Approaches to designing for older adults’ intuitive interaction with complex devices

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Dedication

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Abstract

Many older people have difficulties using modern consumer products due to increased product complexity both in terms of functionality and interface design. Previous research has shown that older people have more difficulty in using complex devices intuitively when compared to the younger. Furthermore, increased life expectancy and a falling birth rate have been catalysts for changes in world demographics over the past two decades. This trend also suggests a proportional increase of older people in the workforce. This realisation has led to research on the effective use of technology by older populations in an effort to engage them more productively and to assist them in leading independent lives. Ironically, not enough attention has been paid to the development of interaction design strategies that would actually enable older users to better exploit new technologies.

Previous research suggests that if products are designed to reflect people’s prior knowledge, they will appear intuitive to use. Since intuitive interfaces utilise domain-specific prior knowledge of users, they require minimal learning for effective interaction. However, older people are very diverse in their capabilities and domain-specific prior knowledge. In addition, ageing also slows down the process of acquiring new knowledge. Keeping these suggestions and limitations in view, the aim of this study was set to investigate possible approaches to developing interfaces that facilitate their intuitive use by older people.

In this quest to develop intuitive interfaces for older people, two experiments were conducted that systematically investigated redundancy (the use of both text and icons) in interface design, complexity of interface structure (nested versus flat), and personal user factors such as cognitive abilities, perceived self-efficacy and technology anxiety. All of these factors could interfere with intuitive use. The results from the first experiment suggest that, contrary to what was hypothesised, older people (65+ years) completed the tasks on the text only based interface design faster than on
the redundant interface design. The outcome of the second experiment showed that, as expected, older people took more time on a nested interface. However, they did not make significantly more errors compared with younger age groups. Contrary to what was expected, older age groups also did better under anxious conditions.

The findings of this study also suggest that older age groups are more heterogeneous in their capabilities and their intuitive use of contemporary technological devices is mediated more by domain-specific technology prior knowledge and by their cognitive abilities, than chronological age. This makes it extremely difficult to develop product interfaces that are entirely intuitive to use. However, by keeping in view the cognitive limitations of older people when interfaces are developed, and using simple text-based interfaces with flat interface structure, would help them intuitively learn and use complex technological products successfully during early encounter with a product. These findings indicate that it might be more pragmatic if interfaces are designed for intuitive learning rather than for intuitive use.

Based on this research and the existing literature, a model for adaptable interface design as a strategy for developing intuitively learnable product interfaces was proposed. An adaptable interface can initially use a simple text only interface to help older users to learn and successfully use the new system. Over time, this can be progressively changed to a symbols-based nested interface for more efficient and intuitive use.
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Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signed

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Chapter 1

Introduction
1.1 Introduction

A significant section of the older population (65+ years) has difficulties in using modern consumer products that have complex interfaces and extensive functionalities. Not being able to use modern technology such as computers, the Internet, and ever increasing self-care medical devices puts the older population at a disadvantage in terms of their ability to live and function independently (Czaja & Lee, 2007). Vanderheiden (1997), paraphrasing Ralph Caplan, notes that ‘disability is the inability to accommodate to the world as it is currently designed’ (p. 2013). What is needed to address this exclusion is more attention to interface design that will help older people access new technologies with ease.

1.2 Importance of this research

Increasing life expectancy and a dropping birth rate have resulted in changes in world demographics over the past two decades. It is estimated that by the year 2050, over 30% of Australia’s population will be aged 60 and above (Department of Economic and Social Affairs, 2008). This trend will also see a proportionate increase in the number of older people in the workforce (Kooij, Lange, Jansen, & Josje Dikkers, 2008). Shrinking care resources will likely see older adults working beyond their normal retirement age. Similar trends can also be seen in most of the developed world (Hawthorn, 2000).

Coupled with this change in demographics, past decades have seen a substantial increase in the use of technology in all aspects of daily living. The gradual shift from hardware-based to microprocessor controlled software-based products has brought a higher level of abstraction into interaction with products (Docampo Rama, Ridder, & Bouma, 2001; Hurtienne & Blessing, 2007). Older generations, who grew up with relatively older technological paradigms, have been left behind. This has resulted in a digital divide between young and old (Lim, 2009; Westerman & Davies, 2000).
Although the use of technologies such as computers and the Internet is increasing among older people, an age-based digital divide still exists (Czaja & Lee, 2007).

This situation has led to research on the use of technology in the aged population in an effort to find ways to effectively engage this group and to help them to lead a productive, dignified and independent life. Ironically, not much attention has been paid to interaction design that would actually enable older users to exploit new technologies (Czaja, Gregor, & Hanson, 2009; Hawthorn, 2001). A study conducted by the Nielsen Norman Group has found, for example, that the web is twice as usable for younger adults than older adults (Nielsen, 2002). One of the reasons, they lament, is that young designers often assume that all users have perfect vision, cognitive processing, motor control, and know everything about the web. This assumption in principle, excludes older people from the sample population (Czaja & Lee, 2007). Interestingly, recent research suggests that although older users have unique usability constraints compared to younger users, these constraints are often shared among all age groups under some circumstances. So, when a product is made more usable for older users it is also improved for other age groups (Fisk, Rogers, Charness, Czaja, & Sharit, 2009). Newell (2008) calls this the ‘ordinary and extraordinary human-machine interaction’ concept.

