the number of controls required to operate the device. It seems that the microwave is a good example of a technology that has multi-functions but this functionality remains fairly simple, making it easy to learn and use. Perhaps the microwave is the result of the application of good design principles and consequently, its high usability means that users view it in a positive light. The microwave may also be a good example of an invisible computer where the user can concentrate on the task in hand (e.g. heating food) rather than focusing on the operation of the technology (Norman, 1995). As Norman suggests, it is those computer-based technologies that are becoming complex and difficult to use that cause people to experience anxiety.

In contrast to microwaves, VCRs and mobile phones have added complex functionality. Although, VCRS have simple functions such as PLAY and RECORD, the programming of a VCR for recording TV programmes at a later time, are often complex and many people avoid using this functionality. This is similar for mobile phones. Dialling a phone number is a fairly straightforward task but the addition of many other functions such as text messaging, stored numbers and Internet functionality has resulted in complex menu systems. Navigating complex menus can often leave users feeling lost and disorientated and can cause 'cognitive overload' (Conklin, 1987). Both VCRs and mobile phones have multi-functions assigned to many of their controls and this could contribute to the more negative attitudes given by the older participants to these technologies.

The three ATS subscales were examined for study 2 and it was found that the younger age group had higher scores on the Performance and the Confidence subscales. Furthermore there was a significant interaction between age group and sex indicating that there was little difference in confidence between younger and older women, but older men had significantly lower mean scores on the confidence subscale than younger men. Therefore, there is little difference between females scores across the age groups but there are significant differences between younger and older males.

Study 2 further looked at whether ATS scores were a significant predictor of 'frequency of use' of mobile phones. Results showed that ATS scores were a significant predictors of frequency of use and this follows on from the previous study where the ATS predicted Internet usage (Chapter 6). If the ATS exhibited predictive power then this would mean that it would be a very useful tool to help developers of new technology to predict usage and technology acceptance. This would be particularly useful if used during the development of technology for elders, as this would give some insight into whether they will accept and use the device. If elders are apprehensive about using or accepting a technological assistive aid, then further investigations could be made to improve the design of the aid as well as making sure that effective training procedures are in place. Indeed, it has been suggested that users' attitudes are more likely to be positive if the development of a piece of technology has been user-driven (Norman, 1995). Furthermore, elders are more likely to use technology if they have received appropriate training (Morrell et al., 1998; Rogers, 1996; Bynam & Rogers, 1987).

7.6 *Summary*

It is hoped that the ATS will be a multi-purpose tool. Indeed, this study has demonstrated that it can be used to research a number of different hypotheses and to progress the research investigating attitudes to technology. In these two studies, the ATS was used to investigate people's attitudes towards three different types of technologies: VCRs, microwaves and mobile phones. To-date, research has focused on attitudes towards computers and not towards other technologies. The ATS was also used to investigate whether there were differences between age groups and between males and females towards VCRs, microwaves and mobile phones. The results suggest that group differences may be dependent upon the type of technology and the level of usability of that technology viewed by each user group.

Continuing on from the study reported in Chapter 6, the current study investigated whether the ATS was a predictive tool that could be used for predicting frequency of use of a technology. This will hopefully lead the way for more research in this area and the beginning of the ATS as a useful research tool.

Chapter 8

Conclusions to the thesis

8.1 Introduction

The work presented in this thesis has been multidisciplinary, drawing upon a number of different fields of research and practice, namely, psychology, gerontology, psychometrics and human-computer-interaction. The research clearly had two distinct parts: firstly the work conducted on PAM-AID and secondly the development of the Attitudes to Technology Scale (ATS). However, these two parts are by no means mutually exclusive and this thesis has attempted to show how, over time, the research evolved.

This concluding chapter gives a brief overview of the studies conducted, how this work has made a contribution to knowledge and recommendations for future research are given, including the planned application of the ATS within two academic projects developing technologies for visually impaired and elderly people. The theoretical implications of this research are also discussed.

8.2 Overview of the research on PAM-AID

Technologies such as PAM-AID are being developed to improve the quality of life for many elderly and disabled people, assisting them to perform everyday tasks and promoting independent living. The impact of the demographic change occurring in Western societies has meant that there is an increasing burden placed upon societies' financial and human resources. Due to increased life expectancy and improved health and hygiene, the elderly population is increasing and, the numbers of people with age-related disabilities. In contrast, the decline in the birth rate has resulted in a decline in the number of working age adults, young people and children, producing an imbalance in the ratio of working or 'active' members of society, compared to economically and physically dependent groups. This has caused concern about how society can provide the support and services needed by the elderly and disabled populations, when the numbers of active members of society are declining. Consequently, a number of technologies have been designed with the intention that they will not only enable elders to maintain independent living, but they will also alleviate the pressure on over stretched human and financial resources.

This thesis has reported two user requirements studies with both carers and elders, conducted to establish elders' needs for the technological walking aid. Professional carers' expertise and knowledge of the user group provided valuable additional information during the requirements gathering process. Overall, these studies gave useful information regarding the physical design of PAM-AID, as well as the possible input and output methods available for operating the walking aid. The results also contributed to the design decisions that lead to the first PAM-AID prototype.

The first PAM-AID evaluation study meant that a number of usability problems came to the fore, some of which could be overcome with small adaptations to the design. For example, the switches were too small and hard to distinguish for visually impaired elders, so their position, size, shape and colour were changed to make them easier to find and operate. Other problems were more severe; the instrumental handles were confusing for elders to operate and not physically supportive and were replaced by a supportive and intuitive bicycle handlebar. A number of other usability problems were raised during this first evaluation study and were solved to produce an improved second PAM-AID prototype.

The next study, evaluating the second PAM-AID prototype, showed how potential users rated the functionality highly and how they operated PAM-AID efficiently and effectively. Again, some usability problems were observed. In particular, the motors that turned the wheels of the device dictated its speed; causing anxiety or frustration when users could not slow down or increase the speed. As a result, the motors that turned the wheels were removed allowing users to push the aid and have more control over the speed. However, the motors that steered the wheels were retained.

Throughout both evaluation studies, the considerable potential of PAM-AID was realised as within the residential homes there were a limited number of staff to care for a large number of residents and it was not always possible for carers to be available to help residents walk around the home. Consequently, so many frail elders were immobile for long periods and perhaps one of the most important outcomes of the studies was the observation of frail elders walking independently and safely with the assistance of PAM-AID, from one part of the residential home to another. Providing independent mobility will undoubtedly relieve elders' dependency on carers as well as promoting physical and psychological well-being.

8.2.1 Contribution to knowledge of PAM-AID

The work on PAM-AID has made a considerable contribution to knowledge regarding the development of technological aids for elders. As far as the author is aware, this was the first time that the basic principles of user centred design have been applied to the development of a technology for very elderly people. Although projects such as the Saturn Project (van Schaik et al., 1995) examined the requirements of older people for ATMs, the users involved in this project were considerably younger than the PAM-AID user group. The PAM-AID research has demonstrated that user centred design works effectively for elders and ensures that as far as possible, the requirements of this user group are met. It is hoped that developers of new technologies for the elderly will look towards the success of PAM-AID and value the inclusion of elders throughout the design and development process.

The user-centred design approach pioneered during the PAM-AID project has continued to be used with the development of PAM-AID. User requirements studies were conducted to establish the needs of people with mobility disabilities, including those with Multiple Sclerosis and Parkinson's disease. Based on the results of these studies, PAM-AID was adapted for these user groups and an evaluation was later conducted with people with Parkinson's disease (PAM-AID D10.1, 1999). Therefore, PAM-AID could potentially become a useful rehabilitation device for users with a range of mobility problems.

Another major contribution of the current research is the walking aid itself, a unique concept that has now become a commercial product called Guido *(see Figure 8.1)* marketed by Haptica.

Figure 8.1 Guido with elderly user

The user centred approach to the design of Guido continues, as an in-depth user trial is currently underway at the US Veterans' Affairs Rehabilitation

Research & Development Center in Atlanta and in Pittsburgh, being led by Professor Rory A. Cooper[9] and Professor Bruce Blasch[10] (G. Lacey, personal communication, 20th May, 2003). An outcome of the work on PAM-AID/Guido has been a number of publications (including two papers[11] by the author) and presentations/demonstrations at international conferences. In 1999, Guido won the Paralyzed Veterans of America (PVA) design award at the Annual Conference of the Rehabilitation Engineering Society of North America (RESNA).

The following description of Guido has been taken from the Haptica website *(Figure 8.2),* describing the sophisticated technology that Guido uses to provide safe navigation for users.

[9] Chairman & Director, Human Engineering Research Laboratories at the Department of Rehabilitation Science and Technology of the School of Health and Rehabilitation Sciences at University of Pittsburgh.

[10] Research Health Scientist & coordinates the Vision Research Program at the Atlanta VA Rehab R&D Center of Excellence on Geriatric Rehabilitation.

[11] Publications are given at the beginning of this thesis in the section *Outcomes of this work*

	Guido builds a map of its immediate environment
 	Guido uses sensors to build a picture of its immediate environment. A laser range finder sends out a beam of light to locate objects in front of Guido. Sonar sensors provide back-up to the laser and sense objects to the side of and above Guido. These sensors enable Guido to identify landmarks and decision points in the environment - such as obstacles, doorways and corridors. Position sensors monitor the wheels and keep track of where Guido has moved.
	Guido uses artificial intelligence to support the user's decision-making
 	Handlebar sensors sense the user's steer and set Guido's direction. Steering motors move the front wheels in response to the sensors' and user's input and ensure that Guido's movement is smooth and refined. Three on-board computers process and control the interaction between Guido and the user. Using artificial intelligence, Guido fuses all the information it is getting from the sensors, the user and the device. Using this data, Guido finds and navigates the safest path to the user's goal - and decides on how and when it needs to give the user information about the directional options and the environment.
	Guido interacts with the user for safe navigation
 	Guido is constantly going through a sensing, planning, interacting cycle to ensure that the user navigates safely and gets the right information at the right time in the right way. The user is always in control of the direction of the device - unless they are in danger: if Guido senses a potential collision, it will gently guide the user away. Via the speaker, Guido provides voice messages about the device, environment and user options in a coherent and useful way. The on-board computer selects the most appropriate message to send to the user and even considers the timing of the message so that it doesn't come too early or too late. An ergonomically designed console presents an easy-to-use intuitive interface including a key switch, a volume control and a mode control to select the mode of operation: park, automatic or manual. Red `turn-on-the-spot' buttons enable the user to turn Guido on its own axis - and get out of tight corners safely. Although Guido stops when the user stops - or when it meets an obstruction, mechatronic brakes ensure the user feels in control at all times.

Figure 8.2 Web page about Guido functionality (www.haptica.com)

8.3 Overview of the research on the ATS

The second part of this research programme detailed the development of a valid and reliable scale for measuring attitudes to different types of technology. An inductive approach was taken and the 5 major stages of scale development were followed (Spector, 1992), beginning with a consultation with experts to define the construct of interest. Experts from the fields of HCI, psychology and computer science were asked to generate content areas that should be considered regarding people's attitudes towards technology and technology acceptance. These experts were chosen because they had extensive knowledge of the fields of HCI, psychology and technology. These content areas meant that the scale could now be designed and the items for the scale generated. The pilot questionnaire was given to 200 people and contained three versions of the scale: one relating to microwaves, one to ATMs and the other relating to computers. An item analysis enabled the reduction of items, and tested the internal consistency of the scale, demonstrating that the scale had high internal reliability (>.80) for each of the three technologies.

A principal components factor analysis simplified the correlation matrix producing a 3-factor solution for each of the three technologies. Factor 1 contained items relating to the *confidence* of the respondent, factor 2 related to the *performance* of the technology and factor 3 contained items relating to peer use and *fashion*.

The validation of the scale began with a consultation with experts, and continued with the factor analysis that provided meaningful subscales. A small exercise demonstrated that the ATS had good face validity, which is an important motivational factor for respondents. A study was also conducted to establish the construct validity of the ATS, whereby a number of hypotheses were made regarding the correlations between the ATS and two other valid and reliable scales. As expected, the ATS measuring attitudes to the Internet significantly correlated with the Computer Attitudes Scale but not with the trait scale from the State Trait Anxiety Inventory. Results of this study also showed that ATS scores were significant predictors of *usage* and this was seen to be a particularly important and valuable feature of the ATS, particularly if used to predict technology acceptance by elders. Finally, age and sex differences were investigated and it was found that older participants had significantly lower ATS scores than younger participants, indicating that the older group was not as positive as the younger regarding their attitudes towards the Internet. This is consistent with past research investigating attitudes of younger and older individuals towards computers (Kelley & Charness, 1995; Laguna & Babcock, 1997; Loyd & Gressard, 1984). However, there were no significant differences in attitudes between males and females towards the Internet.

