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Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability

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ABSTRACT

This paper examines the factors and theoretical frameworks for the adoption of technology for older adults, and proposes two models of technology acceptance and rejection, one from an ease of learning perspective, and one from a system and user perspective. Both models are supported from reports on two case studies of older adults using handheld touchscreen tablet devices; one in which the participants are supported during tasks primarily related to walking and navigation, and one in which participants are unsupported in communication related tasks. The first study shows the powerful role that facilitating conditions have for learning how to use digital technologies for this user group, whether supporting through step by step guidance, providing a friendly space to use trial and error methods, and/or provision of a manual. The second study shows the pitfalls of a lack of facilitating conditions during initial use, and highlights potential for appropriate design in helping to avoid some user errors during this phase.

1. Introduction

Older adults are now widely understood to be an extremely diverse group and do not uniformly conform to technology averse stereotypes (Czaja & Lee, 2006). However, there is reported to be greater fear and anxiety associated with using computers, and in addition, their assessment of their own skills and abilities, with both using and learning to use them, is generally lower than for other age groups (Marquié, Jourdan-Boddaert, & Huet, 2002). Use of technology for older people can often be more dependent on the availability of training (Rogers, Fisk, Mead, Walker, & Cabrera, 1996), and also there seems to be a pragmatic assessment of whether the technology will provide specific desired utility (Czaja, Guerrier, Nair, & Landauer, 1993; Melenhorst, Rogers, & Bouwhuis, 2006) and of the relationship between the perception of this and the perceived difficulty of learning (Venkatesh, 2000).

Digital technologies are becoming ubiquitous in everyday life. There is also a trend towards the use of the internet through mobile devices such as smart phones and handheld tablet devices rather than via laptops and personal computers. Access to information and services can be acquired at almost any time and everywhere. However, a large group of people do not engage with these developments.

There are a number of terms being used to describe those who do not access the internet or who do not engage with digital products or services. For the purposes of this research, we define people as digitally excluded when they do not currently access the internet. Using this definition, 69.8% of the world's population are digitally excluded, a total of 4.8 billion people, and within Europe the figures are 41.7% or 340 million people (Internet World Stats, 2011). For the UK this concerns one third of the population over the age of 15, and 70% of digitally excluded are in the lowest social grouping of 'C2DE' (semi-skilled and unskilled workers, as well as those on the lowest incomes and benefits). 57% are over 65 years old (Milner, 2009). Current internet use in the UK for people of the age range 65–74 is at 40%, and for those over 75 it is at 20% (Dutton, Helsper, & Gerber, 2009). These percentages have not changed significantly since the data was initially collected in 2005. The Office of National Statistics (ONS) in 2010 suggests that 60% of the over 65s have never accessed the internet. The percentage internet access via mobile phone amongst internet users is less than 10% for people aged over 65 in 2011 in the UK (ONS, 2011). In Europe there are variations between countries, in the USA this is less than 20%; however in Japan this percentage is much higher, over 70% (OFCOM, 2010).

In most countries the use of new technologies by older people lags behind that of younger. This is probably not a problem that will go away easily, as new technologies and, potentially more

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importantly, their interfaces and interaction styles are continually evolving. There are many reasons for being digitally excluded including those related to financial constraints, lack of training and prior experience. Younger people have often learned how to use a computer at school or at work; this is often not the case for older people, especially those whose occupation did not involve computer use. The reasons that people say that they do not engage with the internet have been the subject of some considerable research in the UK, although it is acknowledged that the reported responses should be taken with caution, as they may only represent a post-rationalisation of more complex factors at play (Dutton et al., 2009; Morris, Brading, & Goodman, 2006). Of those who have never used the internet, the most important reasons they report are: 61% – no interest or not useful, 11% – do not know how to use or confused by technologies, 7% – no computer or internet connection, 7% – too expensive, 3% – no time or too busy (Dutton et al., 2009). A detailed survey was carried out among older people in Derbyshire and Scotland (Morris et al., 2006). This study would suggest that the internet does not really hold the respondents' interest as 60% of respondents cited this as one of the reasons. 40% of these respondents gave as a reason age and "feeling too old". This may reflect a recognition of the age related learning difficulties they may face in mastering the technology to access the internet. Other experiences with training older people to use computers and computer software has shown that training progresses slowly, and may need to start from the basics at every session (Hawthorn, 2006). However, Mitzner et al. (2010) found that the difference between younger and older people was not so much in the actual knowledge of computers but more in their confidence; older people underestimating their computer knowledge. Training is not only about skills, it may have a positive influence on both attitudes towards technology and self-efficacy of the recipients (Lagana, 2008; Lagana, Oliver, Ainsworth, & Edwards, 2011).

Turner, Turner, and Van De Walle (2007) did an in-depth study on the experiences of older people with interactive technology and the reasons they give for their problems. Next to age-related reasons ("too old"), anxiety and alienation also play a role. More pragmatic reasons are also given such as being too busy, or not seeing any useful purpose. As perceptions about technology use and perceptions about one's own ability are major problems in computer use by older adults, we will in this paper focus on these specific reasons: "I can't do it", "it's not for me", which relate to perceived difficulty and perceived learning effort.

Wagner, Hassanein, and Head (2010) provide an extensive overview of the wide range of research that has been performed on the use of computers by older adults. Much research has focused on personal attributes, and how they influence computer use. However, using technology is not only a matter of the individual and their capabilities, attitudes and perceptions, but is also influenced by environmental factors (such as hardware, software, people, interactions, and context of use) that play a role in influencing behaviour. Wagner et al. stress that research should take into account all three elements and their interactions: the older adults, their computer use, and their environments (including the computer systems), what they call "the triadic reciprocality" (p. 878). In this paper we aim to take these three elements into account.