Czaja and Lee (2007) argue that most of the research in this area is limited by methodological shortcomings. The most glaring issues are very small sample sizes that use only one or two narrow age groups at the extremes of age continuum, as against a continuous age sample (Salthouse, 2010). In addition, most research tends to focus only on the effects of chronological age as variables. This is despite the fact that research has also well established that in terms of capabilities, older people are a heterogeneous group and one should consider the effects of both cognitive ageing as well as chronological age (Czaja & Lee, 2007; Fisk et al., 2009). Similarly, Rogers and Fisk (2010) strongly recommend that research on ageing and use of
technology should focus less on the age variable and more on the source of age-related differences. It is agreed that chronological age is useful for understanding patterns of technology usage, preferences, and difficulty. However, it does not explain why these differences occur, to determine this, there is a need to investigate mediating variables such as cognitive abilities and domain-specific prior experience.

This research was carefully designed, therefore, to investigate the effects of domain-specific prior experience, and both cognitive and chronological ageing on different variables. The insights gained from the outcome of this study have been used to develop an appropriate strategy to help designers facilitate intuitive interaction with complex technological products. An intuitive interface requires minimal new learning as it mostly relies on prior user knowledge for effective interaction (Blackler, 2008; Hurtienne & Blessing, 2007). It was hypothesised that an intuitive product interface, as it is based on prior knowledge, will address the difficulties faced by older adults in learning and using new interface systems.

1.3 Aim, objectives and hypotheses of this study

The overall aim of this research was to develop an approach which will help designers create interfaces for complex technological products that older adults can use more intuitively. The term ‘older adults’, in general, refers to individuals who are 65 years of age and older. It should be noted that there is no definitive boundary between young and old. Ageing is a continuous process with a varying degree of age-related cognitive and sensorimotor changes over a life time (Fisk, 2004; Fisk et al., 2009). The following two objectives were set for this study:

- To identify and investigate one possible strategy for developing intuitive interfaces for older adults.

- To identify and investigate factors that can interfere with intuitive use in older adults.
The scope of the ‘complex contemporary technological devices’ used in this study is constrained to the genre of consumer products that are driven by microprocessor-based, software-controlled interfaces. The basic nature of these kinds of devices is that their interface structure is multi-layered or nested, and the function of their physical controls changes according to the context of their use. For example, up and down arrow buttons are used to increase volume in one context and can also be used to scroll a page in another.

1.3.1 Hypotheses

Two experiments were planned to address the objectives set for this study. Based on the gaps identified in the literature reviewed, the following hypotheses were formulated.

1. That redundancy in interface design helps older users and users with low domain-specific prior experience to use complex technological product interfaces more quickly, more intuitively and with fewer errors.

2. That, with respect to complex interfaces, age and anxiety:

   a. Complex/nested interface structure has adverse effects on time to complete a task and on the percentage of intuitive uses and errors for older participants and participants with low domain-specific prior experience, when compared with younger participants.

   b. Participants who score poorly on the Technology Prior Experience Questionnaire will also score poorly on the Self-efficacy Questionnaire and report high anxiety on the State-Trait Anxiety Inventory (STAI) Questionnaire.
c. Anxiety, induced by stressful condition has an adverse impact on time to complete the task and the percentage of intuitive uses and errors for both younger and older participants.

1.4 Contributions to knowledge and research implications

This study makes a significant contribution to both the knowledge about interaction design practice and about the methods of researching with older people.

Older people and interaction design

First, the findings of Experiment 1 show that, contrary to many existing hypotheses, the use of redundancy in interface to counter the diversity in older people’s capabilities may not be beneficial.

It has been established that a simple text-based interface is most effective to use and learn for older people and people with low prior experience and cognitive capabilities. This supports other research on learnability of interfaces that shows that text-based interfaces are most beneficial for novice users. Most importantly, the finding that text-based interface is most beneficial for older and novice users has contributed to the development of an adaptable interface module for intuitive learning.

Second, the findings of Experiments 1 and 2 establish a possible baseline design for complex interfaces that will significantly minimises difference between ages.

A considerable amount of research has been undertaken in the past two decades on the differences between nested and flat interface structures. In general, most of the research agrees that older people take more time to complete a task on a nested interface and also find it hard to use. However, when the task is designed bearing in mind the cognitive limitations of the older users, the differences in accurate completion of the tasks between young and old are not significant.
Third, the findings of Experiment 2 of this study also supports Attentional Control Theory (Eysenck & Derakshan, 2011) which suggests that anxiety is associated with increased allocation of cognitive resources which, in turn, results in better performance.

Experiment 2 has shows that, contrary to suggestions in the literature, anxious or stressful conditions does not have an adverse effect on the intuitive use of complex technological product interfaces. Indeed, interestingly, older people under stressful condition used interfaces much more intuitively.

Overall, the outcome of this study suggests that building entirely intuitive interfaces for older people is not currently practical. However, it is possible to develop interfaces that are initially intuitive to learn and which over time, can be used intuitively. Based on these findings, an adaptable interface design model for intuitively learnable interfaces has been developed. When this model is implemented, as envisaged, it has the potential to help designers develop intuitively learnable products that will effectively address the diversity in capability of older users.

**Research methodologies for older participants**

The combination of measures and apparatus used in this study, from sociology to cognitive psychology, allowed it to focus more on the source of age-related differences rather than on age as a variable. This research contributes to research methods that involve older participants as explained below.