The differences between age groups and between males and females were followed up in the next two studies, wherein the ATS was used to measure attitudes towards three different types of technologies. To-date, research had focused on individuals' attitudes towards computers and not towards other technologies. The first study investigated age and sex differences in attitudes towards microwaves, and videocassette recorders (VCRs) and the second study investigated age and sex differences in attitudes towards mobile phones. The results showed that there were no differences between males and females across all three technologies. This is not consistent with previous computer attitude research but perhaps this is an indication that sex differences may not exist for certain technologies. New technologies such as the Internet and mobile phones are communication technologies that appeal to both the sexes and consequently, could be viewed as androgynous technologies. Furthermore, household technologies such as microwaves and VCRs may not have been masculinized in the same way that other technologies have been.

The results showed that there were also significant differences between the age groups in terms of attitudes towards VCRs and mobile phones but not towards microwaves. This suggests that the differences may be technology-specific and this could be due to the perception of the usability of each technology. Generally, VCRs and mobile phones have multiple-functions assigned to each control, increasing their complexity, whereas the functionality of microwaves is more likely to have "one-to-one" matching between function and control and therefore are simpler to use.

8.3.1 Contribution to knowledge of the ATS

A main contribution to knowledge has been the development of a useful attitude scale. The ATS could be applied to academic and commercial research and has the potential to contribute to knowledge in a variety of areas. However, the ATS does have some limitations and some more work is needed in the development of the scale. This is discussed in the next section on implications of future research.

In the current studies, the ATS was used to investigate differences in attitudes to different technologies and apart from the research focusing on computers, this is a new area of study. The ATS can be used to continue to build this body of information on attitudes towards all types of technology. Indeed, there is a wide scope for investigating other possible correlates of technology attitudes, such as educational background, self-efficacy, experiences with technology and the role of the 'introducer'. Up to now, very little research has addressed how the attitudes of users will affect their uptake and continual use of technology. Furthermore, the ATS could be used to establish the cultural influences upon our attitudes to technology, and the psychological impact of technology on different user groups. Thus the ATS will be a tool that will continue to make a contribution to many areas of research.

Finally, the development of the ATS has and will contribute to our knowledge of the attitudes of different user groups. Understanding the attitude profile of certain user groups, whether they are defined by age, sex or disability would be useful information when deciding how, and when, to introduce technology to users. Attitude profiles could inform the design of training programmes, so that training is tailored specifically to the needs and attitudes of the user group, particularly since adequate training programmes are essential to the uptake of technology (Morrell et al., 1998) and lead to higher rates of assistive device usage (Bynam & Rogers, 1987).

8.4 Implications for future research

The development of the ATS has followed an iterative process and every effort was made to develop valid and reliable items. However, the ATS is not without it's limitations and further work is needed to address these limitations. This will involve further exploratory work involving other samples and qualitative data.

8.4.1 Generation of content areas

The development of the ATS followed an inductive approach and before the items were generated, content areas were identified. To generate these content areas, Golombok and Rust (1992) proposed that experts in the field of interest be consulted. Therefore, experts in technology and psychology generated the content areas for the ATS. At this stage, it was felt that experts in the field would be able to come up with sufficient content areas that would enable good quality items to be generated.

On reflection, however, consultation with non-experts may have also provided some valuable data regarding the main content areas. A number of focus groups could have been carried out with specific cohorts to see if similar or contrasting content areas would be identified by the subgroups. For instance, elders could have been consulted to provide some insight into the attitudes of elders at this preliminary stage of the scale development. Therefore, future development work should involve running a number of focus groups with different cohorts to establish whether different or similar content areas would be generated. This will identify whether separate scales would be necessary for different groups of individuals.

8.4.2 Explore the fashion concept

The initial consultation with experts to identify the content areas did provide some interesting results. Indeed, the fashion concept, which arose during this consultation, was quite unexpected and later, a fashion factor emerged from the factor analysis. The dramatic increase in use of technologies such as mobile phones has been attributed to the fashion and status of owning and using mobile phones. However, the fashion concept is one that has not been investigated, either in academic or publicly available commercial research. Further work would need to be carried out to examine the influence of fashion and peer usage on an individual's attitudes to technology. For instance, how important is the fashion factor compared to the other two factors that emerged, confidence and performance? This may vary according to user group preferences. Elders may rate the 'performance' of a technology far greater than the 'fashionability' of a technology, whereas younger people may differ in their ratings. This is an important area to understand particularly if the ATS is to be a scale for individuals of all ages.

Further work would need to be conducted to establish what exactly is meant by ‘fashion’ in relation to technology. A technology may be fashionable because one’s peer group uses it or it could be fashionable because of what it looks like. Both of the issues could be important determinants of attitudes towards the technology and may influence whether individuals intend to use it. Visually impaired people often state that they want to use technologies that are aesthetically pleasing, even though they cannot see what the technology looks like. They have coined the term “blindy technology” for horrible looking technology, developed by designers who have assumed that blind people do not mind what their assistive technologies looks like. However, visually impaired people live in a sighted world and want to use technology that pleasing to the eye and popular among their sighted peers.

8.4.3 Establishing test-retest reliability

The work establishing the reliability of the ATS is by no means complete, and some more work will need to be carried out before the scale is ready for publication. As outlined in Chapter 2, a test-retest reliability study is an important part of the development of any scale. The ATS will need to be subjected to a test-retest reliability analysis to establish whether it is reliable over time. That is, does the ATS yield the same scores for the same group of people on different occasions? A test-retest reliability study will be conducted and this will involve giving the ATS to a group of participants of varying ages and occupations on two separate occasions (which will be at least 6 weeks apart). The two sets of scores will then be correlated and will need to reach a satisfactory correlation of at least .70.

8.4.4 Additional evidence for validity

The studies so far, have begun to gather evidence for construct validity of the ATS, but this should be an on-going process and further studies examining the construct validity of the ATS are required. However, until those studies are conducted, the construct validity of the ATS will be assumed.

"Construct validity can be supported but it can never be proven. It is always possible, as with any scientific theory, that later work will reinterpret findings, rendering the original explanation incorrect. The nature of the construct assessed by the scale will be given a new interpretation. However, until that day comes, construct validity for the scale is assumed" (Spector, 1992, p64).

The current studies found that ATS scores predicted levels of usage but these were based on levels reported by participants which may not be that reliable for validation. More studies should be conducted to demonstrate the behavioural validity of the ATS using quantitative measures of actual usage. For example, many elders are prescribed assistive technologies to use at home and it is well established that use of these technologies steadily declines. At the outset, elders' attitudes could be measured using the ATS and this would provide a predicted level of use. Several months later, elders' attitudes could be measured, again using the ATS and the actual level of technology usage recorded. Differences in ATS scores should not change over the time period, and there should not be any significant differences between the predicted usage and the actual usage.

8.4.5 Measuring attitudes of 'resisters'

The ATS was developed to measure users attitudes to technology and this format is consistent with all other scales developed to measure attitudes and anxieties towards computer technology (section 2.7). The ATS was developed for measuring the attitudes of individuals' who *use* or *have used* the technology of interest. One aim of the ATS was to be used as part of the design life cycle during the design and development of new technologies (such as PAM-AID) from which to predict future usage and to improve the design of the technology. In these circumstances, the individuals will have used the technology during an evaluation study.

However, one limitation of this format is that the ATS cannot be used with those individuals who are so resistant that they do not use technology. Future work would involve developing a separate scale specifically for 'resisters' of technology. This would involve initially running focus groups or interviewing resisters before writing the items for the scale. Throughout the development, the samples would include resisters only.

8.4.6 Evaluating the format of the ATS

The ATS was designed to be a practical tool whereby the scale could be used to measure attitudes towards <u>different</u> types of technology. This format was based upon that of the TAM, which can be applied to different types of computer applications. The process of scale development has involved numerous types of technologies, including computers, ATMs, microwaves, VCRs and mobile phones. In the statistical analysis, items were retained if they loaded onto the factors across all technologies. However, more research needs to be conducted to evaluate whether the ATS can be applied to each type of technology. It may be that certain subscales are more applicable to some types of technology than others. For instance, the 'performance' and 'confidence' factors may apply to all types of technology, whereas the fashion factor may be more applicable to one type of technology (e.g. mobile phones) than another (e.g. ATMs). Different technological groups (e.g. information communication technologies (ICTs), entertainment technologies or wearable computers) may require different versions of the ATS. Therefore, new items and subscales may need to be generated for groups of technologies.

Another limitation of the ATS is that some of the items have been written in the first person and others have not. This may be confusing for respondents. For those items in the first person, respondents may give ratings relating to their own attitudes to the technology but for the remaining items, respondents think they have to give ratings regarding other people's attitudes to technology. Another area for future research would be to investigate whether the ATS actually taps into people's own attitudes towards a technology or, whether individuals are giving a more general indication of how that technology is viewed in society. This could be clarified by simply asking people. When they are completing the ATS, are they thinking about themselves in relation to the technology. It may be that all the items on the ATS should be in the first person to be consistent and to tap into people's own personl attitudes.

8.4.7 Application of the ATS in academic research

The ATS will be used in two research projects that are currently running in the Centre for Human Computer Interaction at City University. The VISTA (Virtual Interface for a Set Top box Agent) Project and the LBS4ALL (Location-Based Services for All) Project.

The VISTA project (funded by the PACCIT[12] Programmes of EPSRC[13] & ESRC[14]) is conducting research towards the development of a complete Virtual Human Interface for digital television. A virtual human will be combined with voice input and output systems, to create an easy to use prototype interaction system for elderly and visually impaired digital television

[12] People @ the Centre of Communication and Information Technologies (http://www.paccit.gla.ac.uk/public/start.php)

[13] The Engineering and Physical Sciences Research Council

[14] The Economic and Social Research Council

viewers. The system will help elderly and visually impaired viewers access Electronic Programme Guides (EPGs) which provide information about current and future programming. Often, EPGs are problematic for viewers who are unable to operate a remote control or read the information on the screen. The ATS will be used to monitor visually impaired and elderly viewers' attitudes towards the Virtual Human Interface throughout its development. The measurement of elderly and visually impaired viewers' attitudes using the ATS, will become an integral part of the user centred approach to the development of the VISTA system. Evaluations of the system will not only inform the development of the virtual human interfaces, but will also provide a measure of users' attitudes and the appeal of the VISTA virtual human interface. Furthermore, the use of the ATS will enable future usage levels to be predicted, relevant for the potential commercialisation of the VISTA concept.

The LBS4ALL Project (funded by the PACCIT Programmes of EPSRC & ESRC) will investigate the use of the location-based services that are beginning to be provided via the next generation mobile phone system (for example, a service that notifies you when you are in the vicinity of particular shops). These services need to be made accessible and clearly have great potential for being developed in ways to specifically help visually impaired and elderly people. The ATS will be integrated into the research process to gain a measure of visually impaired and elderly individuals' attitudes towards the location-based services. Measuring their attitudes will provide valuable information regarding the potential uptake and use of these services.

8.4.8 Application of the ATS in commercial research

The ATS could be used within the commercial sector to measure the attitudes of existing customers and potential consumers towards technological devices. The ATS would enable the measurement of (i) *current* attitudes for market analysis and (ii) attitudes to *predict* future level of use. An example given earlier is that of next generation mobile phones and associated technology and services. The telecommunications industry has invested a great deal of resources researching the market for the next generation (3G) mobile phones and services. This research has involved among others, a study whereby a sample of mobile phone users was given 3G phones for a period of time. The study was aiming to assess the usability problems faced by users and to establish overall consumer opinion. Numerous surveys have also been carried out to provide data for market analysis. The ATS could be incorporated into these studies and surveys to provide valid and reliable measurements of users' attitudes, enabling accurate market forecasts of different demographic groups & market segments. The ATS would contribute valuable information about consumer appetite and acceptance of 3G technology and associated services.

8.5 Theoretical implications of this research

The theoretical implications of this research are that the measurement of attitudes could become an integral part of the user centred design life cycle. It has also demonstrated that some elders may have a *barrier* to acceptance of technology, even when the technology has been developed according to their needs and when they would clearly benefit from its use. It has been suggested that attitudes and perceptions of users need to be understood to improve the uptake and the continued use of assistive devices (Wasson, Gall & McDonald et al., 1990). This is also the case of other user groups; their attitudes influence their use of and acceptance of technology.

The main aim of developers must be to create technological innovations that are easy to learn and use - the fundamental aspects of usability. To achieve this, the design of technology must not be driven by technologists but it must be user-driven, thereby involving users at every stage of the research, design and development process. Past researchers have noted the wide gulf between designers and users in terms of attitudes and behaviours (Mumford, 1983). If users are not continuously consulted, this often results in devices or systems that are overly complex and difficult to use. It is these complex devices that create user frustration since they can no longer concentrate on the essential task but instead focus on operating the technology. This is the paradox of technology (Norman, 1995) whereby technology no longer simplifies but complicates life.