As information and services are increasingly becoming exclusively accessible via the internet, it is important to understand the reasons why older people have the perception that digital technologies are difficult to use, and that some perceive that they are not capable of learning how to use them. This is particularly important in the context of the potential for new services that may improve the lives of older people, e.g. m-health. This understanding is needed not only to find better ways to introduce digital technologies to currently excluded potential users, but also to improve the design of digital products in such a way that they are easy to use and easy to learn, which can facilitate adoption for all kinds of users.

In this paper we will first discuss the issues identified in the literature on the models that are used to study technology use and acceptance. Next we will present two case studies on the use of tablet handheld touchscreen computers. The first study presents findings from interviews conducted with older people while going on a walk, navigating with a touchscreen tablet and electronic maps, and finding information about the environment. The second one looks at the problems older people encounter when they use a touchscreen tablet for the first time. The final section of the paper aims to refine the framework models discussed in the next section in order to reflect the findings from the case studies.

2. Theoretical frameworks and models on the use of technology

In this section we will discuss theoretical frameworks with which we may better understand why people use or do not use technology. There are two important elements of the use or non-use of technology. Firstly, a person needs to have the intention to use the technology. This element has been widely studied, leading to models of technology acceptance. The second element is usability, the technology used should not be too difficult to use, as a user may give up or use it incorrectly. Where "intention to use" studies users' attitudes and perceptions, usability is more an attribute of the design of the technology. A more current concept encompassing usability is user experience. This is not only about willingness to use technology that is well-designed, but about giving the user an experience that goes beyond pure functionality and elicits an emotional response. After discussing these elements, we will address the process of learning how to use technology and the difficulties older adults perceive and encounter.

2.1. Intention to use

The Unified Theory of Acceptance and Use of Technology (UTAUT: Venkatesh, Morris, Davis, & Davis, 2003) seeks to synthesise several older theoretical models of acceptance. It is based on the theory of planned behaviour (Ajzen, 1985, 1991), which states that a specific behaviour, for example using some technology, is preceded by a behavioural intention. Intention to behave is determined by attitudes, norms and the perception of control over the behaviour. UTAUT focuses on using technology, the behaviour in using some system. Four components predict the behavioural intention. The first, **performance expectancy**, relates to the perception the potential user has of the utility of the system, how it can help them in what they want to achieve by using it. For example, does a user think that using Skype will help him to be in touch with family abroad? **Effort expectancy** refers to the effort the user has to make in order to be able to use the system. For example, how hard will it be to learn to use Skype? **Social influence** relates to the perception of the user about what significant others would think if they started to use the system. For example, the family may think that it is great that a grandparent uses Skype. Finally, **facilitating conditions** determine whether it is possible to display the actual behaviour. For example, is there support for setting up Skype? Gender, age, experience, and voluntariness of use (especially important in a work environment) mediate the impact of the four key constructs on use intention and behaviour.

In this paper we focus on two of the components: effort expectancy and facilitating conditions. If we assume a situation in which the user perceives the usefulness of the system and the social influences are positive, how will the effort expectancy influence the intention to use the system, and what facilitating conditions may be of help to reduce the effort needed?

2.2. Usability and user experience

Usability is defined in ISO9241 as: 'The effectiveness, efficiency and satisfaction with which specified users achieve specified goals in particular environments.' Where effectiveness is 'accuracy and completeness with which users achieve specified goals', efficiency is 'resources expended in relation to the accuracy and completeness with which users achieve goals', and satisfaction is 'freedom from discomfort, and positive attitudes towards the use of the product'. For interactions for which the potential user does not have a choice (such as for a device that must be used by an employee) this is adequate, however in the domain of user-choice devices, and to ensure and promote continued use of a product, this definition falls short of covering the emotional engagement with the interaction.

In the classical definition of usability, Nielsen (1993) associates usability with five attributes: easy-to-learn, efficient-to-use, easy-to-remember, few errors, and subjectively pleasing. Nielsen's work focuses on usability engineering, designing systems which people *can* use. Theoretical perspectives on acceptance also aim to determine whether people *will* use the system. In Rogers' (2003) Diffusion of Innovations Theory (DIT) the adoption of innovations is impacted by five factors: **relative advantage** (extent to which technology offers improvements over available technology), **compatibility** (consistency with existing values, past experiences and needs); **complexity** (difficulty of understanding and use); **trialability** (the degree to which it can be experimented with on a limited basis); and **observability** (the visibility of its results). These factors form a combination of user and system factors.

Where Nielsen sees emotional aspects (subjectively pleasing) as a part of usability, and thus as a characteristic of the system, the concept of user experience places the user in the centre. ISO 9241-210 defines user experience as 'a person's perceptions and responses that result from the use or anticipated use of a product, system or service' (ISO FDIS 9241-210, 2009). Hassenzahl and Tractinsky (2006) emphasise that user experience is more than a focus on the instrumental needs of technology. User experience is a complex concept, derived from the interplay between the subjective state of the user, the characteristics of the system, and the context of the environment.

2.3. Experimenting with technology

UTAUT states that intention to use is determined by the perceptions of the potential user, and the actual behaviour is further determined by facilitating conditions. However, there is usually a phase where potential users try out a system, either buying it and trying it, followed by adoption or putting the system away and not using it again, or by trying out a system borrowed from family or friends, or seeing others using the system, and if they like it deciding to purchase one themselves. This experimentation phase, in which the perceptions of usefulness and effort needed are tested, may play a crucial role in acceptance or rejection. In the Diffusion of Innovations Theory (Rogers, 2003) trialability is one of the factors determining adoption. Rogers proposed a five-stage model of this adoption process: (1) knowledge phase, to get to know the product, (2) persuasion phase, to be persuaded of the need for the product, (3) decision phase, leading to purchase, (4) implementation phase, when the product starts to be used, and (5) confirmation phase, which seeks confirmation that the right decision has been made.