*The study used a comprehensive mix of data collection methods: measures of technology prior experience, technology self-efficacy, cognitive abilities, level of state anxiety and video observations.*

These methods were developed based on the literature which suggests the use of technology in older people is mediated by prior experience, self-efficacy, anxiety and cognitive abilities. For any meaningful research, these
factors should be considered in order to understand the true effects of age on different aspects of technology use. These methods could be valuable for further studies in interdisciplinary areas that may include interaction design, cognitive science, psychology and social sciences.

1.5 Thesis overview

Chapter 1 introduces the research problem and the reasons why it needs to be addressed. It further presents the aim and objectives of this study and its contributions to the knowledge in the area. Finally, it gives an overview of the thesis structure.

Chapter 2 reviews available literature that is relevant to this research. It discusses the nature of intuitive interaction and how prior experience with related and similar products is important for intuitive use. It also discusses approaches to designing interfaces that are intuitive to use and methods for investigating prior knowledge of users. It also briefly discusses issues related to the development of design methods.

Chapter 3 covers relevant issues of interaction design with specific focus on older adults as users and the impact of ageing on the use of complex technological devices. It also examines the impact of technology prior experience, anxiety and technology self-efficacy on and older people’s intuitive use of technologically complex products.

Chapter 4 summarises the literature reviewed in the earlier chapters to highlight the knowledge gaps, and discusses possible ways that interfaces can be designed to address the issues that interfere with older people’s intuitive use of contemporary technological products.

Chapter 5 presents methodological issues, with specific focus on their appropriateness when working with older participants. It briefly states the direction this research takes – a direction supported by the gaps in the literature reviewed. It also presents the overall research plan and discusses
research methods and techniques, and the data collection methods that are relevant to the design of the experiments.

Chapter 6 and 7 discuss the design of Experiments 1 and 2, the data collection methods used, the procedures employed, and the results of the experiments.

Finally, Chapter 8 presents a brief overview of the research and discusses the overall outcomes of the study and the development of a strategy for developing intuitively learnable interfaces. It also lists the significant contributions to knowledge that the research makes, its few limitations, and its future directions.

1.6 Summary

This chapter provided an introduction to the thesis and explained the research aim and objectives. It also provided a brief overview of the contents of this thesis, the literature reviewed, and the study’s contribution to the knowledge.

Chapter 2 discusses the nature of intuitive interaction and the importance of prior experience for building interfaces that appear intuitive to use.
Chapter 2

Intuitive Interaction
2.1 Introduction

There are some experiences and emotions whose meanings are very hard to explain in words. ‘Intuition’ is one such word in the English language with a very broad and loosely defined meaning. People use different terms interchangeably with intuition, such as ‘right brain thinking,’ ‘gut feeling,’ ‘hunch’, and so forth. Some even say that intuition cannot be explained (Davis-Floyd & Arvidson, 1997). However, Bastick (2003) and Klein (2001), after extensive research on the nature of intuition in decision-making, problem solving and creativity, conclude that intuition is not something mystical but a cognitive process. These authors have developed general frameworks of intuitive processes that satisfactorily explain the nature of intuition in the decision-making and problem solving domains.

This research does not delve deeply into the nature of intuition but, rather, is restricted to understanding the operational meaning of ‘intuition’ in the context of interface design. It uses the definition of ‘intuitive interaction’ as proposed by Blackler (2008). Blackler, based on her extensive literature review of the nature of intuition, defines it as follows:

Intuition is a type of cognitive processing that utilises knowledge gained through prior-experience (stored experiential knowledge). It is a process that is often fast and is non-conscious, or at least not recallable or verbalisable. (Blackler, 2008, p. 65; Blackler, Popovic, & Mahar, 2003)

This chapter reviews the literature on the nature of intuitive interaction and its relationship with prior knowledge. It also discusses the few available intuitive interaction frameworks and their limitations. Finally, it briefly presents issues related to the investigation of prior experience and the development of design methods and strategies.
2.2 Intuitive interaction

As noted earlier, there is some literature on the use of intuition for solving problems and on intuition as a cognitive process. However, there is very little empirical research on the application of this understanding to the design of intuitive interfaces. Interaction design professionals often feel that they understand what ‘intuitive interaction’ is; however, they never really define it clearly (Blackler, 2008; Turner, 2008). For example, a group of experts in the area of universal design have developed seven principles to help designers when developing products and environments (Story, 1997). One of the principles says a product should be simple and intuitive to use. ‘Intuition’ in this context means that the ‘design is easy to understand, regardless of the user’s experience, knowledge, language skills, or current concentration level’ (Beecher & Paquet, 2005). However, it is now well established that intuitive use of a product is based on the prior knowledge of the user (Blackler, 2008; Blackler, Popovic, & Mahar, 2010; Hurtienne, Weber, & Blessing, 2008; Lewis, Langdon, & Clarkson, 2008; Naumann et al., 2008). In other words, intuitive use of a product interface is an outcome of subconscious application of relevant prior knowledge by the users.

Currently, a few groups of researchers are working in the areas related to intuitive interaction. Of these, two groups, Blackler and her colleagues from Australia (Blackler, 2006, 2008) and Intuitive Use of User Interfaces (IUUI) group at the Technical University of Berlin (Hurtienne & Blessing, 2007; Naumann et al., 2007), are directly involved in developing tools for designing interfaces that are intuitive to use. Both these teams have defined the basic nature of intuitive interaction. Blackler suggests the following operational definition:

Intuitive use of products involves utilising knowledge gained through other experience(s) (e.g. use of another product or something else). Intuitive interaction is fast and generally non-conscious, so that
people would often be unable to explain how they made decisions during intuitive interaction. (Blackler, 2008, p. 107).