Currently, many subjective measures used in HCI research are unvalidated and their relationship to technology usage is unknown. This research proposes that the measurement of users' attitudes should become an intrinsic part of the design life cycle. This thesis concludes by putting forward a new model of the design life cycle based on that by Petrie & Johnson et al., (1994) *(see Chapter 2)*. The revised model of user centred design *(Figure 8.3)* illustrates that users' attitudes are continuously measured using the ATS throughout the design process.

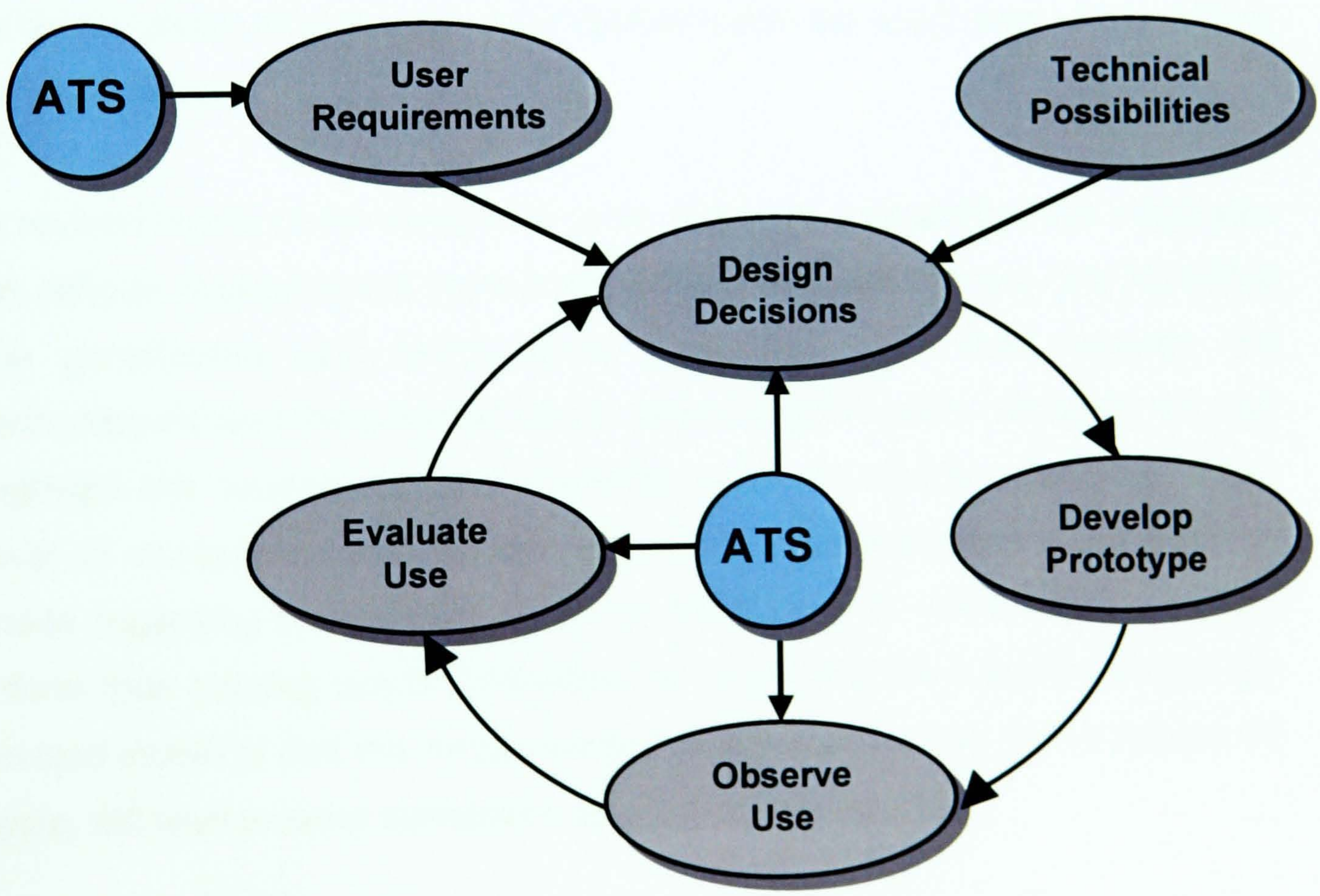


Figure 8.3 Revised model of the design life cycle

Starting with the user requirements process, the ATS can be used to measure users' attitudes. It is important to measure attitudes at this stage so that an attitude profile can be put together for the potential user group. The attitude profile can inform the training programme initially for training users to use the prototypes. As the prototypes are evaluated by users and observed in use, users' attitudes could again be measured using the ATS. Their attitude profile may change throughout the design process either favourably or unfavourably. If it is the latter, then investigations can be made to understand why there has been a negative change in attitude. Information about users' attitudes will enable developers to predict the future use of and acceptance of technology by certain user groups.

8.6 Summary

This chapter has provided an overview of the work presented in this thesis and how this work has made a substantial contribution to knowledge. There is clearly plenty of scope for future research and the application of the ATS is immeasurable.

A revised model of the design life cycle has been proposed which integrates an attitude measurement component. Measuring attitudes will help to bridge the *generational* and *technological gaps* that often exist between the technologists and the potential users. Measuring the users' attitudes will also highlight the *acceptance gap* indicating those individuals who have a low level of acceptance towards the technology. Consideration could then be made regarding the introduction of the technology to these users and help inform their training needs. Therefore the underlying main assumption of the revised model is that the measurement of attitudes as part of the design life cycle, will lead to more acceptable and useable technology.

"Today, it is the individual who must conform to the needs of technology. It is time to make technology conform to the needs of people"

Norman (1998, p. 261)

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Appendix A: Role in the PAM-AID Project

I was employed as a Research Assistant on the PAM-AID Project from 1997-1999. I was not involved in the initial project proposal, which broadly stated that studies would be conducted to establish user requirements and to evaluate the PAM-AID prototypes. The proposal did not state the specific nature or design of the studies and this was identified at a later time once the project had started.

In my role as work package leader, I was responsible for designing the user requirements and evaluation studies for all human factors partners. This involved the design of materials, analysis of results and the presentation of work in reports to the European Commission. Thus, the work included in this thesis is entirely my own.

Signed:

A M O'Neill Burn

Anne-Marie O'Neill Burn

Date: 3/5/2003

Counter signed:

Helen Petrie

Professor Helen Petrie

Date: 3/5/2003

Appendix B: User requirements interview schedule with Carers

C____

A. Description of the potential of the device and the target user group.
Whenever I refer to users of this walking aid, please keep in mind that this refers to elderly people who are very frail and visually impaired.

B. Possible ways/places of use (different scenarios).

C. User Requirements for the Walking Aid
We need you opinions so that we can develop this new walking aid and to make sure that it will be what frail elderly people want.

E. User Requirements for the Walking Aid
Earlier, I explained a new indoor-walking aid to you which will be used by frail, elderly people who are visually impaired. The person using this aid can choose whether to push it <u>or</u> let it gently pull them along while they walk. The aid will automatically move around any obstacles in its pathway or stop if it comes to some stairs for example. I am going to ask you some questions about how you think this walking aid should work.

Input

1. There are several possible ways of making this walking aid move. One way to make it move is by speaking to it. For example, you could say "Forward" to make it go forwards. Do you think frail, visually impaired people would like to use a walking aid which required them to speak to it?

1	2	3	4	5
Definitely would not like to use		May use		Definitely would like to use

Why?____

____

2. Do you think users would be embarrassed about speaking to the walking aid?

1	2	3	4	5
Very emb'd.		Mod'ately emb'd.		Not very emb'd.

3. Do you think users would mind speaking to the walking aid if they were in the privacy of their home/room?

1	2	3	4	5
Mind a great deal		Mod'ately mind		Wouldn't mind at all

Why?____

____

4. Do you think users would mind speaking to the walking aid in a public place? For example, in a hospital or the living room of a residential home.

1	2	3	4	5
Mind a great deal		Mod'ately mind		Wouldn't mind at all

Why?____

5. Another way to make the walking aid move could be by pressing switches on the handles using their fingers. How much do you think users would like to use finger switches to make it move?

1	2	3	4	5
Not like at all		May like		Like very much

6. Another way to make it move could be with thumb switches. How much do you think users would like to use thumb switches?

1	2	3	4	5
Not like at all		May like		Like very much

Output

7. The walking aid will be able to speak back to the user and give them information about their environment. For example, it could tell them that they are passing a doorway on their right-hand side. How useful do you think this kind of information would be?

1	2	3	4	5
Not very useful		Mod'ately useful		Very useful

Why?____

____

8. Do you think users would mind using a walking aid that spoke to them?

1	2	3	4	5
Mind a great deal		Mod'ately mind		Wouldn't mind at all

Why?____

____

9. Do you think users would mind the walking aid speaking to them in a public place? For example, in a hospital or the living room of a residential home.

1	2	3	4	5
Mind a great deal		Mod'ately mind		Wouldn't mind at all

Why?____

____

10. Would users like to be able to turn off the speaking?

Y/sometimes/N

Why?____

____

11. Would users like to be able to change the volume of the speaking?

Y/sometimes/N

Why?____

____

12. What sort of information would you like the walking aid to give users when they are walking indoors? [possible prompts: notification of obstacles, doors, stairs]

____

____

13. Should the spoken information be given to users through an ear-piece?

Y/Sometimes/N

Why?____

____

14. Do you think users would use a walking aid which made different sounds? [e.g.beeping when passing an open door]

1	2	3	4	5
Definitely would not use		May use		Definitely would use

Why?____

____

15. How easy do you think it will be for users to hear these sounds?

1	2	3	4	5
Not very easy		Mod'ately easy		Very easy

____

____

16. Do you think users will be worried that the voice and sounds would make them conspicuous/stand out?

1	2	3	4	5
Not very worried		Mod'ately worried		Very worried

Physical Design/Structure

17. Do you think users will want one handle across or two handles on each side if this new walking aid? [illustrate]

1 / 2

Why?____

18. Will users want to grip the handles in different ways? Can you show me? [e.g. some Ps may prefer to grip palm down, others may feel more comfortable with a joystick grip].

19. Would users like to rest their forearms on the walking frame?

Y/sometimes/N

[If Y or sometimes] Would this be whilst walking or when stopping for a rest? [or both]

20. Do you think the walking aid should come with or without a seat?

With/Without

Comments

21. Do you think the walking aid should have an alarm so that users can summon help if they need to?

Y/N

Comments

22. Do you think users would prefer to push the walking aid or prefer it to gently pull them along?

Push [ ]
Pull [ ]
Either [ ]

Comments ______________________________

____

23. How worried would you expect users to be about the walking aid gently pulling them along?

1	2	3	4	5
Not very worried		Mod'ately worried		Very worried

Comments ______________________________

____

24. Would you expect users to want to change the speed of the walking aid or keep one speed at all times?

One speed/Change

Comments ______________________________

____

If possible find out carers views on:
Size; Weight; Cost to run/purchase

F. Level of Technology Acceptance

25. How useful do think this walking aid will be?

1	2	3	4	5
Not very useful		Mod'ately useful		Very useful

Comments ______________________________

____

26. Do you think that frail visually impaired people would be interested in using such a walking aid?

1	2	3	4	5
Not at all interested		Mod'ately interested		Very interested

Comments ____

____

G. Personal data

Participant's Name/Code______________________

Age:____________

Gender: **M / F**

Occupation: ___________

Place of work:
Private residential home [ ]
Building of private apartments [ ]
Other ________________

How long have you done this job? _______________

Appendix C: Functionality of the first PAM-AID prototype

The functionality of the first prototype was fairly comprehensive, to give the user personal choice when operating PAM-AID but also to make the walking aid more flexible in different environments. The first prototype incorporated an intelligent guiding system that included infrared sensors to detect obstacles to guide users safely around those obstacles. The walking aid also incorporated robotics motors that allowed the device to move with the activation of the input methods.

The functionality included the following:

- Two modes of operation - Automatic and manual
- Two methods of input - Instrumental handles and handles with switches
- Two forms of auditory output - Speech messages and non-speech sounds

Modes of operation

The participants in the previous user requirements study found it almost impossible to envisage how the two modes of operation worked. Therefore, it was important that elders evaluated both modes of operation during this study. These two modes of operation give the user a choice of operation, either (i) **automatic control** - whereby the user takes a fairly passive role while the system actively navigates around obstacles or (ii) **manual control** - whereby the user takes a more active role and operates PAM-AID to navigate around obstacles.

