Predicting Technology Acceptance and Adoption by the Elderly: A Qualitative study

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ABSTRACT
Technology adoption has been studied from a variety of perspectives. Information systems, Sociology and Human-Computer Interaction researchers have come up with various models incorporating factors and phases to predict adoption that, in turn, will lead to persistent use. Technology acceptance by the elderly mobile phone user has received less attention and no model currently exists to predict factors influencing *their* technology adoption. A literature study yielded a set of acceptance factors (derived mostly from quantitative studies) and adoption phases (derived mostly from qualitative studies) that could influence and predict mobile phone adoption by the elderly user. We confirmed a subset of these factors by consulting findings from research into the context of senior mobile phone users, including the needs and limitations of these users. We then verified the factors qualitatively by means of structured interviews with senior mobile phone users. The interviews included the use of scenarios as well as a mobile phone design activity. Triangulating the quantitative findings from literature with the qualitative findings from this study led to a set of interlinked acceptance factors and adoption phases that we present as the *Senior Technology Acceptance& Adoption model* for Mobile technology (STAM). This paper makes a contribution to understanding technology acceptance by senior users and should be of interest to researchers, designers and decision-makers on technology adoption, especially mobile features and services.

Categories and Subject Descriptors
H.1.2 [**User/Machine Systems**]: Human factors, Human information processing, Software psychology; J.4 [Social and Behavioural Sciences] Economics, Psychology, Sociology.

General Terms
Human Factors, Design, Experimentation.

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Keywords
Mobile phone adoption, technology adoption models, elderly

1. INTRODUCTION
People are living longer than ever before in the 21st century, which means that the 'gray' market is growing. Due consideration of their particular needs is essential in the design and marketing of products [5]. Abascal and Civit [1] propose the possibility of government subsidised prices for elderly people and the potential for introducing these products into the mainstream market as reasons why industry is starting to realise the potential of the gray market. Despite the moral and commercial incentives and the fact that they are the only growing group in most developed societies, elderly mobile phone users are an oft neglected group in product development and marketing [22].

Technology acceptance, in general, has been widely studied and several models of technology acceptance have been proposed and tested [9, 28, 34]. However, the life cycle of mobile phone technology—from designing and developing the innovation, communicating or diffusing information about it, deciding to adopt (selecting, purchasing or committing to use it) and then achieving persistent use—is poorly understood for elderly users [8]. One reason could be that few studies differentiate between pre- and post-adoption.

We follow a three-pronged approach firstly by consulting the literature on those factors that influence technology acceptance and summarising these in tabular format. Secondly we considered the context of the elderly mobile phone user and identified factors that might influence their acceptance of mobile phones. Thirdly we conducted interviews with a number of elderly mobile phone users to confirm the identified factors and uncover new factors that influenced their mobile phone acceptance and adoption. Finally we triangulated between the findings obtained from each approach and we conclude by proposing a model that encapsulates our findings. The remainder of section 1 expands on the purpose and motivation of this paper in section 1.1 and the organisation in section 1.2.

1.1 Purpose and Motivation
It is important to make a distinction between *adoption* and *acceptance* of technology. Technology adoption is a process – starting with the user becoming aware of the technology, and ending with the user embracing the technology and making full

use of it. Someone who has embraced a technology is likely to replace the item if it breaks, find innovative uses for it, and cannot contemplate life without it. Many teenaged mobile phone users have embraced the technology without reservation. Acceptance, as opposed to adoption, is an *attitude* towards a technology, and it is influenced by various factors. A user who has purchased a new technology item has not yet adopted it – there are other stages beyond simple purchasing and this is where acceptance plays an important role. If the user buys an item and then does not accept it, it is unlikely that full adoption will occur.

The field of Information Systems (IS), proposes a number of technology *acceptance* models which focus, at a micro-level, on factors influencing *acceptance* (without considering the process towards full adoption) [33]. Sociological studies prefer a macro-level approach, contemplating the purchasing decision as part of a process - incorporating the user's acceptance or rejection and use of technology i.e. the *adoption process* [12]. In this paper we will be focusing on *factors* influencing progression through the different *adoption phases*. Technology adoption and acceptance models contribute towards anticipating future needs in a complex and ever-evolving market scenario. However, existing research on mobile phone adoption focuses mostly on one specific aspect of technology adoption e.g. m-commerce [36] which is rather limited in application and therefore there is a need for research which integrates the different factors into a single model. The factors incorporated into current acceptance models have been quantitatively verified, by questioning students or economically active adults [20]. The context of the elderly user is very different from that of younger people, and it is unlikely that the factors incorporated into the existing fully represent the factors that influence the elderly mobile phone user. A literature study of the needs, limitations and expectations of the elderly adult mobile phone user made it clear that they demand added value in the form of a more social, active, meaningful and independent life [22].

Traditionally technology adoption models in MIS were developed from a positivistic epistemology while the technology adoption models in sociology have been developed from an interpretivistic epistemology. This paper integrates findings from the quantitative as well as the qualitative approaches with the findings from our survey to propose a technology acceptance model that represents the acceptance space of the elderly mobile phone user. The findings of these studies can provide valuable insights into the lives of the elderly user, as well as those aspects of their lives that can have an effect on their acceptance and usage of mobile phones. The scope of this paper is limited to addressing mobile phone acceptance by the elderly within the wider arena of technology adoption. The participants in the survey were all South African residents between the ages of 60 and 92. The research reported in this paper focuses on two sub-questions:

- What are the factors that influence the acceptance of mobile technology by the elderly?
- How can these factors be incorporated into a technology acceptance and adoption model?

1.2 Organisation of this Paper

Section 2 introduces two adoption models and a number of technology acceptance models. Section 3 discusses the context of the mobile phone user including their limitations and challenges. Section 4 describes the interviews. Section 5 presents our findings. Section 6 proposes the STAM model and reflects on the contribution of this paper. Section 7 concludes.