Similarly, the IUUI research group took an empirical approach in developing an appropriate definition for intuitive interaction. Their study involved interviewing users, developers and usability experts and transforming the data into a framework for intuitive use research. The following definition of intuitive use was used as a common ground for discussing and communicating their research:

A technical system is, in the context of a certain task, intuitively usable while the particular user is able to interact effectively, not-consciously using previous knowledge. (Naumann et al., 2007, p. 129)

Apart from these two groups, there is some other literature that point to intuitive interaction. For example, according to Spool (2005), when an interface design meets the following two conditions, users feel that the interface is intuitive to use:

1. If it matches user experience and knowledge; that is, if the user knows everything they need to know to operate the device.

2. If the user does not have the necessary knowledge to use the device: User learns to use the device naturally. That is, the user is completely unaware that the design is helping him/her learn a new system.

In one of the recent studies, O'Brien (2010) defines intuitive interaction as something that takes place when knowledge in the world (product features and affordances) elicits and guides the users to use knowledge in the head (prior experience) (D. A. Norman, 2002). Although O'Brien defines intuitive interaction in her study, her research is more focused on the effects of prior experience and use of technological products. Similarly, Spool (2005) does not provide a critical understanding of the nature of intuitive interaction,
nor does he back his suggestions with empirical research. Hence, this literature review will focus more on the research of Blackler and the IUUI research group.

In summary, the nature of intuitive interaction in the context of interface use is well defined by two independent research teams. In terms of definition, both Blackler et al. and as well as Hurtienne et al. agree on the basic nature of intuitive interaction; that is, it is based on users’ past experiences and that users use this experiential knowledge subconsciously (Blackler & Hurtienne, 2007).

### 2.3 Designing interfaces for intuitive use

The intuitive use of an interface involves subconscious use of users’ prior knowledge. Thus, design for intuitive use basically involves two steps: 1) to understand domain-specific prior experience of the user; and 2) to design interfaces that reflect this prior experience (Figure 2.1). In reality, however, research shows that it is much more complex to implement this framework (Blackler, 2008; Hurtienne et al., 2008). To start with, investigating what target users are familiar with is a very resource intensive process, both in terms of time and money (Spool, 2005). In addition, no two users share similar prior experiences.

![Figure 2.1: Designing interactions for intuitive use](image)

As mentioned in the previous section, there are currently two frameworks that have been developed to help designers design interfaces that appear intuitive to use (Blackler & Hurtienne, 2007). The following section explores these two intuitive interaction frameworks.
2.3.1 Intuitive interaction frameworks

Domain-specific prior experience or knowledge is a critical factor in using an interface intuitively. In this section, two intuitive interaction frameworks are discussed. The backbone of both of these frameworks is the effective matching of the prior knowledge of the users with the interface design.

Blackler (2006, 2008) conducted what was probably the first empirical study on intuitive interaction. This study comprised of three experiments. Experiment One used a digital camera as a mediator product and was designed to investigate if intuitive use of an interface involves use of prior knowledge gained from interaction with other similar products. Two methods were employed in this investigation: video recording of the participants while delivering concurrent protocol and, a Technology Familiarity (TF) Questionnaire. The TF Questionnaire had two components: one for collecting data on participants’ exposure to similar products, and the other for determining the frequency and intensity of the participants’ use of these products. Noldus Observer software was used to code the audio video recording and concurrent verbal protocol for intuitive use. Since intuitive use of an interface involves subconscious use of prior knowledge, the ‘intuitive use’ code was operationalised as ‘fast use of a control with lack of verbalisation, or verbalisation after the action with little or no evidence of reasoning’. TF score was calculated from the questionnaire. The results from this experiment suggest that prior experience with products that use similar features helps participants use the mediator product more quickly and intuitively.

Experiment Two was conducted in similar fashion but used a universal remote control as its mediator product. Both the experiments established that participants who had high general and specific prior knowledge of related technologies used significantly more features intuitively and were faster at completing the tasks. Low prior knowledge participants not only used fewer features intuitively, they also needed more assistance in completing the tasks.
Based on the outcome of the first two experiments, the following principles of design for intuitive use were developed.

1. Use familiar symbols and/or words for well-known functions and place them in the expected location for the type of product.
2. Use metaphors and familiar symbols and/or words for less well known functions
3. Make sure that function, location and appearance of a particular feature is consistent among different parts of the product.

These principles were used to re-design the universal remote control for Experiment Three, which tested four different interface designs on the universal remote control to investigate relationships between prior knowledge, intuitive use, and appearance and location of a feature on a product. This experiment used 60 participants across three age groups: 18 to 29, 30 to 39 and 40+ years. Results from this experiment established that the appearance of a feature, rather than its location, is important for correct and speedy use of a product interface. This experiment also revealed differences between the age groups. The older age group, 40+ years, took more time to complete the task and also used the product less intuitively compared with the younger groups.

Based on the outcome of the third experiment, Blacker refined the earlier principles of intuitive use and suggests the following three principles to help designers develop interfaces that are intuitive to use (Blackler, Popovic, & Mahar, 2007):

*Principle 1: Use familiar features from the same domain*
Use familiar symbols and/or words for well-known functions, arrange them in a familiar or expected layout and match user expectations in terms of function

*Principle 2: Transfer familiar things from other domains*
Use metaphors and things that are familiar to users to make less well-known
functions obvious. This principle makes something that is completely new familiar by relating it to something already existing.