Automatic mode

During this mode, PAM-AID guides the user by actively navigating them safely around obstacles. Input mechanisms are irrelevant in this mode, as operation by the user is kept to a minimum. In fact, users only have to hold onto the handles of PAM-AID as it guides them along their route. Throughout, users receive auditory output, which provides them with feedback regarding the behaviour of the aid.

The automatic mode is a good introduction for users to PAM-AID because they can learn to walk with the aid without having to learn the input methods. After some initial experience with this mode, users may be ready to learn some of the input functionality needed to operate PAM-AID in the manual mode. For the purpose of the evaluation, the researcher manually altered the speed to suit the preferred walking speed of each participant. However, it is the aim that individuals' preferred walking speeds could be stored with other user preferences in PAM-AID, so that the interface to the walking aid could be tailored to individual preferences.

Manual mode

During this mode, the user operates PAM-AID via one of two input methods - instrumental handles or switches, in order to navigate the aid around obstacles. Both handles had similar handgrips and were angled on the aid similar to the handles on the back of a conventional wheelchair *(Figure C.1)*. The switches were placed on both handles to enable easy reach for users.

Input methods

During the previous user requirements study, elders were asked about the use of voice input and switch input. Switch input (that could be operated by fingers or thumbs) was implemented in the first prototype since it received fairly positive ratings in the user requirements study. However, voice input was not implemented in the first prototype for two reasons (i) at this stage, the voice input was still under development by the technical team and was therefore not ready for evaluation, and (ii) the elders in the user requirements study had given a mixed response regarding voice input with many of them expressing that they would feel embarrassed using it. However, voice input may be tested on a later prototype version.

In replace of the voice input, instrumental handles were introduced instead. Although these had not been discussed during the user requirements study, the technical development team had developed these moveable handles as an alternative to using the switches. These would also be evaluated during this first evaluation study to establish whether moveable handles are a viable option for PAM-AID.

Instrumental handles

The instrumental handles move up and down to trigger switches for operating PAM-AID. Moving these handles in different combinations allows the user to manoeuvre the aid in different directions.

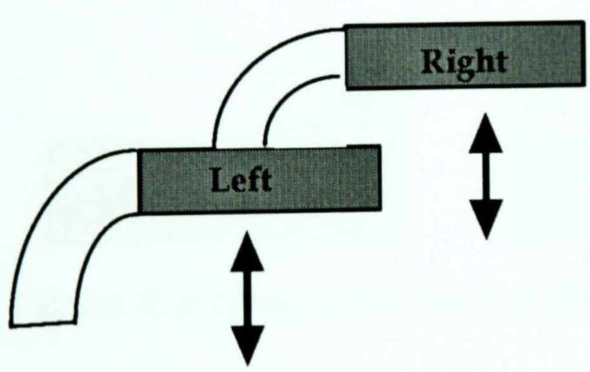

Figure C.1 Lateral view of the instrumental handles

Table C.1 shows that both handles need to be leant on for the aid to move forward, and to reverse, both handles need to be lifted. To turn right, users just lean on the right handle only; making sure that the left handle is not pushed down. To turn left, users have to lean on the left handle only, making sure that the right handle is not pushed down.

Table C.1 Functionality of the instrumental handles

Direction	Operation of handles
Forward	Both handles pushed down
Turn Right	Right handle down only
Turn Left	Left handle down only
Reverse	Both handles lifted upwards

Switches on handles

As an alternative to the instrumental handles, users can operate PAM-AID by pressing switches situated on static handles. The switches were placed on the top of the handles so users could press them with thumbs or fingers. Two switches were situated on each handle, and like the instrumental handles, pressing different switches resulted in moving the aid in different directions *(Figure C.2)*.

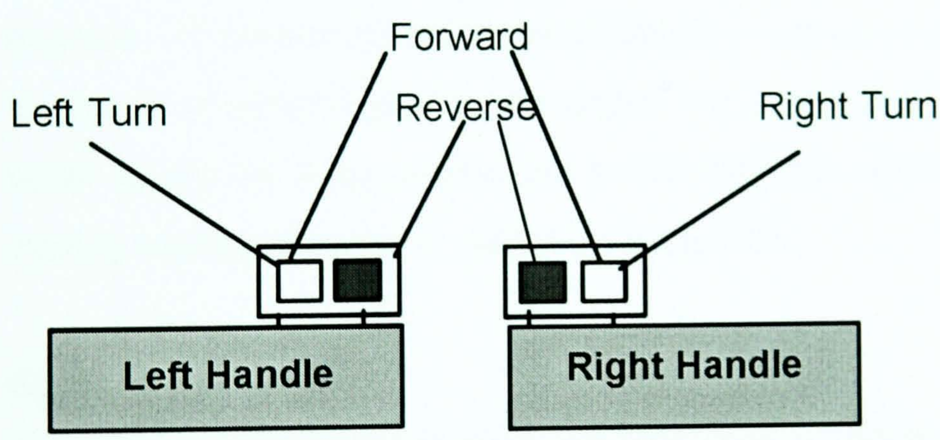

Figure C.2 Downward view of the switch handles

Table CD.2 shows that the two outside switches need to be pressed in order to move forwards and the two inner switches pressed to reverse. To turn right, users press the outer switch on the right handle and to turn left, users press the outer switch on the left handle, thus being consistent with the instrumental handles.

Table C.2 Functionality of the switches

Direction	Operation of Switches
Forward	Both outside switches pressed
Turn Right	Right outside switch down only
Turn Left	Left outside switch down only
Reverse	Both inside switches pressed

Auditory output

The previous user requirements study showed that elders would like speech messages that gave them important information about their environment, particularly if they gave warnings about impending danger. Two forms of auditory output were available for evaluation, speech messages and non-speech sounds. There are a number of possibilities for presenting auditory information to users. For instance, the information could be presented (i) all in speech, (ii) all in non-speech sounds, or (iii) a combination of speech and sounds. If presented as a combination of speech and sounds, there arises the issue of which type of information would be best presented in speech and what would be best presented in non-speech sounds. The auditory output clearly warrants some in-depth investigation.

Speech messages

One form of auditory output incorporated in PAM-AID was in the form of speech messages. These brief messages were digitised speech giving messages warning users about obstacles in their pathway, for example, "obstacle in front" and "bumpers have been hit". The speech messages also gave users command confirmation information once they had operated PAM-AID. For example, when the user turned PAM-AID to the right, the message "right turn" could be heard. Obstacle detection messages always specified the direction of obstacles i.e. in front, to the right, to the left, from which users could infer which way to turn.

Non-speech sounds

An alternative form of auditory output was that of non-speech sounds. Again, these sounds could give users warnings and command confirmation. However, few sounds were implemented for this evaluation in case too many sounds could be difficult to identify. Therefore, at this stage, only two sounds were included: One sound ('Chord') warned that there was an obstacle blocking the route. The other sound ('Beeping') was a command confirmation sound and indicated to users that PAM-AID was reversing.

Appendix D: Functionality of the second PAM-AID prototype

The functionality of the second prototype in given below:

Input options

The instrumental handles were removed because this first evaluation study had shown that these handles had failed to support very frail participants. Furthermore, these handles had previously caused confusion among some participants when using the automatic mode.

Some participants during the evaluation had suggested that the handles could be shaped like bicycle handlebars, since many of them had ridden a bicycle before losing their sight and this would be a more intuitive way to direct PAM-AID. The original handles were replaced by a bicycle handlebar but it was decided that the handlebar would not move to direct the walking aid at this stage. It was important to evaluate whether the new handlebar design would provide adequate support for users whilst walking, otherwise the design would need to be changed. Furthermore, it was also decided that the bicycle handlebar should remain stationary because the moveable instrumental handles had confused participants during this first study.

The switches were retained and were situated on the handles within easy reach of the users' thumbs. The switches were made more distinguishable than they had been in the first prototype, two of the switches were round and high in profile and the other two switches were square and lower in profile. Distinguishable colours were also used for partially sighted participants.

The positions of the switches were rearranged so that they would be more intuitive to participants and easier to remember. Participants now only had to press one switch at a time. Two switches were placed on the right handle, the left square switch moved PAM-AID to the left, and the right round switch moved PAM-AID to the right. Two switches were placed on the left handle, with the front switch moving PAM-AID forwards and the rear switch moving PAM-AID backwards. Once the participant released the pressure off the switches, PAM-AID would stop moving.

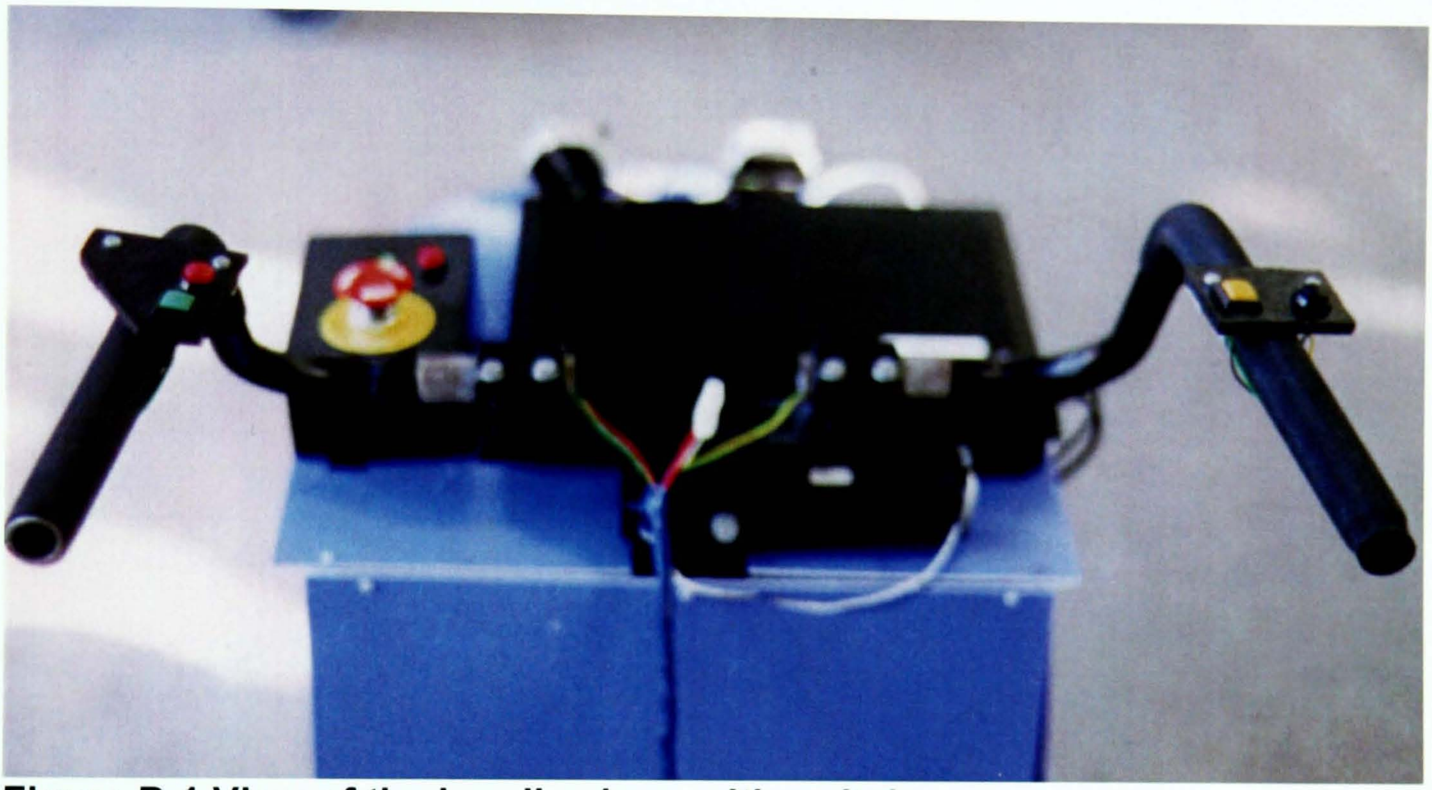

Figure D.1 View of the handles bars with switches

Output options

The first evaluation study had shown that participants were overwhelmed with the amount of functionality they had to experience and comment on in such a short period of time. Therefore, the auditory output from PAM-AID was removed for this evaluation so that the participants could concentrate on evaluating other aspects of usability.

Modes of operation

Both the automatic and manual modes were retained for the second prototype. These modes needed to be evaluated by more users to establish the usability of the modes of operation, particularly with the new handlebar design.

Obstacle detection

The sensitivity of the obstacle detection facility was improved and the over-compensating veering noted in the above evaluation was also corrected.

Appendix E: PAM-AID User Requirements Interview Schedule with Elders

P____

Target participant (P) group: 65+ years, frail (i.e. unable to walk across a room without support), visually impaired (moderate or more).

A. Description of the potential of the device.

B. Possible ways/places of use (different scenarios).

C. Current mobility/support aids

Instructions: Tick boxes for 'yes' answers, otherwise leave blank. Please circle when choices or rating scales are given. Make clear notes of Ps comments. Mark Qs which are not applicable (N/A).