2. TECHNOLOGY ADOPTION

This section reviews technology adoption and acceptance models and extracts a set of factors relevant to mobile phone acceptance by senior users.

2.1 Technology Diffusion - Processes

Two very different models, which depict the *technology adoption process* are presented, one by Rogers [28] and the other by Silverstone and Haddon [31]. Rogers [28] proposed a five stage process of product adoption:

- the knowledge phase where the person gets to know about the product;
- the persuasion phase where he or she becomes persuaded of a need for the product;
- the decision phase which leads to a purchase;
- the implementation phase where the item is used; and,
- the confirmation phase where the individual seeks to confirm that he or she made the right decision in purchasing the product.

Silverstone and Haddon [31] proposed the *domestication of technology* as a concept used to describe and analyse the processes of acceptance, rejection and use as described in Table 1. Users are seen as social entities and the model aims to provide a framework for understanding how technology innovations change, and are changed, by their social contexts. The domestication theory adoption process is more suitable for our purpose in charting acceptance since Rogers' model focuses mostly on the decision to buy or not to buy, which, as we shall see, is less applicable in terms of acceptance by elderly users.

Table 1: Domestication adoption process dimensions [20] :66

Dimension	**Description**	**Examples of potential themes relevant in user experience research**
Appropriation	Process of possession or ownership of the artifact.	Motivation to buy a product. Route to acquire information about a product. Experience when purchasing a product.
Objectification	Process of determining roles product will play.	Meaning of a technology. What function will be used in users' life? Where is it placed? How is it carried?
Incorporation	Process of interacting with a product.	Difficulties in using a product (usability problems). Learning process (use of instructional manual)
Conversion	Process of converting technology to intended feature use or interaction.	Unintended use of product features. Unintended way of user interaction. Wish lists for future products.

2.2 Technology Acceptance Models

The Technology Acceptance Model (TAM) proposes a number of factors that are essential in determining user attitude towards accepting a new technology, as shown in Figure 1 [9, 21], TAM incorporates six distinct factors [9, 24]:

•*External variables* (EV), such as demographic variables, influence perceived usefulness (PU) and perceived ease of use (PEU).

•*Perceived usefulness* (PU) is defined as 'the extent to which a person believes that using the system will enhance his or her job performance' [34].

•*Perceived ease of use* (PEU) is 'the extent to which a person believes that using the system will be free of effort' [34] .

•*Attitudes towards use* (A) is defined as 'the user's desirability of his or her using the system' [21]. Perceived usefulness (PU) and perceived ease of use (PEU) are the sole determinants of attitude towards the technology system.

•*Behavioural intention* (BI) is predicted by attitude towards use (A) combined with perceived usefulness (PU).

•*Actual use* (AU) is predicted by behavioural intention (BI).

The attitude towards accepting a technology is believed to be the result of personal and social influences. The fact that TAM does not account for social influence is a limitation [10, 21]. Furthermore, TAM is somewhat limited since the only determining factor leading to actual system use is depicted as behavioural *intention* to use, which is unrealistic in our context, as we will show later.

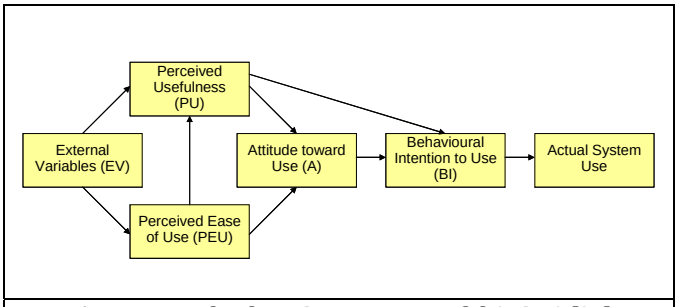

Figure 1 : Technology Acceptance Model (TAM) [21]

Venkatesh *et al.* [34] extended TAM and developed the Unified Theory of Acceptance and Use of Technology (UTAUT), which attempts to explain user intentions to use an information system and subsequent usage behaviour. An important contribution of UTAUT is to distinguish between factors *determining* use behaviour namely the constructs of performance expectancy, effort expectancy, social influence and facilitating conditions and then factors *mediating* the impact of these constructs. The mediating factors noted are gender, age, experience, and voluntariness (i.e. the degree to which use of the innovation is perceived as being of free will). It seems rather restrictive to limit the mediating factors to this group when other factors might well be as influential. Both TAM and UTAUT can be applied to any technology type but there is some value in specialising the models for particular technologies. It is worth noting that whereas TAM includes a module depicting attitude, UTAUT omits this, preferring to expand TAM's external variable module into a number of relevant factors. The following section discusses the application of models which are specific to the mobile technology area.

2.3 Mobile Technology Acceptance Models

Kwon and Chidambaram [19] propose a model for mobile phone acceptance and use which includes the following components: demographic factors, socio-economic factors, ease of use, apprehensiveness, extrinsic motivation (perceived usefulness), intrinsic motivation (enjoyment, fun) social pressure and extent of use. They found that perceived ease of use significantly affected users' extrinsic and intrinsic motivation, while apprehensiveness about cellular technology had a negative effect on intrinsic motivation [19]. The limitation of this model is that it does not include infrastructural factors, which are essential in mobile technology [22].

The Mobile Phone Technology Acceptance Model (MOPTAM), depicted in Figure 2 **[32]**, draws on UTAUT to include the determining and mediating factors and then adapts the result to model the personal mobile phone use of university students. TAM and UTAUT were developed in organisations where the infrastructure was standard and respondents were not affected by the cost. UTAUT includes facilitating conditions (Infrastructure) as a determining factor but restricts the influence to Actual Use whereas MOPTAM predicts the influence of FC on PEU, PU, and BI as well. It is interesting to note that perceived ease of use and actual use are common to all.