Renaud and van Biljon (2008) studied acceptance and adoption of mobile technologies by older people. They also make a distinction between adoption (a process starting with becoming aware of the technology, and ending with embracing and using it fully) and acceptance (an attitude). Acceptance is a precondition for adoption, but adoption means a change in behaviour, giving the use of a technology a place in someone's life. Silverstone and Haddon (1996) proposed the term domestication of technology to describe the process of acceptance, rejection and use of technology.

Renaud and van Biljon (2008) developed the STAM model (Senior Technology Acceptance and Adoption Model). They make a distinction between three phases. In the *objectification phase* the user forms an intention to use the system, based on the user context, including social influences and the perceived usefulness. This is comparable with the components of the UTAUT model. In the *incorporation phase*, the user starts with an experimentation and exploration process. This experimentation gives the user an idea of the usefulness of the system, and if positive, the usefulness is confirmed, leading to actual use, and will finally lead to the last phase: *acceptance*. Facilitating conditions influence the experimentation, exploration as well as actual use. However, this is not the whole story. In the incorporation phase, *ease of learning and use* is a component that influences both experimentation and exploration, and actual use, while the experimentation gives feedback to the user on how easy the use of a system actually is. In this model we are no longer looking only at perception of ease of use (as in most technology acceptance models) but also at experiences in using the system. If experiences are negative, this will lead to rejection of the system. In this model, experimentation and exploration play a large role in the final acceptance or rejection.

This model makes some categorisations differing from the five phases of Rogers' (2003) adoption process, which is more focused on buying and using a product. In STAM, the end phase is rejection or acceptance, which are attitudes. When the technology is accepted, influenced by positive experiences, full adoption, which is behaviour, may take place. This could mean passing to the last phase, the confirmation phase, in Rogers' adoption model, but if the user has experimented with a system owned by someone else, it may also mean purchasing the product and quickly moving through the implementation phase to the confirmation phase.

Saccol and Reinhard (2006) take a theoretically different approach to technology adoption. Their work on adoption of mobile ICT is based on the hospitality metaphor from Ciborra (1996). In this metaphor, a new technology may be seen as a stranger hosted by the organisation that introduces the technology. Users have to get accustomed to this "stranger" and its way of working, understand it and may finally accept it as a friend or reject it as an enemy. This process is an open and incremental one. During the process, the attitude towards the technology is likely to change (positively or negatively), and users will find new ways to deal and to live with the "guest". Again, experience with the new technology is a key element. And it is not only the use that will change over time, also the users themselves will change, their view of themselves, such as on their learning abilities and the new activities they are now able to perform. The idea of seeing technology as a stranger brings into play more complex emotional components than simple concepts like "pleasant" or "perceived effort". Having a "guest" living in your house will bring a set of emotions, in a complex mix of positive and negative aspects. The triadic reciprocality Wagner et al. (2010) introduced also takes into account the way in which a person is influenced and changed by the use of technology, and not only how personal attributes change behaviour, a notion which fits in well with the hospitality metaphor.

2.4. Learning difficulty: perception and experience

Bradley, Barnard, and Lloyd (2010) proposed an abstracted model of learning difficulty perception for novice users of digital technology, assuming a non-user can be motivated by the facilitation of a functional benefit for using a piece of digital technology.

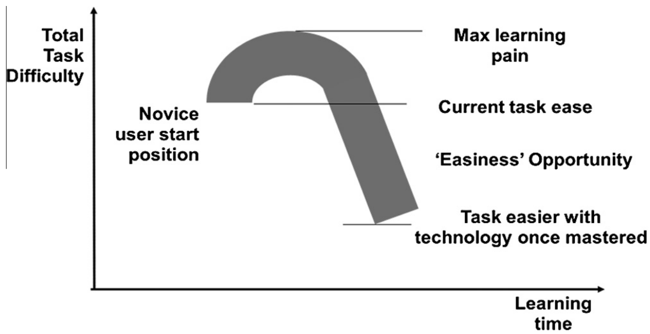

Fig. 1. Abstracted model of learning difficulty perception for novice users of digital technology.

Fig. 1 shows an abstraction of how a novice user might perceive the journey of learning how to use a technology, taking into account the magnitude of the perceived difficulty of learning (to the Max learning pain) and then the opportunity of how much easier the particular task might be once they have acquired the necessary skills (to the 'Task easier with technology once mastered' level). An example task might be to send a letter, where the digital alternative task might be to send an email. At the 'Novice user start position' someone who understands the concept and advantages of sending an email, such as speed, negligible incremental cost as well as lack of need to walk in the rain to post, but does not understand how to send an email, may view the learning process as a 'hump' of difficulty. They will have to expend at least some mental energy to learn how to send an email (in addition to spending real money on the equipment and service to enable it) which will for some users be painful (Max learning pain). The perception of the magnitude of the 'Max learning pain' will be an important negative factor for many to decide whether to make the journey to 'Task easier with technology once mastered', in opposition to the positive factor of the perception of the benefits of the destination the 'Easiness opportunity'.

It is suggested that it is both possible and desirable to lower both the perceived height and the actual height of the 'Max learning pain' part of the figure, to encourage and facilitate engagement with digital technologies. Using this simple model, it would therefore be ideal to be able to remove the hump entirely for this group, and not require any learning at all to be able to gain the benefits of 'Task easier with technology once mastered'.