1. Do you use any walking aids to assist you in moving around? [may answer whether constant or occasional use]

		Any comments
Support/walking stick	[ ]	________
One or two?	**1 / 2**	________
Support/walking stick with tripod	[ ]	________
Guide/symbol cane (i.e. not support, guidance only)	[ ]	________
Long cane (navigational)	[ ]	________

Walking frame without wheels [ ] ________________

Walking frame with wheels [ ] ________________

Reciprocal walking frame [ ] ________________
(allows more natural walking movement)
Wheelchairs [ ] ________________

If <u>one or more</u> of the above aids is mentioned, go to Q3, otherwise go to Q2

2. (i) Why don't you have/use a walking aid at the moment?

____

____

____

(ii) Would you find some sighted/physical assistance helpful?

____

____

____

[Go to Q8]

D. Current Level of Mobility

In this section, try to <u>discreetly</u> elicit information about how frail the person is and what problems they have in moving about e.g. they may indicate that they have balance problems, falls, bump into obstacles etc.

At Home/Place of Residence

3. Do you use your walking aid to walk/move around your home ?

Y/Sometimes/N

Comments: ____

____

4. Do you have any problems using it at home? [possible prompts: getting through doorways, going around certain obstacles]

Y/Sometimes/N

Comments: ______________________________

____

5. What do you like about using it at home? [possible prompts: easy to use in confined space, has a basket]

Comments: ______________________________

____

6. Does your walking aid help you to keep your balance? [note if they say no balance problems]

Y/Sometimes/N

Comments: ______________________________

____

7. Does the walking aid help you to move around obstacles easily?

Y/Sometimes/N

Comments: ______________________________

____

8. Are you able to walk from one side of a room to the other <u>without</u> support [environmental or personal]? **Y/Sometimes/N**

Comments: ______________________________

____

9. How safe do you feel walking/moving around your home?

1	2	3	4	5
Not at all safe	Not very safe	Mod'ately safe	Quite safe	Very safe

Comments: ____

____

10. Do you have any other worries about walking/moving by yourself [with or without walking aid] around your home? [possible prompts: falling over, losing balance, injury fears, bumping into obstacles, falling down stairs]

Comments: ____

____

____

11. Are there other forms of assistance [e.g. environmental or personal] you'd like to have at home?

Comments: ____

____

12. Overall, how happy are you with your ability to move around at home?

1	2	3	4	5
Not at all happy	Not very happy	Mod'ately happy	Quite happy	Very happy

Comments: ____

____

Outside of Home

13. Have you been outside of your home during the past week? **Y/N**

[If yes] How many times? __________

14. Did you go out locally?

Locally [ ]

Further [ ]

Where?____

[If they go out]
15. Do you go out on foot? **Y/N**

16. Are you alone on foot? **Y/N**
[If not] Are you with a companion?_____________________________

17. During the past week have you used:

Public transport	[ ]	____________________
Taxi	[ ]	____________________
Private transport	[ ]	____________________

18. Would you like to go out more often? **Y/N**

19. Overall, how happy are you with your ability to travel outside your home alone?

1	2	3	4	5
Not at all happy	Not very happy	Mod'ately happy	Quite happy	Very happy

Applicable to users of walking aids only:
20. Do you use your walking aid when travelling outside of your home?

Y/sometimes/N

____

____

21. Do you have any problems using it outside?

Y/sometimes/N

____

____

22. What do you like about using it outside?

____

____

23. How safe do you feel walking/moving around outside?

1	2	3	4	5
Not at all safe		Mod'ately safe		Very safe

Comments: ____

____

E. User Requirements for the Walking Aid

Earlier, I explained a new indoor-walking aid to you. The person using this aid can either push it <u>or</u> let the aid gently pull them along while they walk. The aid will also automatically move around any obstacles in its pathway or stop if it comes to some stairs for example. I am going to ask you some questions about how you would like this walking aid to work.

Input

24. There are several possible ways of making this walking aid move. One way to make it move is by speaking to it. For example, you could say

"Forward" to make it go forwards. Would you like to use a walking aid which required you to speak to it?

1	2	3	4	5
Definitely would not like to use		May use		Definitely would like to use

Why?____

____

25. Would you mind speaking to the walking aid in the privacy of your home/room?

1	2	3	4	5
Mind a great deal		Mod'ately mind		Wouldn't mind at all

Why?____

____

26. Would you mind speaking to the walking aid in a public place such as a hospital/residential home?

1	2	3	4	5
Mind a great deal		Mod'ately mind		Wouldn't mind at all

Why?____

____

27. Another way to make the walking aid move could be by pressing switches on the handles using your fingers. Can you say how much would you like to use finger switches to make it move? [Try to illustrate this]

1	2	3	4	5
Not like at all		May like		Like very much

28. Another way to make it move could be with thumb switches. Can you say how much you would like to use thumb switches?

1	2	3	4	5
Not like at all		May like		Like very much

29. Would you need both hands to support you all the time?

Y/Sometimes/N

____

____

Output

30. The walking aid will be able to speak back to you and give you some information. For example, it could tell you that you are passing a doorway on your right-hand side. How useful do you think this kind of information would be?

1	2	3	4	5
Not at all useful		Mod'ately useful		Very useful

Why?____

____

31. Would you mind using a walking aid that spoke to you?

1	2	3	4	5
Mind a great deal		Mod'ately mind		Wouldn't mind at all

Why?____

____

32. Would you mind it speaking to you in a public place such as a hospital/residential home?

1	2	3	4	5
Mind a great deal		Mod'ately mind		Wouldn't mind at all

33. Would you like to be able to turn off the speaking?

Y/sometimes/N

Why?____

____

34. Would you like to be able to change the volume of the spoken information [voice speaking]?

Y/sometimes/N

Why?____

____

35. What sort of information would you like the walking aid to give you when walking indoors? [possible prompts: notification of obstacles, doors, stairs]

____

____

36. Would you prefer the spoken information to be given through an ear-piece? **Y/Sometimes/N**

Why?____

____

37. Would you use a walking aid which made different sounds? [e.g. beeping]

1	2	3	4	5
Definitely would not use		May use		Definitely would use

Why?____

____

38. Do you think it will be useful if the sounds told you information? [e.g. a beep when passing an open door]

1	2	3	4	5
Not very useful		Mod'ately useful		Very useful

39. How easy do you think it will be for you to hear these sounds?

1	2	3	4	5
Not very easy		Mod'ately easy		Very easy

40. Would you be worried that the voice and sounds would make you conspicuous/stand out?

1	2	3	4	5
Not at all worried		Mod'ately worried		Very worried

Physical Design/Structure

41. If you used this new walking aid, would you like it to have one handle/bar across or two handles at each side? [Illustrate this. If a special configuration is given, please describe]

1 / 2

Why ?

42. Can you show me what is the most comfortable way for you to grip handles? [e.g. some Ps may prefer to grip palm down, others may feel more comfortable with a joystick grip].

Describe: ____

____

43. Would you like your forearms to rest on the walking frame?

Y/sometimes/N

[If Y or sometimes] Would you use this arm rest whilst walking or when stopping for a rest? [or both]

Comments ____

____

____

44. Would you like this walking aid to come with or without a seat?

With//Without

Comments ____

____

45a. Would you like the walking aid to have an alarm so that you could summon help if you needed to?

Y/N

Comments ____

____

45b. Would you like the walking aid to come with or without a shopping basket?

With/Without

Comments ____

____

46. Would you prefer to push the walking aid or would you prefer it to gently pull you along?

Push [ ]
Pull [ ]
Either [ ]

Comments ______________________________

____

47. How worried would you be about the walking aid gently pulling you along?

1	2	3	4	5
Not at all worried		Mod'ately worried		Very worried

Comments ______________________________

____

48. Would you like to be able to change the speed of the walking aid?

Y/sometimes/N

Comments ______________________________

____

F. Level of Technology Acceptance

[Previous Qs may also give insight into this area]

49. How useful do think this walking aid will be?

1	2	3	4	5
Not very useful		Mod'ately useful		Very useful

Comments ____

____

50. Would you be interested in using such a walking aid?

1	2	3	4	5
Not very interested		Mod'ately interested		Very interested

Comments ____

____

51. If you have/had to use a wheelchair, would you prefer:

An electronic wheelchair [ ]
<u>or</u>
A standard wheelchair which needed someone to push you [ ]

[probe to see if anxiety of electronic aids]

____

____

G. Personal Data

Participant's Name/Code________________________

Age:____________

Gender: **M / F**

Level of Vision:

Blind [ ] Since birth [ ] or [ ] years of age

Partially sighted [ ] Since birth [ ] or [ ] years of age
Sighted [ ]

Registered [ ]
Non-registered [ ]

Place of Residence:
Own Home [ ] House/Flat
Residential Home [ ] i.e. with carers
Flat in complex with warden [ ]
Hospital [ ]

Do you have to use stairs/steps at all? **Y/Sometimes/N**

Do you need a hearing aid? **Y/N**

Have you ever been given any formal mobility training? **Y/N**
[i.e. training in how to get around since you lost your sight]

Do you have any other disabilities or health problems that may effect your ability to use this walking aid? [e.g. stroke, arthritis]

____

____

Appendix F: Evaluation Procedure

1. Task A - Instrumental Handles for Input & Speech Output

Whilst walking with PAM-AID, Ps will be asked questions A1 to A5 at suitable moments. Researchers should record observations such as technical problems/errors, difficulties exhibited by user and particularly good use exhibited by user. Researchers should note users ideas for improvements obvious user and carer training needs.

(i) Automatic Mode

Ps walk along a corridor on automatic mode and will hear speech output. Ps will hold onto the instrumental handles but they will not need to operate them in this mode . Ps will experience walking with the aid at a certain speed (specified by TCD) and obstacle detection.

One researcher will give directions and explanation about the behaviour of PAM-AID. The R will provide assistance where necessary and the safety of Ps is of paramount importance.

Once Ps reach the end of the corridor they will turn around using the manual mode.

(ii) Manual Mode

Ps will need guidance from Researchers as to operating the instrumental handles.
The P should be shown how to operate the handles and the researcher will give assistance to the P where needed. The researcher will not intervene if Ps are able to operate the switches independently.

2. Task A Evaluation Questions

(Let the P rest while they answer Task A questions).

1. Task B - Switch Input & Non-speech Sound Output

Whilst walking with PAM-AID, Ps will be asked questions B1 to B4 at suitable moments. Researchers should record observations such as technical problems/errors, difficulties exhibited by user and particularly good use exhibited by user. Researchers should note users ideas for improvements obvious user and carer training needs.

(i) Automatic Mode

Ps walk along a corridor on automatic mode and will hear non-speech sound output. Ps will hold onto the switch handles but they will not need to operate the switches in this mode. Ps will experience walking with the aid at a certain speed (specified by TCD) and obstacle detection.

One researcher will give directions and explanation about the behaviour of PAM-AID. The researcher will provide assistance where necessary and the safety of Ps is of paramount importance.

Once Ps reach the end of the corridor they will turn around using the manual mode.

(ii) Manual Mode

Ps will need guidance from researcher s as to operating the switches.
The P should be shown how to operate the switches and the researcher will give assistance to the P where needed. The researcher will not intervene if Ps are able to operate the switches independently.

2. Task B Evaluation Questions

(Let the P rest while they answer Task A questions).

Appendix G: First Evaluation Questionnaire

Personal Data

(i) Participant's Name/Code________________________________

(ii) Age:______________

(iii) Gender: **M / F**

(iv) Did this P take part in the user requirements study?

Y [ ] N [ ]

(v) Blind [ ] for [ ] years <u>or</u> since birth [ ]
Partially sighted [ ] for [ ] years <u>or</u> since birth [ ]
Sighted [ ]

(vi) Residential Home [ ] i.e. with carers
Own Home [ ] House/Flat
Flat in complex with warden [ ]

(vii) Do they use a hearing aid? **Y/N**

(viii) Do they have any other disabilities or health problems [e.g. stroke, arthritis].

____

____

1. Questions DURING Task A

Instrumental Handles/Speech Output

A1: Were you able to hear that message clearly?

Y [ ]   N [ ]

If No, ask why______________________________

____

A2: Was the wording of the message good, poor or average ?

Good [ ]   Poor [ ]   Average [ ]

*Comments:*______________________________

____

=========================

A3: Is the speed of the walking aid too fast, too slow or about right?

Too slow [ ] Too fast [ ]   About right [ ]

*Comments:*______________________________

____

A4: Would you like to be able keep it at one speed or to change the speed ?

Change [ ]   One speed [ ]

____

____

A5: Does the walking aid jerk at all or is it smooth?