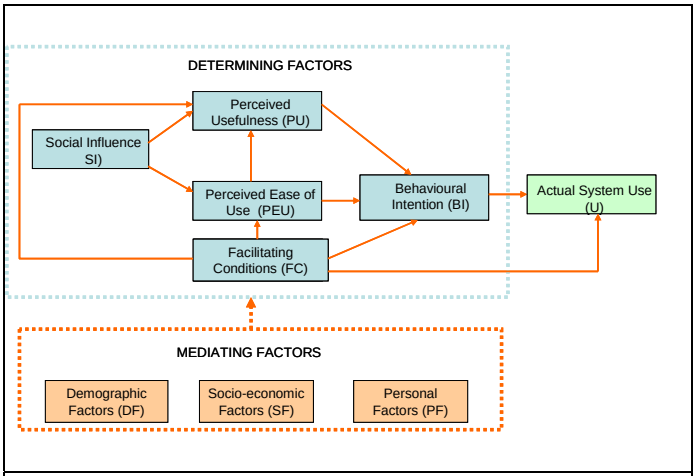

Figure 2: Diagrammatic representation of MOPTAM [32]

Based on exploratory research, Sarker and Wells [30] propose a framework that relates *exploration* and *experimentation* to the *assessment of experience* that determines *acceptance outcome*. The mediating factors are: context, technology characteristics, modality of mobility, communication/task characteristics and individual characteristics. Phang *et al.* [25] proposes a model for senior citizen acceptance of eGovernment services based on their findings that:

- Intention to use is influenced by Perceived Ease of Use, Perceived Usefulness, Internet safety perception, Gender Education, Age and Internet experience.
- Perceived usefulness is influenced by preference for human contact, self-actualisation and resource savings.
- Perceived ease of use is influenced by computer anxiety, computer support and declining physiological condition.

Arning and Ziefle, [2] found evidence to support the moderating effect of individual variables such as age, gender, subjective technical confidence and computer expertise on the relationship between attitude towards a technology and performance. Taking all these studies into account, Table 2 summarises the most fundamental factors incorporated into the models listing the following : Social influence (SI), Perceived Ease of Use(PEU), Perceived Usefulness (PU), Facilitating Conditions (FC), Behavioural Intention (BI), Demographic Factors (DF), Socio-Economic Factors(SE), Personal Factors(PF) and Exploration and Experimentation (EE).

Note that perceived ease of use is the common factor across all the models, while some variables are subsumed under other factors. For example, age and gender are subsumed under demographic factors while computer support is subsumed under facilitating conditions.

Table 2. Factors influencing mobile phone acceptance.

	Models and theories				
Factor	TAM	UT-AUT	Kwon & Chidam-baram	Sarker & Wells	MOP - TAM
SI	No	Yes	Yes	Yes	Yes
PEU	Yes	Yes	Yes	Yes	Yes
PU	Yes	No	No	Yes	Yes
FC	No	Yes	No	Yes	Yes
BI	Yes	Yes	Yes	No	Yes
DF	External variables	No	Yes	Yes	Yes
SE	External variables	No	Yes	Yes	Yes
PF	No	No	No	Yes	Yes
EE	No	No	No	Yes	No
Accep-tance	No	No	No	Yes	No

It is interesting to note that only Sarker and Wells include an acceptance module – the others all appear to assume that actual use implies acceptance, an assumption we will challenge in this paper.

3. Context of the senior adult

The mobile phone needs of the elderly centre around critical services such as emergency and health support that enhance safety and those services that make everyday life and tasks easier [20, 22]. The elderly position mobile phone use in terms of value, which is mostly based on communication and safety aspects [20].

In the mobile context, the user and the equipment can be mobile and the surroundings may therefore change constantly. This opens up fundamental differences in the context of use between the traditional computing environments and information appliances such as mobile phones [14]. Four different aspects of the mobile phone context have been noted [17, 18] in past research: physical context as discussed in section 3.1, social context as discussed in section 3.2, mental context as discussed in section 3.3 and the technological context as discussed in section 3.4.

3.1 Physical Context

The physical context denotes the physical constraints of the usage environment [17, 18]. We need to consider both the physical limitations of the device as well as the limitations of the surrounding physical context. Screen size, memory, storage space, input and output facilities are more limited in mobile devices such as mobile phones [6, 35], while sound output quality is often poor with restricted voice recognition on input [11]. The undeniable potential of the 'gray' market is hampered by the physical and cognitive limitations of aging. Elderly mobile phone users make use of fewer mobile phone features than younger users [20]. Ziefle and Bay [37] suggest that elderly mobile phone users do not have a mental model of the ubiquitous hierarchical menu system used by mobile phones. They struggle to find the features they want to use and therefore do not use them. This is confirmed by a study carried out by Osman *et al.* [23] who interviewed 17 elderly users and asked them to name the most important features of a mobile phone. 'Easy menus' was mentioned most often, followed by large screen. The latter is unsurprising since many elderly users have impaired vision. Another factor mentioned is that they require large buttons, due to the inevitable decrease in manual dexterity experienced by many elderly users [20]. It follows that the effects of aging, such as impaired hearing, vision and loss of manual dexterity impact negatively on the ease of use of mobile phones. However, it would be a mistake to classify users strictly according to age. Mallenius *et al.* [22] argue for using functional capacity (consisting of the physical, psychological and social aspects), rather than age as a facilitating condition.

3.2 Social Context

Social context concerns the social interaction involved and enabled by using the mobile device [17, 18]. Phillips and Sternthal [26] found that with increasing age comes reduced involvement with other people, as confirmed by Abascal and Civit [1]. The reasons are argued by experts, but the net effect is unarguable: reduced access to information that is readily available to younger people. Elderly people make extensive use of the television to give them the information they no longer get from other people [26]. The social contact they *do* have is primarily with their extended family and this group appears to provide them with the advice and support they need. Friends and relatives, especially the opinion of children and grand-children impact the behaviour of the elderly mobile phone user [20, 22], therefore social influence as proposed in MOPTAM is an important factor in mobile phone acceptance.