2.5. Focus of the paper

As we are interested in the ease of learning and the relation with technology acceptance and adoption, we need to investigate the following components derived from the models discussed above:

Learning effort expectancy: the perception of the user of how difficult it will be to use, and to learn how to use the system. This is related to Rogers' factors of compatibility (past experiences and needs) and complexity (difficulty of understanding and use) and the ease-of-learning in the STAM model. What is not very explicit in these models is the perception of users about their own learning capabilities. It is implicit in the effort expectancy. People have an idea about their self-efficacy (Lagana et al., 2011), how difficult it would be to learn to use a system, making a mental calculation of their own ability versus the difficulty of a particular system. Ideas about one's own capability may be either based on individual experiences or on social conceptions (for example, their idea that older people have difficulties in learning new technologies).

Experimentation and exploration: the possibilities for using the system freely and safely (for example trying it out in the shop, borrowing the system from someone, trying out the system together with other people etc.). This is related to Rogers' trialability (the degree to which the system can be experimented with on a limited basis) and observability (the visibility of its results). Observability is important for users to find out whether they are successful in the experimentation. Experimentation and exploration are key elements of the STAM model.

Usability and user experience: when users start using the system, it becomes clear to them how usable the system is. Usability is related to the intrinsic characteristics of the system in relation to the abilities, skills, perceptions and attitudes of the user. The usability factors of special interest here are easy-to-learn and easy-to-remember. Efficiency is more related to confirmed usefulness. Few errors relate to system performance, however, there is also an element of how well users can deal with system errors, whether these errors make them lose trust in the system and reject it. Users may attribute errors to themselves or to the system. In the first case, they may lose confidence in themselves and believe that the system is too difficult to learn. Users with some personality traits may be more prone to attribute errors to themselves, such as people with an internal locus of control personality or with an introvert personality. The factor of subjectively pleasing is an interesting issue. While for some people, such as early adopters, trying out a new system is pleasant in itself, for others, such as those reluctant to adopt technology, pleasantness is not at all a given. If users do not like the system they may also have greater difficulties in learning how to use it, and they may be less willing to engage in exploration and experimentation.

Facilitating conditions to support learning and use: such as support for learning (support people, help desks, courses, learning materials, documentation, etc.), support if things go wrong and the user does not know how to proceed, and a social context in which the user feels comfortable to learn.

3. Methods

As the aim of the studies was to gain more insight into the elements that play a role in learning and technology acceptance and adoption, a qualitative approach was chosen. Two case studies will be described in the next sections. The first case study aimed to explore the attitudes and experiences of people using mobile technologies. In this study, a mixture of semi-structured interviews and open discussion was used. Interviews and discussion took place while using and demonstrating mobile technologies. An interview protocol was used by the researchers to make sure all the questions related to the components described above were addressed. In the open discussion participants were encouraged to talk about their experiences, both with the mobile technologies used during the study, and their previous experiences with technology in general. The second case study focused on the difficulties people encounter when using new technologies. In this study a more experimental approach was taken, in which participants were given several tasks to perform. Older adults were recruited on the basis of their prior experience with information technology. All sessions were recorded and videoed, and subsequently reviewed by the investigators. The analysis of the first case study focused on what participants could tell about the four model components (learning effort expectancy, exploring and experimentation, usability, and learning and facilitating conditions). The second case study analysed and classified the errors that the participants made when performing the tasks.

As older adults are such a diverse group, there cannot be any claim that the groups are representative, nor do we claim that the issues we identified are exhaustive. We worked with older adults with different levels of familiarity with information technology in order to get a broader picture of the challenges they face, and insight into different ways of coping with technology. No information was gathered about personal characteristics such as personality traits or intelligence. Although these characteristics may play an important role in the ease with which individuals (learn to) deal with technology, they were not within the focus of the studies as defined in Section 2.5.

3.1. Case study on the use of mobile technologies to support walking

A case study on the use of mobile technologies by older people illustrates the issues involved in learning how to use new systems. In this case study 13 older people over 65, with a mean age of 68, participated, seven females and six males. Five of them (two males, three females) were experienced and competent users, using computers and being on the internet daily or several times a week, and using a computer for a variety of activities. Two of them also used a smart phone with internet access. Three other participants (two males, one female) may be classified as intermediate users, they used a computer occasionally and for limited purposes, such as email (this spelling is used in the rest of the paper, else it should be change into e-mail everywhere), they needed support from family to do new things with their computers or if they had problems with it. They had only a basic mobile phone. The other five participants (two male, three female) did not use a computer at all and did not have a smart phone.

These participants came for an hour and a half to the University of Leeds to be interviewed during a walk around the campus using a Samsung Galaxy Tab handheld touchscreen tablet with a seven inch screen. None of the participants had experience with this type of technology. After some initial questions about their background we previewed the route we were going to walk using Google Maps, with different views. After this introduction, we went outside, two researchers and the participant, and walked the route holding the tablet and regularly checking our position and landmarks previously identified. Next, we entered a building where we sat down searching information, starting from Google maps, about the university on Wikipedia, shops in the neighbourhood, bus stops and travel planner to plan a bus journey home. We used Skype with video to chat with a colleague. Back in the office we asked the participant to search on Google maps for the nearest bus stop and to look at the street view from this stop. They had to use the touchscreen of the tablet themselves, if necessary we provided guidance. During the whole walk we posed questions about their experiences with technology, their opinion of the applications we used, their problems with technology and their aspirations. The walking ensured an informal and friendly context, and the participants came up with many ideas and stories, often unsolicited, and they talked a lot about their personal lives and the use of technologies by their spouses, children, grand-children and friends. At the end of the interview all participants told us they had had an interesting and enjoyable morning or afternoon. For more detail of the procedure followed see Hodgson, Barnard, Bradley, and Lloyd (2012). During the interviews, we used a list of questions based on the factors playing a role in the UTAUT and STAM model (for example about perceived usefulness).