Jerky [ ] Smooth [ ]

Comments:

2. Questions AFTER Task A

1a. When the walking aid guided you across the room, did you feel safe or unsafe or neither?

[If safe/unsafe, ask "Would you say that you felt quite safe/unsafe or very safe/unsafe?"].

Unsafe Safe

very quite quite very

b. [If applicable] What was it that made you feel particularly safe/unsafe?

2. When you operated the walking aid with the handles, did you find them easy, manageable or difficult?

Difficult — Manageable — Easy

very — quite — quite — very

3. Is there any way we can improve the handles?

4. Overall, how efficient was the walking aid in helping you to walk? Would you say the walking aid was good, poor or average?

Poor — Average — Good

very — quite — quite — very

5. Did you think the messages were useful, not useful or neither?

Not useful — Neither — Useful

Not at all — Not very — quite — very

6 a. Would you have liked to have heard more messages, less messages or was it about right?

More [ ]   Less [ ]   About right [ ]

b. Was the length of messages too long, too short or about right?

Long [ ]   Short [ ]   About right [ ]

c. Did you find the messages understandable?

Yes [ ]   No [ ] Sometimes [ ]

7. Would you like to be able to turn off the messages?

Y [ ]   N [ ]   Sometimes [ ]

8. Would you like to be able to change their volume?

Y [ ]   N [ ]   Sometimes [ ]

End of Task A Questions

3. Questions DURING Task B

Switches/Sounds

B1: Are the switches well positioned for you, not well positioned or about right?

Well positioned [ ] Not well positioned [ ] About right [ ]

*Comments:*____

____

B2: Are they easy or difficult for you to operate?

easy [ ] difficult [ ]

==========================

B3: Is the speed of the walking aid too fast, too slow or about right?

Too slow [ ] Too Fast [ ] About right [ ]

*Comments:*____

____

B4: Does the walking aid jerk at all or is it smooth?

Jerky [ ] Smooth [ ]

*Comments:*____

____

B5: Reverse Sound

Were you able to hear that sound clearly?

Y [ ] N [ ]

If No, ask why____

____

Do you like this sound?

Y [ ] N [ ]

If No, ask why____

____

4. Questions AFTER Task B

1. When the walking aid guided you down the corridor, did you feel safe, unsafe or neither?

Unsafe Safe

very quite quite very

____

____

2. [If applicable] What was it that made you feel safe/unsafe?

____

____

3. When you operated the walking aid with the switches, did you find it easy, manageable or difficult?

Difficult Manageable Easy

very quite quite very

4. Is there any way we can improve the handles?

5. How efficient was the walking aid in helping you to walk? Would you say the walking aid was good, average or poor?

Poor Average Good

very quite quite very

6. Can you remember what the sounds were for? {should mention reverse]

7. Do you think the sounds are easy to remember, difficult to remember or manageable?

Difficult Manageable Easy

very quite quite very

8. Do you think the sounds are useful, not useful or neither?

Not useful Neither Useful

Not at all Not very quite very

9. Do you think there should be more sounds, less sounds or was the number of sounds about right?

More [ ] Less [ ] About right [ ]

10. Would you like to be able to turn off the sounds?

Y [ ]   N [ ]   Sometimes [ ]

____

____

11. Would you like to be able to change their volume?

Y [ ]   N [ ]   Sometimes [ ]

____

____

End of Task B Questions

Technology Acceptance

Researcher: "I am going to ask you a few more questions. Some of these questions may sound like ones I have asked you before, but I have to try and get a detailed picture of what you think".

1. Overall, did you find the walking aid easy to use, difficult to use or manageable? [If easy/difficult, ask "Would you say that it was quite easy/difficult or very easy/difficult?"].

Difficult Manageable Easy

very quite quite very

2. What was it that made the walking aid easy/manageable/difficult to use?

3. Do you think this walking aid would be useful for you, not useful or neither? [Probe for: Not at all useful/not very useful/quiteuseful/very useful].

Not useful Neither Useful

Not at all Not very quite very

Comments: ____

____

4. Can you explain why you think it would be useful/not useful [or neither] for you?

Comments: ____

____

5. What about other visually impaired elderly people in general? Do you think this walking aid would be useful for them, not useful or neither? [Probe for: Not at all useful/not very useful/quiteuseful/very useful].

Not useful — Neither — Useful

Not at all — Not very — quite — very

Comments: ____

____

Appendix H: Second Evaluation Questionnaire

Personal Data

(i) Participant's Name/Code________________________________

(ii) Age:______________

(iii) Gender: **M / F**

(iv) Did this P take part in the user requirements study?

Y [ ] N [ ]

(v) Blind [ ] for [ ] years <u>or</u> since birth [ ]
Partially sighted [ ] for [ ] years <u>or</u> since birth [ ]
Sighted [ ]

(vi) Residential Home [ ] i.e. with carers
Own Home [ ] House/Flat
Flat in complex with warden [ ]

(vii) Do they use a hearing aid? **Y/N**

(viii) Do they have any other disabilities or health problems [e.g. stroke, arthritis].

____

____

(ix) Present mobility

____

____

Whilst Walking

1. Is the speed of the walking aid too fast, too slow or about right?

Too fast [ ]   Too slow [ ]   About right [ ]

2. Would you like to be able keep it at one speed or to change the speed?

Change [ ]   One speed [ ]

3. Does the walking aid jerk at all or is it smooth?

Jerky [ ]   Smooth [ ]

Switches

Ask while walking:

1. Are the switches well positioned for you, not well positioned or about right?

Well positioned [ ] Not well positioned [ ] About right [ ]

Ask after walk:

2. When you were using the switches, did you find them easy, manageable or difficult?

Difficult Manageable Easy

very quite quite very

Probe:

3. Would you say they were easy or difficult to learn how to use?

Difficult Manageable Easy

very quite quite very

Probe: ____

4. Do you think you would find it is easy or difficult to remember how to use the switches?

Difficult — Manageable — Easy

very — quite (Difficult); quite — very (Easy)

Probe: ____

5. Did you like or dislike using the switches to operate the walking aid?

Dislike [ ]   Like [ ]

Why? ____

6. Is there any way we can improve the switches?

Voice Input *(Explain to Ps)*

1. Would you like or dislike speaking to the walking aid?

Dislike [ ]   Like [ ]

Why? ____

2. Do you think you would find it embarrassing speaking to your walking aid?

Emb'ssed   Not sure   Not Emb'ssed

very   quite   quite   very

Probe: ____

General

1. On one occasion, the walking aid helped to guide you and you did not have to operate the aid at all. Did you prefer this or did you prefer to operate it yourself?

Automatic [ ] Manual [ ]

2. We showed you how the handles can lift you up from your seat. Do you think this is useful or not very useful?

Not useful Neither Useful

Not at all Not very quite very

3. Did you feel safe or unsafe, when the handles lifted you up?

Unsafe Safe

very quite quite very

4. Did the handles support you when you were walking?

Y [ ]   Sometimes [ ]   N [ ]

5. Would you like to direct the walking aid with the handles?

Y [ ]   Sometimes [ ]   N [ ]

6. Overall, how efficient was the walking aid in helping you to walk? Would you say the walking aid was good, poor or average?

Poor   Average   Good

very   quite   quite   very

7. When the walking aid guided you across the room, did you feel safe or unsafe or neither?

a. [If safe/unsafe, ask "Would you say that you felt quite safe/unsafe or very safe/unsafe?"].

Unsafe Safe

very quite quite very

b. [If applicable] What was it that made you feel particularly safe/unsafe?

Technology Acceptance

1. Overall, did you find the walking aid easy to use, difficult to use or manageable?

Difficult Manageable Easy

very quite quite very

2. Do you think this walking aid would be useful for you, not useful or neither?

Not useful Neither Useful

Not at all Not very quite very

3. What about other visually impaired elderly people in general? Do you think this walking aid would be useful for them, not useful or neither?

Not useful Neither Useful

Not at all Not very quite very

Appendix I: Questionnaire for HCI experts

Attitudes to Technology

This research is investigating attitudes to technology and whether these attitudes can predict acceptance of, and use of technology. 'Technology' should be taken in the broadest sense e.g. *computer & information technologies* such as computer software & hardware; *telecommunication technologies* such as fax machines, mobile phones; *consumer technology* such as microwave ovens, VCRs.

Some possible attitudes to technology have been generated and are listed below. The purpose of this questionnaire is to find out whether HCI experts agree or disagree with these statements, and also to gather suggestions for other possible attitudes that may affect level of use of technology.

Please give your gender, age and occupation:

Gender: Male/Female

Age: _____years

Occupation: ____________________

Please tick how much you agree or disagree with each of the statements below.

Users are more likely to be positive towards a technology if...

it is perceived to be useful

Strongly disagree [ ]
Disagree [ ]
Neither [ ]
Agree [ ]
Strongly Agree [ ]

2. learning to use it, is easy

Strongly disagree [ ]
Disagree [ ]
Neither [ ]
Agree [ ]
Strongly Agree [ ]

it rarely makes errors/goes wrong

Strongly disagree [ ]
Disagree [ ]
Neither [ ]
Agree [ ]
Strongly Agree [ ]

4. it is perceived to be safe

Strongly disagree	[ ]
Disagree	[ ]
Neither	[ ]
Agree	[ ]
Strongly Agree	[ ]

5. it is efficient to use

Strongly disagree	[ ]
Disagree	[ ]
Neither	[ ]
Agree	[ ]
Strongly Agree	[ ]

6. it improves quality of life

Strongly disagree	[ ]
Disagree	[ ]
Neither	[ ]
Agree	[ ]
Strongly Agree	[ ]

7. it is easy to remember how to use

Strongly disagree	[ ]
Disagree	[ ]
Neither	[ ]
Agree	[ ]
Strongly Agree	[ ]

8. it is perceived to be easy to use

Strongly disagree [ ]
Disagree [ ]
Neither [ ]
Agree [ ]
Strongly Agree [ ]

9. it is pleasant to use

Strongly disagree [ ]
Disagree [ ]
Neither [ ]
Agree [ ]
Strongly Agree [ ]

10. it is aesthetically pleasing

Strongly disagree [ ]
Disagree [ ]
Neither [ ]
Agree [ ]
Strongly Agree [ ]

11. it does not cause anxiety

Strongly disagree [ ]
Disagree [ ]
Neither [ ]
Agree [ ]
Strongly Agree [ ]

If possible, please suggest any other positive or negative attitudes people may have of technology.

1. ______________________________

____

2. ______________________________

____

3. ______________________________

____

4. ______________________________

____

5. ______________________________

____

Other comments:

____

____

____

____

____

____

____

Appendix J: Pilot questionnaire

Questionnaire

The following questionnaire refers to technology you may use at home, in public places or for work/study.

Please read each of the statements contained in this questionnaire and make a **CROSS** like this, ☐ inside of the box using a pen. Try not to cross outside of the box.

There are 2 types of question in this questionnaire:

1. For some questions where you are given a choice of responses. Please **CROSS** the response which is most appropriate for you.

Eg:

How often do/did you use a microwave?

Daily	Few times a week	Few times a month	Rarely	Never
☐	☐	☐	☐	☐

2. For some questions, you will need to **CROSS** the box on the rating scale which best indicates how much you agree or disagree with that statement. Please respond to every statement in terms of your own experience of using the technology.

If you are not completely sure which response to **CROSS**, put the response which you feel is most appropriate. Do not spend too long on each statement.

The rating scale gives you 5 choices to indicate how much you agree or disagree with a statement:

Eg:

Video recorders are easy to use.

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
☐	☐	☐	☐	☐

ALL INFORMATION WILL BE TREATED WITH THE STRICTEST OF CONFIDENCE.

Please CROSS (X) the most appropriate response for you

	I have used it often	I have used it occasionally	I have not used it	I haven't heard of it
Video Recorder	☐	☐	☐	☐
Playstation	☐	☐	☐	☐
Personal/Electronic Organiser	☐	☐	☐	☐
Ticket Machine	☐	☐	☐	☐
Mobile Phone	☐	☐	☐	☐
Telephone Answering Machine	☐	☐	☐	☐
Photocopier	☐	☐	☐	☐
Pager	☐	☐	☐	☐
Fax Machine	☐	☐	☐	☐

Microwaves

1a. Do you use a Microwave?

Yes (go to 2.) ☐ No (go to 1b.) ☐

1b. Did you use a Microwave in the past?

Yes (go to 2.) ☐ No (go to next page) ☐

2. How long have you used or did you use a Microwave for?

Less than a year ☐ 1- 3 years ☐ 3 or more years ☐

3. How often do you or did you use a Microwave?

Daily ☐ Few times a week ☐ Few times a month ☐ Rarely ☐ Never ☐

4. How many different things do/did you do with a Microwave?

Generally only 1 ☐ 2 - 3 ☐ 4 or more ☐

5. What is/was your main reason for using a Microwave? (just a few words)

____

____

Please CROSS (X) to indicate how much you agree or disagree with each of the following statements.