3.3 Mental Context

The mental context relates to aspects of the user's understanding of the mobile handset usage model [18]. Mobile phones are acquired by a widespread population of users who will probably not have any formal training in operating them and consider them as devices to be used rather than computers to be maintained [11]. Furthermore, device vendors consolidate multiple functions into a single device. The mobile user has to handle interleaving of multiple activities and multiple public faces, previously unknown when only a landline or a stationary computer was used [27]. Cognitive demands are exacerbated due to physical constraints on size, bandwidth and processing power, which restricts the communication bandwidth and places extra demands on the user's attention [13]. The mental strain described above is amplified for the elderly mobile phone user. People perform more slowly and with less precision as they age, elderly users appear to have difficulty learning how to use a new mobile phone [4] and use

fewer of the available features [33]. The *ability* to learn is not impaired but the *rate* of learning *is* reduced [3, 29]. Burke and Mackay [7] mention that the formation of new memory connections is impaired with age. Therefore it is beneficial to allow elderly people to regulate their own rate of information processing. They struggle to filter out irrelevant stimuli so it takes them longer to process the relevant information in order to learn to use the device [26]. This is because they have reduced visual processing speed [15] and working through mobile phone menus is likely to be more difficult for them, purely because of this.

3.4 Technological Context

The technological context refers to the mobile infrastructure including the networks available, services provided and features of the mobile device [17]. The mobile context poses unique challenges and opportunities in terms of mobility, portability and personalisation [36], and yet there is an overlap between the factors influencing mobile phone adoption and technology adoption in general [19]. Therefore we will now consider factors from models for technology adoption as the basis for proposing a model for mobile phone adoption.

4. INTERVIEWS

Our investigation set out to confirm the factors that influenced mobile technology acceptance by the elderly user and to determine whether other new factors were involved. The best way to understand influencing factors is to allow participants to talk, so we decided to make use of a semi-structured interview which would allow participants to contribute to the discussion as they wanted to. The data was captured by the researchers during the interviews. The questionnaire provided under Appendix 1 consists of four sections: Section A captures demographic data for the user profile as discussed in section 4.1. Section B describes five scenarios seniors typically encountered in their everyday life, the scenarios were presented to the participants as discussed in section 4.2. Section C focuses on technology acceptance factors as described in section 4.3.

4.1 Participants' profile

Thirty four elderly people participated in our study (10 male and 24 female). The participants per age distribution were: 60-70 years: 13, 70-80 years: 16 and 80-92 years: 5; hence the majority were in the 60-80 age group. Considering mobile phone use, 19 of the participants had contracts and 15 used pre-pay. They obtained the phones by buying them (16), having the phone bought by someone else (3) or getting the phone as a gift (15). The majority who bought the phones themselves were in the 60-70 age group i.e. the younger participants.

4.2 Scenarios

'A scenario is a description of the world, in a context and for a purpose, focusing on task interaction. It is intended as a means of communication among stakeholders, and to constrain requirements engineering from one or more viewpoints (usually not complete, consistent, and not formal)' [16]:3. Carroll explains that scenarios are valuable because they are both concrete and flexible [16]. In considering the categorization of scenarios, our scenarios could be categorized as *activity scenarios* because they describe and suggest the *use* of the mobile phone artifact.

In this study we used activity scenarios to tell a carefully tailored story that reveals life aspects that influence mobile phone usage by the elderly. The researcher detailed the scenarios and allowed the participant to comment. The participants responded actively, eager to discuss their difficulties and experiences of mobile technology. Participants often made a distinction between what they do and what other people do. This supports our decision to present scenarios for discussion rather than rigid questionnaires where the social desirability bias may deliver less candid responses. Scenarios are a traditional and useful design tool and, in this case, the informal approach was best suited to the exploratory research activity. By presenting the scenarios before the design activity, we hoped to suggest additional uses of the phone that they had not anticipated before.

4.3 Factors from Acceptance models

In line with TAM, we are particularly interested in ease of use, perceived usefulness, and attitude towards use. Furthermore, we want to include other applicable external factors that influence acceptance. We assessed the different TAM factors as follows:

4.3.1 Ease of Use and Actual Use

It is clear that *ease of use* cannot really be self-reported and actual use is as hard to determine since users sometimes do not remember particular features until they need to use them again. It is far more enlightening to observe users making use of a product. We therefore asked participants:

- To name the three features they used most often, and
- Then ask them to show us how their phone performed the features.

4.3.2 Perceived Usefulness

We asked participants to design their own phone on the assumption that they would include features based on perceived usefulness. We provided a paper facsimile of a mobile phone, together with a number of buttons (with function names) that they could affix to the phone in an empty space provided. A number of blank buttons were provided should additional features be required. They were asked to choose the six most important buttons to place on 'their' ideal phone.

4.3.3 Intention to use

We only interviewed users who owned mobile phones, and this suggests a pre-existing implicit intention to use.

4.3.4 External Factors and Facilitating Conditions

To open the way for discussions that would help us to identify particular external factors, we sketched scenarios involving familiar problems experienced by an elderly person, as evidenced by the literature review, and asked for the participant's opinion or advice about the situation.

4.3.5 Acceptance

One cannot directly ask a user whether he or she has accepted a technology. We also know acceptance cannot be accurately inferred based merely on usage. However, people's attitudes tend to influence what they say about the technology. We therefore recorded our participants' comments about their phones, and used this to gauge the extent to which they had embraced the technology.

5. RESULTS AND FINDINGS

We sketched a number of scenarios and asked our participants to comment on them. This was to explore their concept of the perceived usefulness of the mobile phone as a technology. We were also hoping that some influential factors would emerge from the discussion.

5.1 Findings from scenarios

Scenario 1 (obtaining information about mobile phones): Relating to information gathering, the responses fell into three groups: nine said that people would ask their children; two said that they should ask people of their own age (not their children); while 23 reckoned that people would go to mobile phone vendors for information.