The walking interviews were performed by two experienced researchers. The participants and one of the researchers wore a recording device. The interviews were transcribed and coded, using a simple coding scheme related to the components from the technology acceptance models. Fragments from the interviews sometimes relate to several components. As this paper is focused on the learning aspect, we will not discuss all the findings from these interviews but concentrate on the four model components described above. For the learning effort expectancy we looked at fragments related to how participants first learned how to use a computer or other technology, and to opinions about how (older) people learn. For exploring and experimentation fragments were analysed that relate to their experiences in using technologies, and their preferences concerning how they want to learn to use new technologies. Usability was addressed by looking at questions and remarks on how easy it is to use the tablet computer (and other technologies). Finally, facilitating conditions were analysed by looking at fragments in which participants mention any condition that would make the use and the learning process less difficult. We looked especially at the role support may play.

3.2. Case study on errors made during first use of a tablet computer

While the case study described in the previous section looked into the experiences of older adults with technology, and their subjective opinions, the case study described in this section focuses on the difficulties that they may encounter when they actually use a system for the first time without support or instruction. The purpose of this study was to elicit some of the types of errors made by older users in their first use of a touchscreen tablet device as a means to indicating the types of interaction patterns that cause difficulties to older unfamiliar users.

Ten older people (aged 58–78), recruited through opportunistic sampling, participated in the study. Nine had little prior experience with digital technology. They were asked to carry out a series of tasks using a Samsung Galaxy Tab handheld touchscreen tablet with a seven inch screen. The tasks ranged from simply turning the device on, to attempting to send an email. Participants were asked to imagine that they had been sent the Galaxy Tab as a present through the post, without instructions, and nor was there assistance available to guide their actions. It was explained that the device was a kind of combination of computer and mobile phone, as well as that it was a touchscreen device. This study focused primarily on user errors as Hawthorn (2007) had found that for older people the avoidance of errors was the most important usability aspect, particularly as errors often lead to significant ‘lostness’ in the system when error recovery is not facilitated (Murad, Bradley, Kodagoda, Barnard, & Lloyd, 2012). The errors were recorded and categorised through reaching consensus by a team of three researchers reviewing video footage of the participants interacting with the device. A formal qualitative analysis method was not applied to this data as the goal was to establish typical errors experienced by this group for further subsequent investigation.

4. Results

4.1. Case study on the use of mobile technologies to support walking

In this section are described the findings resulting from the analysis of those parts of the walking interviews that relate to learning effort expectancy, exploring and experimentation, usability and learning, and facilitating conditions.

4.2. Learning effort expectancy

Most of the participants who use a computer have either learned to use it at work or took a computer course. Courses are sometimes criticised for being too technical, aiming to explain the computer itself and not focused on what you can do with it. One woman (69, intermediate user) said that she went to a class when she first had a computer with a group of neighbours and her daughter. “To me it was .... at my age, it was too much about the hard drive .... I didn’t wanna know, what I wanted to know which button to press to get me where I wanted to go, I'm not interested in what's in it, I want to know how to use it".

People who have been using a computer at work usually had some formal introduction to it, followed courses and progressed when new technologies arrived. They did continue the use after retirement and discovered and mastered new applications. They have self-confidence in their ability to use technology and to learn about it. However, if new technology starts to differ too much from what they were used to at work, they may still run the risk of being left behind. One woman (65, experienced user) told that at work she went on a number of training courses and that she became quite good at the applications. She was trained as a secretary so she felt going from typewriters to computers was a natural progression.

Several of our participants told that a few years before their, or their spouse's, retirement, computers or new technologies were introduced in the workplace and that they were not able to cope with them. Sometimes this was due to bad introduction or bad technology that was later abandoned, sometimes because they did not manage to master it. Consequences of these bad experiences were taking early retirement and rejecting computers in their personal lives. One woman told us: "I worked till I was 64 and 2 months for the City council and I was getting to the stage where I finally had to get my head round (the technology), and that was one of the deciding factors of me retiring and not wait till 65, because I couldn't get my head round it to be honest. ...." Another woman (65, experienced user) told that when her husband retired, he was happy to be able to leave because they were getting SatNavs and Blackberry's and he was dreading it.

The participants were mostly active people with all kinds of interests and activities. Most of them did not hold the belief that technology could not be learned by old people. Even if they could not do it, they knew people older than themselves who did use a computer. A woman (67, non-user) said: "I know, I know, I should be able to do these things. I do occasionally see a lady in the elderly group, she must be in her eighties; she does a lot of administration, and she does it on the computer."

4.3. Exploring and experimenting: learning preferences

Exploration and experimentation are essential for learning how to use new technologies, but this is not always easy. A male participant (70, intermediate user), who had a computer for 4 years, said: "I was not really sure how to use it properly; it was a case of trial or error. I got a little bit frustrated first, because I don't have a great deal of patience, I expect results, quick results, you don't always get them with a computer when you learn, you go round and round in circles and then I lose interest, and then, close it up. It can be frustrating at times. Coming back to the same, not getting to where I wanted to be, coming back to something I couldn't get rid of, eventually got rid of it and then went round and round again, come back with it again. I thought if this is a computer I don't want to know."