**Principle 3: Redundancy and internal consistency.**

Redundancy involves use of tactics such as providing both visual and audible feedback, and both symbols and written labels, to provide more options for interface control recognition. Internal consistency relates to the increase of consistency of function, location and appearance of features across and within different parts of the product, or across and within the different stages of product use.

Based on these three principles a continuum of intuitive interaction was developed. Figure 2.2 illustrates how the three principles relate to the continuum of intuitive interaction.

![Figure 2.2: Intuitive interaction continuum (Blackler, 2008)](image)

Based on this intuitive interaction continuum framework, Blacker also suggests a conceptual tool for applying intuitive interaction principles during the design process. This design tool has different entry and exit points based on the complexity of interaction being designed. This iterative process has two dimensions: one represents the ‘intuitive interaction continuum’ model; and the other addresses function, appearance and location of the interface (Blackler & Hurtienne, 2007, pp. 42-43).
Similarly, Hurtienne and Blessing (2007) propose a continuum of knowledge sources as a means of understanding various sources of prior knowledge. They classify the knowledge sources along a continuum from *innate knowledge* acquired at birth and hardwired into the brain, to *sensorimotor knowledge* acquired throughout life from interaction with the physical world, to *cultural knowledge* acquired in the cultural context, to *expertise knowledge* which is specialist knowledge acquired in one’s profession.

![Figure 2.3: Continuum of knowledge sources (Hurtienne & Langdon, 2009)](image)

The top three sources of knowledge - sensorimotor, culture and expertise - might involve specialist knowledge about using respective tools and technologies. For example, the cultural level might involve tools and technologies shared by many people such as mobile phones for communication. Similarly, at the expert level, a doctor might use a profession-specific tool such as a Sphygmomanometer. The first and lowest level in the knowledge framework is innate knowledge. This knowledge is acquired at birth and represents behaviour drawn upon from reflexes and instincts.

As one moves from the top to the bottom of the continuum, the frequency of encoding and retrieval of knowledge increases. At the top, where there is a
higher degree of specialisation, the number of users sharing common knowledge is potentially small. At the bottom, innate level, almost all users share common knowledge.

Based on the continuum of knowledge, Hurtienne and Blessing (2007) propose image schema theory as the most promising candidate for facilitating intuitive use: ‘An image schema is a recurring, dynamic pattern of perceptual interactions and motor programs that gives coherence and structure to our experiences’ (Johnson, 1987). Image schema can be placed on the sensorimotor level of the continuum of knowledge. For example, the UP-DOWN schema originated from thousands of perceptions and activities one experiences every day, such as a tree growing, water filling a tub, climbing up a stair, falling down. People make use of these schemas through metaphors to make sense of new experiences; for example, ‘increase’ is up, ‘reduce’ is down. These schema are deeply embedded in the human subconscious. Hurtienne (2007) suggests that the characteristics of image schema can be used effectively to develop interactions that are intuitive in nature. For example, moving a slider up on a control increases volume and moving it down decreases it. The research team identified 30 to 40 such schemas to be used as the basic patterns for developing interactions. These patterns are documented in an image schema catalogue called ‘ISCAT’ (Image Schema CATalogue).

Hurtienne (2009) conducted seven experiments in total to test and validate image schema and their metaphorical extensions for developing intuitive interfaces. Like Blackler (2008), he has developed three measures to evaluate subconscious use of prior knowledge as evidence for intuitive use. However, it is acknowledged that it is extremely difficult to prove the subconscious application of prior knowledge. In practice, operationalised subconscious use of prior knowledge can be gauged in terms of mental efficiency (response times controlled for non-mental processes) supported by effectiveness (errors) and satisfaction (suitability judgements).
Based on these studies, Hurtienne concludes that image schema and their metaphorical extensions could be used in design interfaces that are intuitive to use. However, he highlights that most of these studies were conducted using low-fidelity prototypes and interfaces were assessed for intuitive use based on the satisfaction of the users. To use the other two measures of intuitive use, ‘effectiveness’ and ‘mental efficiency’, it is essential to use high-fidelity prototypes (Hurtienne, 2009).

Both Blackler’s and Hurtienne’s approaches have some advantages and disadvantages. The ISCAT (Hurtienne & Blessing, 2007) approach is much simpler and more resource-efficient, but limited by the scope of an identified number of patterns in the catalogue. Furthermore, once the scope of this approach is extended, interpretation of metaphorical extension might become more culturally sensitive and rely more on users’ domain-specific prior knowledge. Blackler’s design framework for developing intuitive interaction is very comprehensive but uses a traditional top down approach to designing.

To effectively use both these frameworks designers need a clear understanding of domain-specific prior knowledge of the user. As no two individuals would share the exact same knowledge and experiences, this exercise in identifying shared knowledge of a target user group becomes difficult (Spool, 2005). As one moves to higher levels in the knowledge continuum, the exercise becomes especially more time consuming and expensive. Furthermore, although designers have found Blackler’s conceptual tool useful for designing interfaces that are intuitive to use, they have also reported that the tool itself is difficult or non-intuitive to use (Blackler, Popovic, & Mahar, 2007). Some of the reasons for designers’ problems with using these tools or methods are discussed under Section 2.6. Overall, in their present forms, both approaches are complex, and do not yet provide tools to investigate prior knowledge of the target users.
2.3.2 Limitations of intuitive interaction studies

One of the biggest limitations of these studies was the subjective nature of coding intuitive uses. Intuitive use is a subconscious cognitive process, yet the protocol used for coding intuitive use does not provide an objective way to capture subconscious cognitive process. Blackler (2008) codes intuitive use based on observable characteristics such as quick and certainty of use, lack of reasoning (verbalisation or lack of it), and observation of expectation of a feature's function. However, most of these coding strategies present problems when a study involves a wide range of participants with varying ages and sensorimotor capabilities. Younger people, for example, are faster compared to older people. Furthermore, while very old people tend to stop delivering concurrent verbal protocol when the task gets difficult, lack of verbalisation is one of the characteristics of intuitive use in younger users.