Scenario 2 (accepting a cast-off phone): Relating to the impact of decreased ability to learn versus other motivations, three main groups of responses arose: 11 answered yes, citing the *economical* 'You can sell the old one'; the *philosophical* 'You should take the challenge'; and the *pragmatic*: 'The old phone may be getting out of date' as reasons. Seventeen answered no, stating memory loss and difficulty in learning as reasons. A third group of 6 reasoned that it depended on the person and the circumstances.

Scenario 3 (emergencies such as having a stroke): Relating to safety and ease of use, 21 participants said that a mobile phone could be useful in emergencies, 12 felt that the elderly person would be 'too scared and confused', or 'unable to find spectacles'. The rest felt that theoretically it was a good idea, but not practical since elderly people find phones difficult to use, even more so when stressed.

Scenario 4 (accessory in helping to remember): Relating to the need for organisation, 28 reckoned that people could set a reminder, of these 5 had reservations about whether elderly people would manage to do that, whilst 1 was unsure that a mobile phone would be of any help.

Scenario 5 (safety aid in travelling): Relating to safety and usefulness the majority (27) agreed that it could be useful, they gave different reasons such as the traveller contacting (phone or SMS) the family or vice versa, but some believed it could be used by a third party in the event of an emergency.

Participants demonstrated a clear intention to use mobile phones. Possession of a phone, on its own, does not indicate that an intention to use exists because many had been given their phone and therefore did not necessarily consider it useful enough to purchase a phone themselves. However, what *was* clear was that everyone considered the phone useful in all of our scenarios and that they consequently intended to use it and offered advice related to possible usages to the persons in the scenarios. Furthermore, some interesting influential factors emerged from the discussions.

Scenarios 3 and 5 highlight their strong focus on safety and security issues and their awareness of the fact that a mobile phone can help them to feel more secure. Scenarios 2 and 4 demonstrated the participants' awareness of their functional limitations such as reduced memory and limited ability to learn how to use a new phone or new features on their own phone. Scenario 1 responses demonstrated that our participants would not investigate the market themselves if they wanted to purchase a phone – they would all consult either a family member, friend or mobile phone vendor.

These scenarios point to a number of influential factors: user context, which includes such aspects as functional capacity, safety and security, economic limitations and recommendations from friends and family. Now that we have shown the existence of an intention to use in a variety of situations (usefulness) it is necessary to explore what happens once these have been established.

5.2 Usefulness

In this section we consider the findings from the design activity (Appendix A) where participants had to select the six most important features from the given set, (a number of blank buttons were provided in case participants required an additional feature). The most popular features are depicted in Table 3 ordered according to priority. The features focus on communication, safety and the need to organise, supporting earlier findings on the importance of communication and safety aspects [20].

Table 3: Features desired

Button	Name on button	Number of times selected
1	Nearest&Dearest	27
2	SMS_write	12
3	SMS_read	11
4	Police	11
5	Display_Own Number	9
6	Phone_book	8
7	Ambulance	8
8	CareUnit	6
9	Reminders	5

Our participants were free to choose any functionality they wanted from the available buttons, yet the buttons chosen were quite predictable. Numbers 1-4, 7 and 8 were all related to communicating with others. Numbers 5, 6 and 9 were essentially using the phone to help them remember numbers or events. Given the availability of a wide variety of buttons, it is surprising that the chosen buttons are so limited. The activity reported in this section was designed to assess perceived usefulness. The following section reports on actual use.

5.3 Actual use

Sarker and Wells [30] suggested an exploration and experimentation module, and certainly we had the sense that many of our participants had experimented with their phones soon after coming into possession of them. Some communicated a sense of frustration, verbalised as follows:

I just can't use that predictive text, even though my daughter has tried to show me how.

Table 4: Feature use frequency (N=32)		
Feature	Sum	Associated factor
Phone book	24	user context – memory limitations
SMS	14	user context – economic limitations
Phone using number	11	user context – need for social contact
Alarm	9	perceived usefulness
Check Missed calls	4	social influence
Camera	4	social influence

I am sure there is a way to get the phone to remind you about things, but I can't find it.

Please could you help me find my phone numbers – I have tried but I can't find them.

If the participants did indeed engage in an exploration phase, the obvious outcome of that phase would be the usage of features they had discovered and could use. Table 4 lists the features our participants told us they used regularly (see question 8 in Appendix A) and therefore depicts the outcome of their experimentation with, and exploration of, the phone. We confirmed that a general intention to use the phone plus their sense that the phone could be useful, when they first got it, resulted in a period of experimentation. However, their current use appeared to include only a minimal subset of features – mostly related to communicating as they would using traditional phones. We intended to count the button presses in the second part of this process in order to gauge effort expended and consequent *ease of use*. We had to discontinue this since it became obvious that the participants had difficulty finding their most-used features. Some participants asked the interviewer for assistance in finding the feature; others tried various routes down the menu structure before triumphantly locating the desired feature. We felt that the button press count was so inaccurate as to be useless and therefore discontinued counting. Since the type of mobile possessed by the participants was diverse, the unavoidable conclusion is that most of our participants had serious ease-of-use issues with their phones, whatever make they are.

It became clear that participants fell into two distinct groups: those who had mastered the beast and those who were bemused by it. The former were more adventurous in their use of the phone, using more than just the minimal communication facilities. The latter appeared to own the phone merely because it had been given to them. They clearly saw that the phone could be useful, especially in emergencies, but they did not enjoy ownership the way the former group did. It appeared that for the latter group full adoption had not occurred – they had not *converted* to the technology — and this is likely to be due to a less than wholehearted acceptance of the technology. Our findings suggested that all users had explored the mobile phone but that a number of them found a number of features too difficult to find and reverted to using it merely as a mechanism for phoning people when not at home – using a fraction of the functionality of the phone.