We asked participants about how they normally learn or like to learn some new technology or device. We identified three different preferred learning styles:

(1) Having someone to tell them step by step how to do things, and having this person looking over their shoulder to guide them if necessary. A woman (66, non-user) about learning to use a mobile phone: "I followed my husband's instructions, do this, do that."
(2) Trial and error: playing with the system and trying out different things. A man (76, non-user) said: "If I get anything that is probably technical I don't even read the instructions. I open the box, get it out and fiddle about. Sometimes successfully, more often than not unsuccessfully. I have to wait till one of my sons comes to sort it out."
(3) Reading a manual or instructions. Sometimes this style is combined with trial and error, either first reading a manual and then trying things out, or first doing some trial and error and when being stuck going to the manual to find out what to do. A woman (67, non-user) told about how she learned how to use new household appliances, like irons: "I get them out of the box and try and get them to work and when I get to an obstacle I get the information sheets out and reading where it went wrong .... I'm a bit of self-learning first."

In principle, these are common learning strategies and all three may be effective. However, the way in which the participants talk about learning also reveals something about their mental models of the systems. Some of them want to know exactly what to do step by step, writing down the instructions so they can follow the steps exactly the next time. They seem to see the use of technology as a series of procedures. This may work fine when using a washing machine or some other system with a limited functionality, but is rather inadequate for a model of surfing the internet or using a word processor. The degrees of freedom and the number of actions and sequences of actions are often too enormous to write down complete instructions as a simple list of steps.

The participants who are not very experienced sometimes are afraid to "break" something or not to know what to do if something goes wrong. As several people like a procedural way of learning things (following instructions noted down step by step) they will not be inclined to experiment, in order to stay on the safe side.

4.3.1. Usability and learning

Most of the participants thought it would not be very difficult to learn how to use the tablet; they had the feeling that it was easier than a computer. One of the reasons may be that they saw it demonstrated in a calm and friendly atmosphere without any pressure on them. The size of the tablet may also be an advantage, big enough to see things well, in comparison with a phone, and small enough not to look like a complex system. Being able to hold it, pick it up and touch it in different ways may make the system less daunting. One participant mentioned having the keyboard and the screen in one place making things easier so you don't have to look away from the keyboard to the screen. People would need some time to get used to manipulating the touchscreen, but most participants had no problem doing some basic manoeuvres after a few minutes of trying. A woman (67, non-user) answered the question whether she thought it would be easy to learn: "That is much easier than anything I have encountered before." On our question how long it would take to learn, a male participant (76, non-user) answered: "probably a couple of hours for basic use, where to go, what to do and how to manoeuvre. But someone else might be able to do it in 20 minutes." Another man (72, non-user) remarked: "It felt strange because of not being used to something like this. It's all strange, although I'm heavy-handed I try to be a little bit gentle, but I don't think there's any need to be to be as gentle as I did by touching it. I think you have to be onto it straight away."

4.3.2. Facilitating conditions: the role of support

Participants who are not expert users often organise support, usually from family. However, getting support from someone very competent, like a computer expert or a technologically gifted grandson also means that the idea that you have to be an expert or very intelligent to use a computer is reinforced. One participant (72, non-user), whose wife uses a computer, told a story about how they have support from a computer expert. "He is very good and very eccentric and very highly strung and when you look at him you can see the intelligence coming out of his eyes. The only problem is he charges 50 quid for a visit. And anytime you have a problem you call him and he sorts it out.'' However, having a good level of support may greatly facilitate the learning process. One participant (69, intermediate user) is not afraid at all of exploring her computer, she does what she wants and if it does not work out, which frequently happens, she calls her grandson who lives over the road to sort things out for her.

4.4. Case study on errors made during first use of a tablet computer

4.4.1. Problems encountered by participants

This study was carried out to find out the kinds of errors made by older novice users of a touchscreen device. Due to the nature of the study it was impossible to identify with certainty the definitive causes of the errors from the users' side, but some errors may be related to the age of the participants, such as reduced visual capability: e.g. the labelling on some of the controls was too illegible for some participants to see or be able to recognise. Another problem was reduced dexterity and muscle control (and in some cases inappropriate finger characteristics to operate a capacitive touchscreen reliably). Some controls required very specific inputs to operate correctly, whether for press duration time, accuracy, speed or simply, the touchscreen capacitance range was calibrated to younger fingers.

Other problems seemed to be caused by inexperience, users having not enough transferable prior technology experience, or by conflicting prior experiences. For example, there is sometimes a lack of explicit labelling on controls, so users do not have a clue what the control is meant to do. Another problem seemed to be a lack of confidence, making participants hesitant to engage in a 'trial and error' exploration approach.

The main generic problems the participants encountered can be categorised as follows:

- Problems with operating the touchscreen reliably – both failed and repeated activations. The operation of the touchscreen appeared to be incorrectly calibrated for older users' fingers' capacitances, and so despite them carrying out what appeared to be the requisite length of time tapping, the device would simply not register a tap event.
- Confusion about how to move the cursor to the desired location. The touchscreen required that users tap to locations where they wanted the cursor to be, rather than using the keyboard tab key in certain situations. This seemed problematic for some users who did not find it easy to learn to touch the screen to move the cursor, when the keyboard was present.
- Conceptual problems, such as confusion between the concepts of backspace (delete to the left) and back (go to previous screen/back out of interface). Participants seemed to transfer knowledge from prior experiences with non-digital interfaces (such as typewriters) and their limited digital experiences.

4.4.2. Errors made during task performance

The participants were asked to perform some, relatively simple, tasks with the tablet. Next to the general problems encountered, participants made more specific errors, discussed below.

Errors made during turn on. The first task required was to turn on the tablet. Nine of the participants struggled for some considerable time to turn the device on, for some or a combination of the following reasons. They were not able to feel or see the button at all, to see that there was a label on the button or they did not recognise the on/off button label. Since the button required a long button press to get response from the device and there was no feedback to a shorter than required press, this contributed to participants eliminating the correct button and focusing their attentions elsewhere. Some even came to the erroneous conclusion that the button required a hard press to work.