Some of these limitations were also observed by a recent study by O’Brien (2010). O’Brien (2010, p. 19) notes that coding intuitive use based on the level of verbalisation could be problematic as there could be many other reasons for the participants' level of verbalisation; for example, they may have forgotten to do so or they may have been distracted by the task. Similarly, while Hurtienne (2009) used efficiency (time on task) and self-evaluation of participants to measure intuitive uses, he also acknowledged that, as of the time of his study there were no proven methods for measuring subconscious use of prior knowledge, a primary indicator of intuitive use (Hurtienne, 2009).

Blackler and Hurtienne, however, both used mix methods to measure intuitive uses in their studies to minimise the possibilities of inaccurate coding. Although none of these methods are entirely objective, and as Hurtienne (2009) has noted, there is currently a lack of proven alternative methods for measuring intuitive use. Therefore, this study used measures suggested by Blackler (2008), as her study is one of the few that used a very systematic method to measure intuitive use (O’Brien, 2010).
2.4 Prior experience

Prior experience with technology is a strong predictor of performance for a variety of computer-based tasks (Czaja, Sharit, Ownby, Roth, & Nair, 2001); the more experience a user has with related technology the faster they will learn to use new technology (Lewis et al., 2008). As discussed in the previous sections, prior experience or familiarity is also the backbone of intuitive interaction (Blackler, 2008; Blackler, Popovic, et al., 2010; Hurtienne et al., 2008). Moreover, literature on interaction design and usability stresses the need to design products based on users’ experience, familiarity, and prior knowledge (Preece, Rogers, & Sharp, 2002). Also, interactions that exploit a user’s prior knowledge are significantly faster and are less prone to errors (Langdon, Lewis, & Clarkson, 2007; Lewis et al., 2008; O’Brien, 2010).

Although technology prior experience is absolutely critical for intuitive use of technological products, the concept of technology experience is ill-defined and used inconsistently across studies (Hurtienne, Horn, & Langdon, 2010; Lawry, 2012). Lawry (2012) argues that current research literature in this area uses the terms ‘prior experience’ and ‘prior knowledge’ interchangeably and suggests a proper distinction should be made between these terms to minimise subjective interpretations. He further suggests that prior experience can be defined as experiences that an individual accumulates over time, and that prior knowledge is applicable knowledge that an individual constructs based on a collection of past experiences. On the other hand, this confusion with definition of the term could be simply a result of semantics or the context of use. ‘Experience’, when used as a noun, means, ‘skill’ or ‘knowledge’; when it is used as a verb, it means ‘to under go or come across a situation’ (Oxford University Press, 2011). In this study, prior experience and prior knowledge are used interchangeably based on the context of the literature referenced.
However, there is indeed a need for a common understanding and operationalisation of experience with technology. Hurtienne et al (2010), after reviewing different technology prior experience operationalisations, found three core components of operationalisation of ‘technology prior experience’: exposure to technology, competence with the technology, and the subjective feeling of the technology. The exposure and competence with technology components are further split into the following sub-components: exposure/competence with the specific product, exposure/competence with other but similar types of products, and exposure/competence with a broad range of different types of products. Furthermore, Hurtienne et al’s (2010) study suggests that, to predict usability of a product, it is important to measure both exposure and competence with specific products and related technological products. This is also supported by another recent study by O’Brien (2010) that reports a lack of predictability of exposure to technology in usability of novel technological products, and suggests that competence with technology should be considered. In summary, both technology prior experience and competence with related technologies are crucial for using a product with ease.

2.4.1 Investigation of technology prior experience

Section 2.3.1 discussed two approaches that describe the importance of prior knowledge in designing interfaces for intuitive to use. However, these approaches do not exactly elaborate on methods for eliciting a user’s domain-specific knowledge. Although Blacker (2008) has developed the Technology Familiarity Questionnaire for her research, it is limited in capturing users’ exposure to the domain-specific technology and its intensity of use (Lawry, 2012). Related research has applied similar self-evaluating questionnaires to gauge participants’ prior knowledge (Kang & Yoon, 2008; Langdon, Lewis, & Clarkson, 2010; O’Brien et al., 2010; Wilkinson, Langdon, & Clarkson, 2010). While these questionnaires were all adequate in meeting their respective research objectives, they may not serve
as a universal tool (Lawry, 2012). This problem is mostly due to the nature of self-evaluating tools.

The realisation of the limitation of self-evaluation tools is not new; anthropologists and social scientists have found that what people say and what they actually do can vary significantly (Blomberg & Burell, 2008). This could mean that tools such as questionnaires, interviews or focus groups may not provide reliable insight into information related to the task. To understand the actual behaviour of people rather than self-perception of that behaviour, ethnographic research is essential. Ethnographic research tools use a combination of observation, interviews and participation to gain better insight into users’ behaviour (Lazar, Feng, & Hochheiser, 2010).