6. Proposing STAM

Based on the integration of the three main activities in our research approach: a literature study on technology adoption models, an investigation into the context of the senior user and the findings from our interviews, we propose the Senior Technology Acceptance & Adoption Model (STAM) as depicted in Figure 3. STAM consists of the following components, defined as:

- *User Context* such as demographic variables, social influence and personal factors such as age and functional ability, for example. Social influence is the prevalent external variable and therefore depicted as a module in the user context. Social influence aligns with Rogers' *observability* innovation attribute.
- *Perceived usefulness* is defined as 'the extent to which a person believes that using the system will enhance his or her job performance' [34]. This aligns with Rogers' [28] *compatibility* and *relative advantage* innovation attribute.
- *Intention to Use* is influenced by perceived usefulness and also by user context.
- *Experimentation and Exploration*, which is the module where the user first starts using the technology and forms first impressions of the ease of use. Note that the experience obtained here will feed back into confirmed usefulness. The importance of this module confirms findings by Arning and Ziefle [2] that performance was the main predictor of ease of use. It also aligns with Rogers' [28] *trialiability* innovation attribute.
- *Ease of learning & use* results from the perceived ease of use ie. 'the extent to which a person believes that using the system will be free of effort' [34], and the final conclusion about ease of use is directly influenced by the experimentation and exploration stage. This aligns with Rogers' [28] *complexity* innovation attribute. Finally, whereas other models do not incorporate the ease of learning aspect, the senior model needs to, since difficulty in learning to use a device is a determining factor for the elderly [37] as is the fear of failure [2] .
- *Confirmed usefulness* is the usefulness of the person's phone to him or her – composed of the features he or she is able to learn to use.
- *Actual use* is indirectly predicted by the outcome of the experimentation, which leads to ease of learning & use. Facilitating conditions and the consequent ease of learning & use predict *actual use.*

Finally, *acceptance* or *rejection* is predicted by ease of learning & use and actual use, with the former more strongly influencing acceptance.

STAM, like UTAUT and MOPTAM does *not* include attitude as a determining factor. Van Biljon found no significant correlation between attitude towards use and any of the other determinants. This is supported by our observation that most people between the ages of ten and 70 use mobile phones and indeed all our participants owned and used phones. Dissatisfaction with the ease of use of the phone did not deter people from intending to use the phone – the social influences were far too strong to be offset by a phone that was difficult to use. What *was* affected by ease of use was actual use of the phone, and eventual acceptance.

Figure 3 depicts the Senior Technology Acceptance & Adoption Model (STAM) which models both acceptance factors and adoption phases. We have replaced the multi-faceted attitude module with modules depicting this progression from first ownership towards actual acceptance.

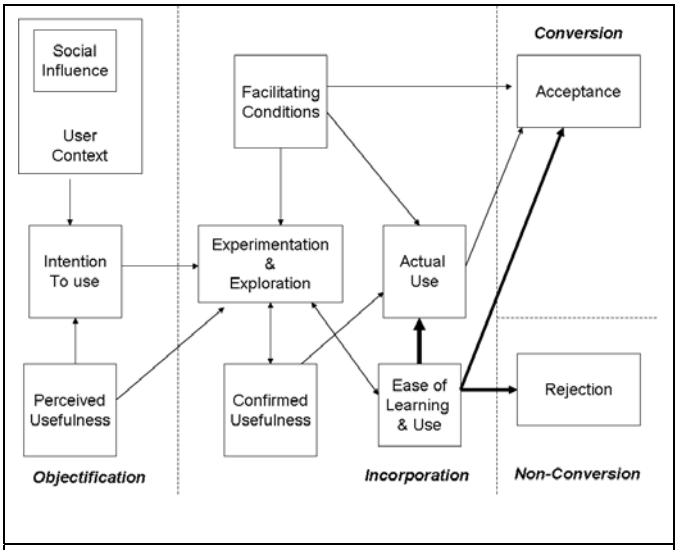

Figure 3: Senior Technology Acceptance & Adoption Model (STAM)

The newly proposed STAM captures the context of the elderly mobile phone user in an improved way since it relates technology acceptance factors to the adoption phases in the following way. For elderly people the appropriation phase (see Table 1) is often skipped. They seldom make the decision to buy as their first phone is often given to them or bought for them (note that fewer than 50% of our participants bought their current phone themselves). In the objectification phase (see Table 1) determining the role the technology will play manifests in the behavioural intention which is influenced by *social factors* and *perceived usefulness*. The incorporation phase describes the interaction with the technology as represented by the *experimentation and exploration* module. It is well known that the elderly consider spending very carefully and the price of a device or service is a differentiator for use [22, 33]. This is depicted in the *facilitating conditions* module. Facilitating conditions, perceived usefulness and ease of learning & use all influence *actual use*. Acceptance implies that the user has progressed through all the phases without being derailed by the various facilitating factors. Rejection would result from a poor experimentation experience and a resulting perception that the device is too difficult to learn or to use. Whereas most other models suggest eventual acceptance by all users, our experience suggests otherwise, and our model reflects this. As noted in section 2.3, STAM is not the first attempt at modelling technology acceptance by the elderly adult user. Arning and Ziefle [2] studied the influence of TAM factors on performance and found a significant correlation between performance and ease of use. That correlation was even stronger for the elderly age group. This study is therefore consistent with their findings about the dominant influence of ease of use in full-adoption. Phang *et al.* [25] presented a model for representing the factors that influence intention to use, where perceived ease of use as well as perceived usefulnes was found to be highly significant in determining intention to use. However, they found that age was not significant in determining intention to use. This is consistent with our findings that the elderly clearly intend to use a mobile phone but *actual* use is clearly hampered by ease of use. While confirming the importance of perceived usefulness and ease of use as fundamental factors determining technology acceptance for this age group, there are also significant differences between these models because they focus on different components of the adoption process. In contrast STAM depicts the transition from usage to acceptance and conversion (adoption) – a step that some users will never take since their progress is inhibited by poor ease of use and consequent less than optimal confirmed usefulness. Elderly people have the added complication of often skipping the appropriation phase and this provides a plausible explanation for the fact that some elderly mobile phone users never progress to acceptance and the conversion phase.