Errors in entering password. The next task was to enter the password given to unlock the tablet. Seven of the participants entered the number correctly first time, but six struggled to find the 'OK' button to enter the number. Screen timeouts (in some scenarios only 4 s before the screen timed out and deleted entered numbers) caused much frustration.

Table 1
Errors and system characteristics.

Errors highlighted from study	Characteristics of system difficulty for learning			
	Transparency	Affordance	Feedback	Error recovery
1. Not operating the touchscreen reliably		X	X	
2. Confusion about how to move the cursor	X	X	X	
3. Confusion between back and backspace	X			
4. Not being able to feel or see the button		X		
5. Not seeing that there was a label on the button		X		
6. Not recognising the on/off button label		X		
7. Long button press elimination of correct button		X	X	
8. Screen timeouts resetting data	X		X	X
9. Thinking that the 'Email' button label was a verb	X			
10. Not recognising or understanding the function of the 'new compose email' icon/button	X	X		
11. Not detecting the fleetingly displayed 'Sending…' notification shown at the top of the screen	X		X	
12. A button which was intended to hide the keyboard from the screen was located where a shift key would be on a typewriter or computer keyboard	X	X		X
13. Not realising that they could enter their search terms into the space allocated on the home screen	X	X		
14. Entering a name without spaces		X		
15. Not finding alarm clock function	X	X		
16. Problems setting an alarm – touching the clock face allows user to alter its appearance but takes away ability to set the alarm	X	X	X	X
17. Confusion about the feedback to correct activation of alarm			X	
18. Looking at the touchscreen display area to find a function to turn the device off/standby	X	X		
19. Pressing the power button but often for the incorrect length of time to turn system off		X		
20. Confusion about the difference between off and standby	X		X	

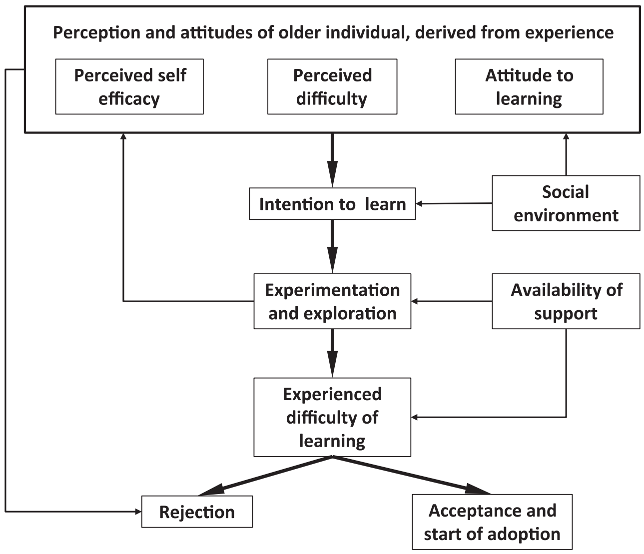

Fig. 2. Users perspective of Model of technology acceptance or rejection from an ease-of-learning perspective.

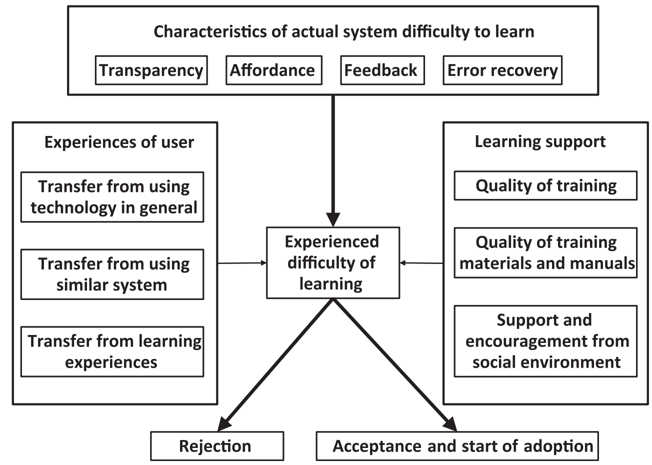

Fig. 3. Model of technology acceptance or rejection from a system and user perspective.

Errors in sending an email. Participants were asked to send a simple email. One participant thought that the 'Email' button label was a verb, and therefore that something would need to be created prior to execution of the 'to email' function. Other errors were not recognising or understanding the function of the 'new compose email' icon/button, or as one user described it the 'sausage in a grate'. None of the users detected the fleetingly displayed 'Sending...' notification shown at the top of the screen.

Errors in using the keyboard. Four participants appeared to extend their typewriter/computer keyboard model of interaction to the similar keyboard to include functionality. This manifested itself in irrecoverable errors when a button which was intended to hide the keyboard from the screen was located where a shift key would be on a typewriter or computer keyboard.

Errors in searching on the internet. Participants were asked to search for a relative or a friend on the internet. Four users did not realise that they could enter their search terms into the space allocated on the home screen. Three participants curiously entered their relative's name without spaces, although Google was in each case able to segregate the names correctly.

Errors in setting the alarm. Another task was setting the alarm. Three participants struggled to find the alarm clock function (it is located within the 'Applications' menu). Many struggled to add an alarm – touching the clock face allows the user to alter its appearance but takes away the ability to set the alarm. Once participants had found where to set the alarm time, actually setting the time caused few difficulties, but feedback to correct the activation of the alarm was poor, causing further confusion.

Errors in activating standby and turning off. Turning off the tablet also posed difficulties. Four participants looked at the touchscreen display area to find a function to turn the device off or standby. Seven users pressed the power button but often for the incorrect length of time (a short press invokes standby, a long press invokes the phone options menu with a 'Power off' option, and then a further confirmation dialogue). There was some confusion about the difference between off and standby, which was highlighted in post-study discussions.