There are many methods in the field of human computer interaction that use ethnography as an investigative tool. One of the user research methods that are based on the ethnography is contextual inquiry or contextual task analysis. In this method, the researcher observes and analyses the task procedures that a user follows to reach a goal (Lazar et al., 2010). This observation is usually followed by an interview to understand the rationale behind a user’s actions while performing the task. This tool is very effective in gaining an insight into a user’s competence with product features.

Another popular usability method that is often used to understand users’ prior knowledge is pluralistic walkthroughs during early product development state. Pluralistic walkthrough is a usability method that includes target users and the product design team in the development process (Bias, 1994). It is used to identify user expectations of product functionality and interface structure while still in the development stage. Boards representing interface display and controls are used to evaluate the usability of the system. The outcome helps the design team to observe users projecting their prior knowledge in shaping the product interface.

Recent research on investigating prior knowledge of target users follows a method that is similar to the methods described above. The author calls it
the ‘primed task recall method’ (Lawry, 2012). Primed task recall basically follows three steps: participants are shown a list of tasks that need to be performed, are asked to describe how they will accomplish the tasks, and are allowed to actually use the product to complete the tasks. The observation of this procedure provides both the participants’ knowledge of the product features and their competence in using them. However, currently, this tool is still under development.

In summary, available literature on the investigation of domain-specific prior exposure and competence are roughly based on the self-evaluation, ethnography and participatory research methods. Although there appears to be no one universal investigation tool, using a combination of these tools appropriately should provide an adequate picture of users’ domain-specific knowledge.

### 2.5 Intuitive use is not infallible

An intuitive interface is most beneficial for first, early and intermittent use (Blackler, 2006, 2008; Hurtienne & Blessing, 2007). The biggest advantage of an intuitive interface is that it does not require explicit learning of a system to use. However, intuitive interaction is not embedded in the interface of a product; it is something that results from the user-product relationship. In other words, an interface that appears intuitive to use for one segment of users may not be so for others who come from a different background (Marsh & Setchi, 2008).

Most researchers agree that the intuitive process is often correct but is not infallible (Bastick, 2003). Intuitive interaction, by definition, does not necessarily produce desirable results in every instance. There are times when people encounter situations that appear very similar to their past experiences, but in reality, they are not. In these situations intuition may lead to incorrect actions, resulting in errors. Of course, these errors will eventually contribute to the experience, which will enrich the person for future encounters (Bagnall, 2007). If a person does not have experience in
the same field, they tend to transfer knowledge from other experiences closely matching the present situation. However, when a person transfers knowledge from irrelevant experiences or has insufficient knowledge, the outcome is prone to errors (Bastick, 2003).

To intuit, a person should be in stress free condition, as stressful and oppressive environmental conditions are not conducive to intuitive thinking (Bastick, 2003). Then again, according to Klein (2001) and Bastick (2003), people are more likely to use intuition when there is greater time pressure, they lack experience in that field/situation, conditions are dynamic, or goals are ill-defined. In other words, people tend to rely on intuition for decision making under uncertain, unfamiliar and stressful situations. Since most of these conditions are a product of incomplete knowledge, they may contribute to incorrect intuition (Bastick, 2003). However, most of these observations are made while examining intuitive cognitive processes in the context of decision-making.

In spite of these uncertainties outlined above, intuitive interaction is still a promising approach to make a product interface more usable for older users with age-related cognitive deficiencies that hampers the acquisition of new knowledge. The biggest advantage of a product that is intuitive to use is that it does not require learning and by its very nature looks familiar to target users. However, the potential impact of stressful conditions on intuiting needs some attention.

2.6 Designing and design methods

Blackler et al. (2007) report that designers find their proposed conceptual tool for designing for intuitive use difficult to use and overly prescriptive. As this current study also involves developing an approach for designing interfaces that are intuitive to use, this section briefly reviews the relevant literature that looks at the reasons why existing tools/methods are not adequate in meeting current requirements. Moreover, it is important to note that a basic understanding of design activity and how designers work
contributes to making useful suggestions for the strategies or tools that can help designers to develop intuitive interfaces for older adults.

2.6.1 Design and design problems

Designing is defined as an activity that should involve preparation or formation of a prescription or model for an artefact in advance of its embodiment (Archer, 1984a; Cross, 2008). In other words, designing involves a plan or model for an artefact before it is built or made, and the resulting outcome/solution is seen to be novel.

It is generally accepted that a design problem is ill-structured (Simon, 1973; Visser, 2009). Furthermore, Rittel and Webber (1984) refer to design problems as ‘wicked’. Wicked problems do not have definitive formulation; the problem and solution are linked in such a way that to define the problem, a designer has to attempt a solution (Cross, 2008; Lloyd & Scott, 1994). Another characteristic of design problems is that there is no one definitive solution that can be termed as correct (Visser, 2009). An ill-defined problem has several acceptable solutions, and designers settle for the one that they deem the most satisfactory (Simon, 1975).