Scenarios can be limiting due to their textual, sequential and finite format, but we found the combination of scenarios and the design activity useful in capturing attitudes and minimizing social desirability bias.

7. CONCLUSION

This study investigated mobile phone acceptance by the elderly adult user. We considered existing technology acceptance models and extracted a set of factors that could influence mobile phone acceptance. These factors were filtered by considering the context of the elderly and then validated by means of semi-structured interviews that included the presentation scenarios. The main contribution of this paper is to propose the STAM for modelling the acceptance process as driven by the factors that influence mobile phone adoption in the context of the elderly mobile phone user. By relating acceptance factors to adoption stages STAM provides an explanation why many elderly adults never reach the final adoption phase and never fully accept the technology. This approach may also be useful in modelling technology acceptance of other demographic groups. This paper also makes a contribution of integrating research from different fields, i.e. the qualitative research focusing on the acceptance process (from Sociology) with quantitative research on the factors that influence adoption (from Information Systems).

Research results from larger groups are needed to test the validity and reliability of STAM in explaining the mobile phone adoption of the elderly adult user. Furthermore the age group identified (60-92) is quite broad and further work includes testing the model on smaller age ranges e.g. 60-70 to ensure that cognitive abilities are comparable across the age range.

8. ACKNOWLEDGMENTS

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Appendix A: Questionnaire

1. What is your mother-tongue (first language that you learned to speak)? ……

2. Are you?

[a] Male	[b] Female

3. How old are you?

[a] 60- 69	[b] 70- 79	[c] 80 or older

4. How would you describe your general level of computer experience?

[a] None - I have never used a computer	
[b] Low - I have used a computer belonging to someone else	
[d] Medium - I own a computer	
[e] High - I am comfortable using a computer	

5. Is your phone?

[a] Contract	[b] Pay as you Go

6. Did you?

[a] Buy your phone	[b] It was bought for me
[c] It was passed on by someone else	

7. Scenarios presented in questionnaire:

1) Jim lives alone. One of his children has emigrated. He is 75 years old and needs to keep in touch. He has decided to get a mobile phone so he can receive pictures and messages. Who should he get advice from before he goes to buy a phone?

2) Leslie is a 75 year old with a mobile phone, which was given to him by his daughter, and he has been using it for 2 years. He now feels confident using it. She has now renewed her contract and wants to give him her old Cell Phone. Do you think he will take it?

3) Pam has had a stroke. She is worried that it will happen again. Do you think she could use her mobile phone in some way to make her feel less vulnerable?

4) Peter, aged 85, needs to take his medication every day at 12 noon and he keeps forgetting. Can his mobile phone help him?

5) Tim likes to travel alone now that he has retired. His family is concerned about him. He says they shouldn't worry because he has his mobile phone with him. Is he right? What should he do to allay their fears?

8. Tick features that the participant uses and record keys pressed to do so:	
Alarm	Games
Calculator	Torch
Calendar	Phone with Phone Book (save numbers)
Camera	Phone typing in number
Check missed calls	Photo album/gallery
SMS	Picture messaging
SMS with predictive text	Personalised ringtones
E-mail	Profiles(change volume etc.)
Transfer Money	Set reminders on calendar
FM radio	Stopwatch
Other? Features you would like to use but don't know how to: ...	

Design activity:

A paper prototype of a phone (depicted in Figure 4) together with separate paper buttons with the function names on (listed in Table 4) was presented to the participants. The buttons were randomized for each participant who was then requested to select the six most important functions (as represented by the buttons) and place them onto the phone prototype in the designated space above the menu bar.

Table 4: Functions on phone buttons

Ambulance	Games	Reminder	Alarm	Police
Get Directions	Bank	Read SMS	Write SMS	Take Photo
Send Picture	Nearest & Dearest	Display my number	See my photos	Balance
Directory Services	Call Register	Internet	Bluetooth	Phone Book

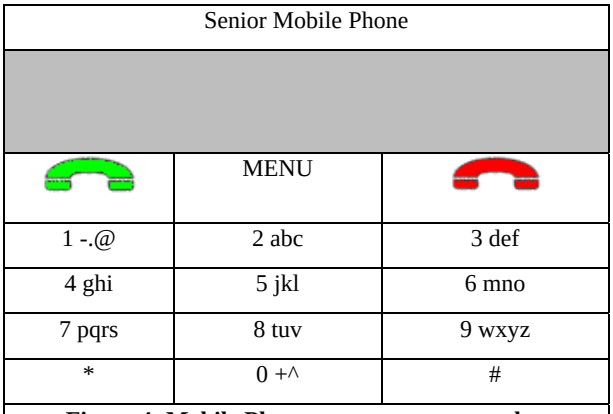

Figure 4: Mobile Phone prototype presented to participants

9. REFERENCES

[1] Abascal, J.,Civit, A. *Universal Access to Mobile Telephony as a way to enhance the Autonomy of Elderly People*, In *WUAUC 2001*. Alcacer so Sal. Portugal. (2001).

[2] Arning, K.,Ziefle, M. Understanding age differences in PDA acceptance and performance. *Computers in Human Behaviour*. 23 (2007), 2904-2927.

[3] Baldi, R.A. Training older adults to use the computer. Issues related to the workplace, attitudes and training. *Educational Gerontology*. 23 (1997), 453-465.

[4] Botwinick, J. *Cognitive processes in maturity and old age*. Springer, (1967).

[5] Brennan, Z. *Oldmobiles roll up for grey drivers, The Sunday Times*. (1997), 13.

[6] Brewster, S. Overcoming the lack of screen space on mobile computers. *Personal and Ubiquitous Computing*. 6(3) (2002), 188-205.

[7] Burke, D.M., Mackay, D.G. Memory, Language and ageing. Philosophical Transactions of the Royal Society: Biological Sciences, 352 (1997), 1845–1856.

[8] Carroll, J., Howard, S., Peck, J., Murphy, J. From adoption to use The process of appropriating a mobile phone. *AJIS*. 10 (2) (2003), 38-48.