	Strongly Disagree				Strongly Agree
Microwaves are useful	☐	☐	☐	☐	☐
Microwaves are unreliable	☐	☐	☐	☐	☐
Learning to use a microwave is easy	☐	☐	☐	☐	☐
Microwaves are unsafe to use	☐	☐	☐	☐	☐
I can confidently operate a microwave	☐	☐	☐	☐	☐
Microwaves look rather ugly	☐	☐	☐	☐	☐
A microwave improves my quality of life	☐	☐	☐	☐	☐
Microwaves are rather difficult to use	☐	☐	☐	☐	☐
Fashionable people use microwaves	☐	☐	☐	☐	☐
I could not manage without a microwave	☐	☐	☐	☐	☐
Overall, Microwaves are the best available option	☐	☐	☐	☐	☐
Microwaves are efficient	☐	☐	☐	☐	☐
When I use a microwave, I am afraid I will break it	☐	☐	☐	☐	☐
I had adequate instructions for using my microwave	☐	☐	☐	☐	☐
Microwaves do not do the job for which they were intended	☐	☐	☐	☐	☐
Microwaves are reliable	☐	☐	☐	☐	☐
Microwaves do not make life easier	☐	☐	☐	☐	☐

	Strongly Disagree				Strongly Agree
Microwaves are value for money	☐	☐	☐	☐	☐
I have difficulty remembering how to use a microwave	☐	☐	☐	☐	☐
A microwave helps me to do things I would not otherwise be able to do	☐	☐	☐	☐	☐
Microwaves make me nervous	☐	☐	☐	☐	☐
Microwaves save time	☐	☐	☐	☐	☐
I often need to refer to a manual for help	☐	☐	☐	☐	☐
Microwaves are the only option available for the job	☐	☐	☐	☐	☐
Microwaves are pleasant to use	☐	☐	☐	☐	☐
A microwave does not save me money	☐	☐	☐	☐	☐
A microwave helps me to do a task effectively	☐	☐	☐	☐	☐
Microwaves cannot do more than one task	☐	☐	☐	☐	☐
A microwave is easier to use than alternatives	☐	☐	☐	☐	☐
Microwaves are used by most people	☐	☐	☐	☐	☐
I feel anxious when using a microwave	☐	☐	☐	☐	☐
I have no choice but to use a microwave	☐	☐	☐	☐	☐
Microwaves are not fashionionable items	☐	☐	☐	☐	☐

	Strongly Disagree				Strongly Agree
Microwaves have many useful features	☐	☐	☐	☐	☐
Microwaves feature a lot in the media	☐	☐	☐	☐	☐
I did not have adequate instructions for using my microwave	☐	☐	☐	☐	☐
I use a microwave because lots of other people use one	☐	☐	☐	☐	☐
Microwaves are too expensive	☐	☐	☐	☐	☐
Using a microwave is very rewarding	☐	☐	☐	☐	☐
Microwaves are not any faster than other alternatives	☐	☐	☐	☐	☐
Using a microwave is good for my image	☐	☐	☐	☐	☐
Microwaves are unpleasant to use	☐	☐	☐	☐	☐
Microwaves are the best option for the job	☐	☐	☐	☐	☐

The above questionnaire was repeated for ATMs and Computers during the pilot study.

Appendix K: The Attitude to Technology Scale

Attitude to Technology Scale (ATS)

The following questions concern peoples' opinions and beliefs about a particular piece of technology. For each question, **TICK** the box on the rating scale which best indicates how much you agree or disagree with that statement. Please respond to every statement in terms of your own experience of using the technology.

If you are not completely sure which response to **TICK**, put the response which you feel is most appropriate. Do not spend too long on each statement.

The rating scale gives you 5 choices to indicate how much you agree or disagree with a statement:

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
☐	☐	☐	☐	☐

ALL INFORMATION WILL BE TREATED WITH THE STRICTEST OF CONFIDENCE

Thankyou for taking the time to complete this questionnaire

Please TICK to indicate how much you agree or disagree with each of the following statements.

	Strongly Disagree				Strongly Agree
1. ______________ are efficient	☐	☐	☐	☐	☐
2. ______________ make me nervous	☐	☐	☐	☐	☐
3. ______________ have many useful features	☐	☐	☐	☐	☐
4. Fashionable people use ____________	☐	☐	☐	☐	☐
5. I have difficulty remembering how to use a ______________	☐	☐	☐	☐	☐
6. ______________ are reliable	☐	☐	☐	☐	☐
7. I feel anxious when using a ________	☐	☐	☐	☐	☐

8. A ____________ helps me to do a task effectively ☐ ☐ ☐ ☐ ☐

9. I can confidently operate a ____________ ☐ ☐ ☐ ☐ ☐

10. Learning to use a ____________ is easy ☐ ☐ ☐ ☐ ☐

11. Using a ____________ is good for my image ☐ ☐ ☐ ☐ ☐

12. I often need to refer to a manual for help ☐ ☐ ☐ ☐ ☐

13. ____________ are rather difficult to use ☐ ☐ ☐ ☐ ☐

14. ____________ are the best option for the job ☐ ☐ ☐ ☐ ☐

15. When I use a ____________,
I am afraid I will break it ☐ ☐ ☐ ☐ ☐

16. ______________are value for
money ☐ ☐ ☐ ☐ ☐

17. ______________do not make life
easier ☐ ☐ ☐ ☐ ☐

18. I use a _____________ because
lots of other people use one ☐ ☐ ☐ ☐ ☐

Personal data form

Please answer the following general questions about yourself (this information is confidential and remember, we do not want your name)

1. Age: ______yrs

2. Are you? Male ☐ Female ☐

3. Are you a student? Yes ☐ No ☐ **go to 5**

If Yes:

State title of degree course: ____________________ **go to 5**

4. Are you in work? Yes ☐ No ☐

If **Yes**, what is your occupation? ____________________

If **No**, are you:

- **Unemployed?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Retired?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Housewife/husband?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

5. How long have you used a ____________ for?

Less than a year	1- 3 years	3 or more years
☐	☐	☐

6. How often do you use a ______________?

Daily	Few times a week	Few times a month	Rarely	Never
☐	☐	☐	☐	☐

Appendix L: ATS scoring sheet

Attitude to Technology Scale (ATS)

SCORING SHEET

1.	**1**	**2**	**3**	**4**	**5**
2	**5**	**4**	**3**	**2**	**1**
3.	**1**	**2**	**3**	**4**	**5**
4.	**1**	**2**	**3**	**4**	**5**
5.	**5**	**4**	**3**	**2**	**1**
6.	**1**	**2**	**3**	**4**	**5**
7.	**5**	**4**	**3**	**2**	**1**
8.	**1**	**2**	**3**	**4**	**5**

9.	**1**	**2**	**3**	**4**	**5**
10.	**1**	**2**	**3**	**4**	**5**
11.	**1**	**2**	**3**	**4**	**5**
12.	**5**	**4**	**3**	**2**	**1**
13.	**5**	**4**	**3**	**2**	**1**
14.	**1**	**2**	**3**	**4**	**5**
15.	**5**	**4**	**3**	**2**	**1**
16.	**1**	**2**	**3**	**4**	**5**
17.	**5**	**4**	**3**	**2**	**1**
18.	**1**	**2**	**3**	**4**	**5**

*Scores will range between **18** and **90**, the middle score-point will be **36**

Appendix M: Questionnaire for Internet study

Attitudes to the Internet & Computers

This study is being conducted by Anne-Marie O'Neill, a PhD student in the Psychology Department at the University of Hertfordshire (UK). The study is investigating people's attitudes to the internet and to computers. This web site consists of 3 short questionnaires and a few questions asking you how much you use the internet and computers. Please answer all the questions, it should only take about 15 minutes to complete.

All information submitted on this website will be treated with the strictest of confidence. Information will used for the sole purpose of this study and any publication of the results will not identify any individuals.

The data for this study will have been analysed by the beginning of January 2000. If you wish to get information regarding the results of this study and/or get feedback about your own scores on the following questionnaires, please email me at

a.m.o-neill@herts.ac.uk

Computer Use

1. Do use a computer for work, leisure or both?

☐ Work ☐ Leisure ☐ Both

2. How long have you used a computer for?

________Years ______Months

3. How often do you use a computer?

Daily	A few times a week	A few times a month
☐	☐	☐
(go to 4)	(go to 5)	(go to 6)

4. On average how many hours a day do you spend using a computer?

______ hours

5. On average how many hours a week do you spend using a computer?

______ hours

6. On average how many hours a month do you spend using a computer?

______ hours

Internet Use

1. Do use the internet for work, leisure or both?

☐ Work ☐ Leisure ☐ Both

2. How long have you used the internet for ?

______Years ______Months

3. How often do you use the internet?

Daily	A few times a week	A few times a month
☐	☐	☐
(go to 4)	(go to 5)	(go to 6)

4 On average, how many hours a day do you spend using the internet?

______ hours

5. On average, how many hours a week do you spend using the internet?

______ hours

6. On average, how many hours a month do you spend using the internet?

______ hours

Questionnaire 1

The following questions concern people's opinions and beliefs about the internet. For each statement, choose the response on the rating scale which best indicates how much you agree or disagree with that statement. Please respond to every statement in terms of your own experience of using the internet.

If you are not completely sure which response to choose, put the response which you feel is most appropriate. Do not spend too long on each statement.

Please indicate how much you agree or disagree with each of the following statements.

	strongly disagree	disagree	don't know	agree	strongly agree
1. The internet is efficient	☐	☐	☐	☐	☐
2. The internet makes me nervous	☐	☐	☐	☐	☐
3. The internet has many useful features	☐	☐	☐	☐	☐
4. Fashionable people use the internet	☐	☐	☐	☐	☐
5. I have difficulty remembering how to use the internet	☐	☐	☐	☐	☐
6. The internet is reliable	☐	☐	☐	☐	☐
7. I feel anxious when using the internet	☐	☐	☐	☐	☐
8. The internet helps me to do a task effectively	☐	☐	☐	☐	☐

9. I can confidently operate the internet ☐ ☐ ☐ ☐ ☐

10. Learning to use the internet is easy ☐ ☐ ☐ ☐ ☐

11. Using the internet is good for my image ☐ ☐ ☐ ☐ ☐

12. I often need to refer to a manual for help ☐ ☐ ☐ ☐ ☐

13. The internet is rather difficult to use ☐ ☐ ☐ ☐ ☐

14 The internet is the best option for the job ☐ ☐ ☐ ☐ ☐

15. When I use the internet, I am afraid I will break/crash it ☐ ☐ ☐ ☐ ☐

16. The internet is value for money ☐ ☐ ☐ ☐ ☐

17. The internet does not make life easier ☐ ☐ ☐ ☐ ☐

18. I use the internet because lots of other people use it ☐ ☐ ☐ ☐ ☐

Questionnaire 2

The following questions concern people's opinions and beliefs about computers. For each statement, choose the response on the rating scale which best indicates how much you agree or disagree with that statement. Please respond to every statement in terms of your own experience of using computers.

If you are not completely sure which response choose, put the response which you feel is most appropriate. Do not spend too long on each statement.