4.4.3. System characteristics related to errors and learning

Errors may be attributed to the users, and to their unfamiliarity with the system or their lack of understanding of the basic concepts. However, if we look at the system itself, its characteristics contribute to error making and to difficulties in learning how to use it. In Table 1 the errors highlighted above are listed with usability characteristics of the tablet that contribute to the errors. These were selected to indicate the range of errors experienced by the participants, and although clearly not representing a complete picture of potential errors, it demonstrates how some specific design characteristics can dramatically affect the use experience for this type of user.

Four system characteristics are mentioned here, that are especially relevant for novice users. **Transparency**: allowing the users to understand what they can do with the system and the effects of their actions. Transparency is important when starting with a task; a transparent system means that the perceived (learning) difficulty is small. **Affordance**: meaning that the system can be used intuitively and the action to take presents itself naturally. An affordant system does not require much learning effort. **Feedback**: this is necessary so that the user does not get lost and is sure that the system does what it was intended to do. A system that provides sufficient and clear feedback facilitates learning, it helps the users understand what they did correctly or incorrectly and the actions they should take next time when they want to perform the same task. **Error recovery:** the users do not have to worry about errors they make, the system either recovers from the error itself or lets the user know what to do. If the user is confident that errors do not have serious consequences, experimentation is encouraged, leading to a better learning process.

In terms of the four focus points of this paper, learning effort expectancy, experimentation and exploration, usability and user experience, and facilitating conditions to support learning and use, the following conclusions could be drawn from this case study. As the participants were given the tablet without any instruction and without any manual or help, there was a complete lack of facilitating conditions. The only way to perform the tasks was to engage in experimenting behaviour. Some poor usability features for novices, such as a lack of labels on controls, made this even more necessary. At the same time, features such as lack of feedback did not encourage exploration. Failure to succeed in a task, or failing to understand how the task could ever be accomplished, gives the impression to users that the system requires a large learning effort. With this study we aimed to illustrate the connection between the characteristics of the users and the system in determining the difficulty of learning.

5. Discussion and conclusions

The studies presented in this paper are of a qualitative and explorative nature, providing some insight into the issues older adults face when using, and learning to use, new technologies, as well as directions for facilitating the acceptance and adoption of technologies, and the learning processes involved. Small-scale qualitative studies have the advantage that they provide a rich picture of the ideas and experiences of the participants; but they are limited in the sense that they are not able to provide a complete and representative picture of all the issues that are involved. In order to provide a concise picture, to inspire further research in this area, we summarised our results in two models.

Fig. 2 summarises the different aspects that play a role in learning how to use new technologies and in their rejection or acceptance. Note that this model only focuses on learning, not on the very important aspect of usefulness; it is not meant as a replacement for technology acceptance models.

Older people have experiences with learning and ideas about their own self-efficacy, and more or less positive attitudes towards learning new things, as well as ideas about how difficult it would be to learn a given new technology. In the first case study it was seen that sometimes these perceptions and attitudes are derived from (good or bad) experiences at work. Also the social environment may influence how people see themselves with regard to their learning abilities. For example, the idea that people are too old to learn may come from an individual him/herself, but also from the environment. If the self-perception is too negative, people will not start with the learning process, but reject the technology as being too difficult for them. If the "learning pain" is not perceived as too big, people will have an intention to learn to use it (given that they see the technology as useful and the facilitating conditions are right). The social environment plays an important role in encouraging (or discouraging) this intention.

When there is an intention to learn the individual will start exploring the possibilities to acquire the technology, buying it or borrowing it from a relative, for example, and will start to experiment with it. In our case study participants told, for example, about trying out the computer of their grand-children, and borrowing the satnav from their children. Others will watch friends or family use the technology and discuss it. The first case study provided the opportunity to explore the use of a tablet computer. Exploring and experimenting gives the user a more realistic picture of how difficult it is to learn. This may lead to either rejection or acceptance. (Again, usefulness plays a major role but is not the focus of this model). Availability of support, technical and emotional, is crucial in the experimentation phase. Participants in the first case study explained their fears of breaking things and how important it is to have someone nearby who is able to fix things if anything goes wrong. The availability of support will also influence how people experience difficulties. The woman in the first case study whose supportive grandson lives over the road is quite prepared to try out new things because she knows her grandson is at hand for learning support and to assist in error recovery.

How difficult it is to learn a new technology is not only dependent on the perceptions and experiences of the users. The characteristics of the technology itself also determine how difficult it is. Fig. 3 summarises the factors that influence the experienced difficulty of learning of a person who explores some new technology. The characteristics of the system and/or its interface that especially influence the ease-of-learning are transparency, affordance, feedback, and error recovery.

Next to the characteristics of the system there are also the experiences of the user with learning to use technology. Positive transfer from previous experiences makes the learning process easier. Transfer can be from learning technology in general or from systems that are quite similar to the one to be learned. Transfer can also be based on learning experiences in general, for example, if a user had positive experiences with learning complex things, he/she may find it easier to engage with a new system. In case study one, for example, a participant made a comparison with knitting. Finally, the support that is available for the learning process determines how difficult it is. The quality of the training, such as in a course, and the available training materials, such as manuals, are an important factor in making learning easier. For example, in case study one, participants mentioned courses that were too technically oriented, and their use of manuals. Again, the social environment is crucial, encouragement and support will facilitate learning.

It is important to combine the user and system perspectives from a learning point of view. The learning point of view is important for older users, because of their perception of learning, and the realities of learning for them. There will always be new technologies and new generations of older adults who have to learn how use these. In the development and deployment of new technologies, the learning perspective should play a major role to avoid exclusion of older users.

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