[9] Davis, F.D. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*. 13(3) (1989), 319-340.

[10] Davis, F.D., Bagozzi, R.P., Warshaw, P.R. User acceptance of computer technology A comparison of two theoretical models. *Management science*. 35(8) (1989), 982-1003.

[11] Dunlop, M., Brewster, S. The Challenge of Mobile Devices for Human Computer Interaction. *Personal and Ubiquitous Computing*. 6(4) (2002), 235–236.

[12] Haddon, L., *Domestication and Mobile Telephony*. In J. Katz, (eds.) Machines that Become Us: The Social Context of Personal Communication Technology. Transaction Publishers, New Brunswick, New Jersey, 2003, 43-56.

[13] Hyyppä, K., Tamminen, S., Hautala, I., Repokari, L. The effect of Mental Model Guiding User's Action in Mobile Phone Answering Situations. In *Electronical Proceedings from The 1st Nordic Conference on Computer Human Interaction*. 2000. Stockholm, Sweden NordiCHI and STIMDI 2000.

[14] Iacucci, G. *Bridging Observation and Design in Concept Development for Mobile Services*. In: (eds.): Third International Symposium on Human Computer Interaction with Mobile Devices, IHM-HCI 2001. Lille, France, 2001.

[15] Jackson, G.R., Owsley, C. Visual dysfunction, neurodegenerative diseases and aging. *Neurology and Clinical Neurophysiology*. 21(3) (2003), 709-728.

[16] Jarke, M., Bui, X.T., Carroll, J.M. Scenario Management: An Interdisciplinary Approach. *Requirements Engineering Journal*. 3 (1998), 3-4.

[17] Jones, M., Marsden, G. *Mobile Interaction Design*. John Wiley and Sons, Hoboken, NJ, (2005).

[18] Kiljander, H. *Evolution and Usability of Mobile Phone Interaction Styles*. Thesis, Department of Computer Science and Engineering, Helsinki University of Technology, Helsinki, 2004.

[19] Kwon, H.S., Chidambaram, L. *A test of the technology acceptance model: The case of cellular telephone adoption.* In Proceedings of the 33rd Hawaii International Conference on System Sciences. IEEE Computer Society, Hawaii (2000), 1-10.

[20] Lee, Y.S. *Older adults' user experiences with mobile phones:Identification of user clusters and user requirements.* Thesis, Industrial and Systems Engineering, Virginia Polytechnic Institute and State University, Virginia, 2007.

[21] Malhotra, Y., Galletta, D.F. *Extending the Technology Acceptance Model to Account for Social Influence: Theoretical Bases and Empirical Validation*. In Proceedings of the Thirty-Second Annual Hawaii International Conference on System Sciences. IEEE, 1999, 1006.

[22] Mallenius, S., Rossi, M., Tuunainen, V.K. Factors affecting the adoption and use of mobile devices and services by elderly people – results from a pilot study. (2010).

[23] Osman, Z., Maguir, M., Tarkiainen, M. Older Users' Requirements for Location Based Services and Mobile Phones. *LNCS*. 2795 (2003), 352-357.

[24] Pedersen, E. Adoption of Mobile Internet Services: An Exploratory Study of Mobile Commerce Early Adopters. *Journal of Organizational Computing and Electronic Commerce*. 15(3) (2005), 203 - 222.

[25] Phang, C.W.J., Sutano, A., Kankanhalli, L., Yan, B.C.Y., Teo, H.H., Senior citizens' acceptance of informations systems: A study in the context of e-Government services. *IEEE Transactions on Engineering Management. 2006*

[26] Phillips, L., Sternthal, B. Age differences in information processing: a perspective on the aged consumer. *Journal of Marketing Research*. 14(2) (1977), 444-457.

[27] Preece, J., Sharp, H., Rogers, Y. *Interaction Design - beyond human-computer interaction*, ed. K. Santor. John Wiley & Sons, Inc., New York, (2002).

[28] Rogers, E.M. *Diffusion of Innovations.* 5 th ed. The Free Press, New York, (2003).

[29] Salthouse, T.A., *Speed of behavior and its implications for cognition.* Handbook of the psychology of aging. Van Nostrand Reinhold, New York, 1985.

[30] Sarker, S., Wells, J.D. Understanding Mobile Handheld Device use and adoption. Communications of the ACM, 46(12) (2003),35-40.

[31] Silverstone, R., Haddon, L., *Design and the Domestication of Information and Communication Technologies: Technical Change and Everyday Life*. In Communication by Design: The Politics of Information and Communication Technologies. Oxford University, Oxford, 1996, 44-74.

[32] Van Biljon, J. ,Kotzé, P., *Modelling the Factors that Influence Mobile Phone Adoption*. ACM International Conference Proceeding of the 2007 annual research conference of the South African institute of computer scientists and information technologists on Riding the wave of Technology. Port Elizabeth, (2007), 152 - 161.

[33] Van Biljon, J.A. *A Model for Representing the Motivational and Cultural Factors that Influence Mobile Phone Usage Variety*. PhD Thesis, School of Computing, University of South Africa, Pretoria, 2007.

[34] Venkatesh, V., Morris, M.G., Davis, G.B., Davis, F.D. User acceptance of information technology: Toward a unified view. *MIS Quarterly*. 27(3) (2003), 425-478.

[35] Young, T. *Software Interface Design for Small Devices*. (2003) [cited 2006/10/12] Available from: http://www.cs.ubc.ca/~trevor/writings/SmallScreenDesign.pdf.

[36] Yuan, Y., Zhang, J.J. Towards and appropriate business model for m-commerce. *Mobile communications*. 1(1-2) (2003), 35-56.

[37] Ziefle, M., Bay, S. Mental Models of a Cellular Phone Menu. Comparing Older and Younger Novice Users. *Lecture Notes in Computer Science: Mobile Human-Computer Interaction – MobileHCI 2004*. LNCS 3160/2004 (2004), 25-37.