Please indicate how much you agree or disagree with each of the following statements.

	strongly disagree	disagree	don't know	agree	strongly agree
1. I think computers are fascinating	☐	☐	☐	☐	☐
2. If I used a computer, I could save time and work	☐	☐	☐	☐	☐
3. I feel very negative about computers in general	☐	☐	☐	☐	☐
4. Only computer specialists can use computers	☐	☐	☐	☐	☐
5. Computers control too much of our world today	☐	☐	☐	☐	☐
6. Computers are having a bad effect on my work and my life	☐	☐	☐	☐	☐
7. A computer could make learning more fun for me	☐	☐	☐	☐	☐
8. Computers intimidate and threaten me	☐	☐	☐	☐	☐
9. Even though computers are valuable and necessary, I still have a fear of them	☐	☐	☐	☐	☐

10. All computer people talk in a strange and technical language	☐	☐	☐	☐	☐
11. Given a little more time and training anybody could learn to use computers	☐	☐	☐	☐	☐
12. Government regulations should be established to control computers	☐	☐	☐	☐	☐
13. Computers make mistakes	☐	☐	☐	☐	☐
14. Using a computer could be enjoyable	☐	☐	☐	☐	☐
15. I look forward to computers taking over certain routine tasks of my home and job	☐	☐	☐	☐	☐
16. If I had the money I'd buy a home computer	☐	☐	☐	☐	☐
17. I would rather have a computer present in my instruction than a teacher	☐	☐	☐	☐	☐
18. Computers are so complicated I would rather do my work manually	☐	☐	☐	☐	☐
19. Computers are being forced on us; we are having our decision process replaced by them, making us lose control of our lives	☐	☐	☐	☐	☐
20. Computers are superior to humans in processing information	☐	☐	☐	☐	☐

Questionnaire 3

Directions: A number of statements which people have used to describe themselves are given below. Read each statement and then tick the appropriate box to indicate how you *feel* right now, that is *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

I feel calm	☐	☐	☐	☐
I feel secure	☐	☐	☐	☐
I am tense	☐	☐	☐	☐
I am regretful	☐	☐	☐	☐
I feel at ease	☐	☐	☐	☐
I feel upset	☐	☐	☐	☐
I am presently worrying over possible misfortunes	☐	☐	☐	☐
I feel rested	☐	☐	☐	☐
I feel anxious	☐	☐	☐	☐
I feel comfortable	☐	☐	☐	☐
I feel self-confident	☐	☐	☐	☐
I feel nervous	☐	☐	☐	☐
I am jittery	☐	☐	☐	☐
I feel "high strung"	☐	☐	☐	☐
I am relaxed	☐	☐	☐	☐
I feel content	☐	☐	☐	☐
I am worried	☐	☐	☐	☐
I feel over-excited and "rattled"	☐	☐	☐	☐
I feel joyful	☐	☐	☐	☐
I feel pleasant	☐	☐	☐	☐

Finally, please answer the following general questions about yourself (this information is confidential and remember, we do not want your name)

1. What is your age? _____Years

2. Are you? Male ☐ Female ☐

3. Are you in work? Yes ☐ No ☐ (go to 4)

If **Yes**, what is your occupation? ____________________

If **No**, are you:

- Unemployed? Yes ☐ No ☐

If so, what was your last occupation? ____________________

- Retired? Yes ☐ No ☐

If so, what was your last occupation? ____________________

- Housewife/husband? Yes ☐ No ☐

If so, what was your last occupation? ____________________

4. Are you a full-time student? Yes ☐ No ☐

If **Yes**, what is the title of your course? ____________________

Thank you for taking the time to complete these questionnaires

Appendix N: Questionnaire for age/gender study

Attitude to Technology Scale (ATS)

The following questions concern peoples' opinions and beliefs about a particular piece of technology. For each question, **TICK** the box on the rating scale which best indicates how much you agree or disagree with that statement. Please respond to every statement in terms of your own experience of using the technology.

If you are not completely sure which response to **TICK**, put the response which you feel is most appropriate. Do not spend too long on each statement.

The rating scale gives you 5 choices to indicate how much you agree or disagree with a statement:

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
☐	☐	☐	☐	☐

ALL INFORMATION WILL BE TREATED WITH THE STRICTEST OF CONFIDENCE

Thankyou for taking the time to complete this questionnaire

Please TICK to indicate how much you agree or disagree with each of the following statements.

	Strongly Disagree		Neither		Strongly Agree
1. Mobile Phones are efficient	☐	☐	☐	☐	☐
2 Mobile Phones make me nervous	☐	☐	☐	☐	☐
3. Mobile Phones have many useful features	☐	☐	☐	☐	☐
4. Fashionable people use Mobile Phones	☐	☐	☐	☐	☐
5. I have difficulty remembering how to use a Mobile Phone	☐	☐	☐	☐	☐
6. Mobile Phones are reliable	☐	☐	☐	☐	☐
7. I feel anxious when using a Mobile Phone	☐	☐	☐	☐	☐

8. A Mobile Phone helps me to do a task effectively	☐	☐	☐	☐	☐
9. I can confidently operate a Mobile Phone	☐	☐	☐	☐	☐
10. Learning to use a Mobile Phone is easy	☐	☐	☐	☐	☐
11. Using a Mobile Phone is good for my image	☐	☐	☐	☐	☐
12. I often need to refer to a manual for help	☐	☐	☐	☐	☐
13. Mobile Phones are rather difficult to use	☐	☐	☐	☐	☐
14. Mobile Phones are the best option for the job	☐	☐	☐	☐	☐
15. When I use a Mobile Phone, I am afraid I will break it	☐	☐	☐	☐	☐

16. Mobile Phones are value for money ☐ ☐ ☐ ☐ ☐

17. Mobile Phones do not make life easier ☐ ☐ ☐ ☐ ☐

18. I use a Mobile Phone because lots of other people use one ☐ ☐ ☐ ☐ ☐

Please answer the following general questions about yourself (this information is confidential and remember, we do not want your name)

1. Age: _____yrs

2. Are you? Male ☐ Female ☐

3. Are you a student? Yes ☐ No ☐ **go to 4**

If Yes:
State title of degree course: ____________________ **go to 5**

4. Are you in work? Yes ☐ No ☐

If **Yes**, what is your occupation? ____________________

If **No**, are you:

- **Unemployed?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Retired?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Housewife/husband?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

5. How long have you used a Mobile Phone for?

Less than a year	1- 3 years	3 or more years
☐	☐	☐

6. How often do you use a Mobile Phone?

Daily	Few times a week	Few times a month	Rarely	Never
☐	☐	☐	☐	☐

Yes ☐ No ☐

If so, what was your last occupation? ____________________

• **Housewife/husband?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

5. How long have you used a Mobile Phone for?

Less than a year	1 - 3 years	3 or more years
☐	☐	☐

6. How often do you use a Mobile Phone?

Daily	Few times a week	Few times a month	Rarely	Never
☐	☐	☐	☐	☐

Attitude to Technology Scale (ATS)

The following questions concern peoples' opinions and beliefs about a particular piece of technology. For each question, **TICK** the box on the rating scale which best indicates how much you agree or disagree with that statement. Please respond to every statement in terms of your own experience of using the technology.

If you are not completely sure which response to **TICK**, put the response which you feel is most appropriate. Do not spend too long on each statement.

The rating scale gives you 5 choices to indicate how much you agree or disagree with a statement:

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
☐	☐	☐	☐	☐

ALL INFORMATION WILL BE TREATED WITH THE STRICTEST OF CONFIDENCE

Thank you for taking the time to complete this questionnaire

Please TICK to indicate how much you agree or disagree with each of the following statements about VCRs (video recorders).

	Strongly Disagree		Neither		Strongly Agree
1. VCRs are efficient	☐	☐	☐	☐	☐
2 VCRs make me nervous	☐	☐	☐	☐	☐
3. VCRs have many useful features	☐	☐	☐	☐	☐
4. Fashionable people use VCR	☐	☐	☐	☐	☐
5. I have difficulty remembering how to use a VCR	☐	☐	☐	☐	☐
6. VCRs are reliable	☐	☐	☐	☐	☐
7. I feel anxious when using a VCR	☐	☐	☐	☐	☐
8. A VCR helps me to do a task effectively	☐	☐	☐	☐	☐

9. I can confidently operate a VCR ☐ ☐ ☐ ☐ ☐

10. Learning to use a VCR is easy ☐ ☐ ☐ ☐ ☐

11. Using a VCR is good for my image ☐ ☐ ☐ ☐ ☐

12. I often need to refer to a manual for help ☐ ☐ ☐ ☐ ☐

13. VCRs are rather difficult to use ☐ ☐ ☐ ☐ ☐

14. VCRs are the best option for the job ☐ ☐ ☐ ☐ ☐

15. When I use a VCR, I am afraid I will break it ☐ ☐ ☐ ☐ ☐

16. VCRs are value for money ☐ ☐ ☐ ☐ ☐

17. VCRs do not make life easier ☐ ☐ ☐ ☐ ☐

18. I use a VCR because lots of other people use one ☐ ☐ ☐ ☐ ☐

Please answer the following general questions about yourself (this information is confidential and remember, we do not want your name)

1. Age: _____yrs

2. Are you? Male ☐ Female ☐

3. Are you a student? Yes ☐ No ☐ **go to 4**

If Yes:
State title of degree course: ______________________ **go to 5**

4. Are you in work? Yes ☐ No ☐

If **Yes**, what is your occupation? ______________________

If **No**, are you:

- **Unemployed?** Yes ☐ No ☐

If so, what was your last occupation? ______________________

- **Retired?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Housewife/husband?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

5. How long have you used a VCR for?

Less than a year	1- 3 years	3 or more years
☐	☐	☐

6. How often do you use a VCR?

Daily	Few times a week	Few times a month	Rarely	Never
☐	☐	☐	☐	☐

Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Housewife/husband?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

5. How long have you used a VCR for?

Less than a year	1- 3 years	3 or more years
☐	☐	☐

6. How often do you use a VCR?

Daily	Few times a week	Few times a month	Rarely	Never
☐	☐	☐	☐	☐

Attitude to Technology Scale (**ATS**)

The following questions concern peoples' opinions and beliefs about a particular piece of technology. For each question, **TICK** the box on the rating scale which best indicates how much you agree or disagree with that statement. Please respond to every statement in terms of <u>your own experience</u> of using the technology.

If you are not completely sure which response to **TICK**, put the response which you feel is most appropriate. Do not spend too long on each statement.

The rating scale gives you 5 choices to indicate how much you agree or disagree with a statement:

Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
☐	☐	☐	☐	☐

ALL INFORMATION WILL BE TREATED WITH THE STRICTEST OF CONFIDENCE

Thankyou for taking the time to complete this questionnaire

Please TICK to indicate how much you agree or disagree with each of the following statements about MICROWAVES.

	Strongly Disagree		Neither		Strongly Agree
1. Microwavess are efficient	☐	☐	☐	☐	☐
2 Microwaves make me nervous	☐	☐	☐	☐	☐
3. Microwaves have many useful features	☐	☐	☐	☐	☐
4. Fashionable people use microwaves	☐	☐	☐	☐	☐
5. I have difficulty remembering how to use a microwaves	☐	☐	☐	☐	☐
6. Microwaves are reliable	☐	☐	☐	☐	☐
7. I feel anxious when using a microwaves	☐	☐	☐	☐	☐
8. A microwaves helps me to do a task effectively	☐	☐	☐	☐	☐

9. I can confidently operate a microwaves ☐ ☐ ☐ ☐ ☐

10. Learning to use a microwaves is easy ☐ ☐ ☐ ☐ ☐

11. Using a microwaves is good for my image ☐ ☐ ☐ ☐ ☐

12. I often need to refer to a manual for help ☐ ☐ ☐ ☐ ☐

13. Microwaves are rather difficult to use ☐ ☐ ☐ ☐ ☐

14. Microwaves are the best option for the job ☐ ☐ ☐ ☐ ☐

15. When I use a microwaves, I am afraid I will break it ☐ ☐ ☐ ☐ ☐

16. Microwaves are value for money ☐ ☐ ☐ ☐ ☐

17. Microwaves do not make life easier ☐ ☐ ☐ ☐ ☐

18. I use a microwaves because lots of other people use one ☐ ☐ ☐ ☐ ☐

Please answer the following general questions about yourself (this information is confidential and remember, we do not want your name)

1. Age: _____yrs

2. Are you? Male ☐ Female ☐

3. Are you a student? Yes ☐ No ☐ **go to 4**

If Yes:
State title of degree course: ____________________ **go to 5**

4. Are you in work? Yes ☐ No ☐

If **Yes**, what is your occupation? ____________________

If **No**, are you:

- **Unemployed?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Retired?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Housewife/husband?** Yes ☐ No ☐

Please answer the following general questions about yourself (this information is confidential and remember, we do not want your name)

1. Age: ______yrs

2. Are you? Male ☐ Female ☐

3. Are you a student? Yes ☐ No ☐ **go to 4**

If Yes:
State title of degree course: ____________________ **go to 5**

4. Are you in work? Yes ☐ No ☐

If **Yes**, what is your occupation? ____________________

If **No**, are you:

- **Unemployed?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Retired?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Housewife/husband?** Yes ☐ No ☐

Please answer the following general questions about yourself (this information is confidential and remember, we do not want your name)

1. Age: ______yrs

2. Are you? Male ☐ Female ☐

3. Are you a student? Yes ☐ No ☐ **go to 4**

If Yes:

State title of degree course: ____________________ **go to 5**

4. Are you in work? Yes ☐ No ☐

If **Yes**, what is your occupation? ____________________

If **No**, are you:

- **Unemployed?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Retired?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Housewife/husband?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

5. How long have you used a microwave for?

Less than a year ☐ 1- 3 years ☐ 3 or more years ☐

6. How often do you use a microwave?

Daily	Few times a week	Few times a month	Rarely	Never
☐	☐	☐	☐	☐

Yes ☐ No ☐

If so, what was your last occupation? ____________________

- **Housewife/husband?** Yes ☐ No ☐

If so, what was your last occupation? ____________________

5. How long have you used a microwave for?

Less than a year ☐ 1- 3 years ☐ 3 or more years ☐

6. How often do you use a microwave?

Daily	Few times a week	Few times a month	Rarely	Never
☐	☐	☐	☐	☐