2.6.2 Design methods

Over time, a large number of design methods or models have been published and are usually grouped under the term ‘design methods’ (Cross, 2008). It seems that there are as many design methods as there have been authors and no two authors have agreed on a method (Gedenryd, 1998). Some models are descriptive, simply describing the sequence of steps in designing, and some are prescriptive, suggesting systematic processes to follow. The intention of prescriptive models is to bring rational procedure into the design process. Design methods are usually described in the literature through block diagrams, matrices, or network diagrams with boxes and arrows that closely resemble the flow chart of a computer programme (Jones, 1992).
After reviewing a large number of design methods variants, Gedenryd (1998) suggests that there is an underlying pattern that shows most of them share similar ideas. He examined a few prototypical methods and summarised their essence into four fundamental principles that make up the core of design method thinking as seen in (Table 2.1) below.

Table 2.1: Core ideas behind design methods (Gedenryd, 1998).

<table>
<thead>
<tr>
<th>Idea</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation</td>
<td>Design process is separated into distinct phases, with each phase or activity being performed in isolation from the other.</td>
</tr>
<tr>
<td>Logical order</td>
<td>Specification of explicit order in which different activities are to be performed</td>
</tr>
<tr>
<td>Planning</td>
<td>Pre-specification or strategy for performing activates in an orderly manner within a phase</td>
</tr>
<tr>
<td>Product-process symmetry</td>
<td>Plan is organised in an order that makes the design process reflect the structure and the sub-components of the resulting product</td>
</tr>
</tbody>
</table>

The intention of design methods is to bring an amount of control in to the increasingly complex design and manufacturing process of products, to help in making sure that there are no costly mistakes due to oversight or omissions (Cross, 2008; Jones, 1984). However, many designers do not apply design methods because at times they are too formal, rigid and systematic (Cross, 2008). There is a good reason behind this mistrust: design methods do not work (Gedenryd, 1998). A comment made by Alexander (1984), in an interview on design methods, succinctly captures this point of view: ‘...my feeling about methodology is that there are certain mundane problems which it has solved – and I mean really incredibly mundane’ (p. 312). Furthermore, Alexander (1984) comments on future directions in design methodology, stating that: ‘Until those people who talk about design methods are actually engaged in the problem of creating
buildings and actually trying to create buildings, I wouldn’t give a penny for their efforts’ (p. 313). These and similar observations made on design methods have shifted the focus from prescriptive models of design to a greater consideration of design as a cognitive activity (Visser, 2009).

### 2.6.3 Cognitive process of designers

Designerly ways of ‘knowing’ and communicating differ from scientific approaches (Archer, 1984b). In an interesting study, Lawson (2006) compared the way scientists and designers find solutions to a problem. He found that scientists use a strategy where they systematically analyse a problem to find an optimal solution. In contrast, designers tend to explore the problem cursorily, and proceed to suggest a variety of solutions, and settle for one that is most satisfactory. In other words, scientists use problem-focused strategies and designers use solution-focused strategies (Cross, 2008).

Many cognitive studies on design observe that reuse of knowledge (from earlier relevant design experiences) through analogical reasoning is a central approach in design (Bhatta & Goel, 1997; Casakin & Goldschmidt, 1999; Visser, 1996, 2009). Klein & Brezovic (1986), in their research on the design process, found that designers seldom use systematic decision making strategies during practice. Visser (2009) extends this notion by stating that design activity is mostly opportunistically organised. In other words, designers approach a design problem in a non-systematic and multi-directional way (could be top-down, bottom-up, in breadth or in depth). The direction they take is based on their subject knowledge, information at hand, their representation of design problems and the state of their design in progress.

Experienced designers solve design problems primarily based on their past experiences (i.e. intuitively). During the initial stage of a design process, they try to find earlier solutions that are similar to the present problem, proceed to fine-tune them and see if they could help them in their present situation.
A study by Kim & Yoon (2005) on the cognitive process of interface designers found that designers base initial design concepts on their prior experience, reusing elements from earlier designs that are relevant to the current task. They adopt opportunistic or bi-directional design processes when addressing issues in design problems that closely match their prior knowledge. Visser (1990, 1996) suggests that this opportunistic design process is a result of designers cognitively selecting the most economical actions in solving design problems. She also suggests that when an activity is opportunistically organised, any system/method that imposes a hierarchical or structured design process will severely constrain the designer (Visser, 1990).

2.6.4 Design strategies

Most of the prescriptive design methods are not able to meet their intended objectives because designers seldom use systematic decision-making strategies during practice (Klein & Brezovic, 1986; Visser, 2009). In other words, suggesting any rigid external structure or rules may not produce the desired design outcome. This is the probable reason why most recent tools, frameworks and methods do not appear to have made any visible impact on the design research or practice communities.

2.7 Summary

This chapter has discussed the literature on intuitive interaction, prior-experience and methods for developing intuitive interfaces. The basic process of developing intuitive interactions is very simple, involving just two steps: investigating what target users are familiar with, and investigating how to effectively take advantage of users’ familiarity to develop intuitive interactions.

The chapter also discussed in depth two particular methods of developing intuitive interfaces. Although both of these methods were well researched, they have limitations in terms of providing universal tools for investigating
prior knowledge. Other tools for investigating prior knowledge were also discussed. The chapter also discussed at few limitations of interactions that are intuitive to use. Finally, it presented some issues related to developing design methods.

Chapter 3 discusses research on ageing, age-related sensorimotor and cognitive decline and older people's use of technology.
Chapter 3

Older Adults and Use of Technological Products
3.1 Introduction

Research suggests that many older adults have difficulty using contemporary consumer products due to their complexity both in terms of functionality and interface design. Moreover, recent studies have found a strong correlation between age and the time taken to use modern electronic devices (Lewis, Langdon, & Clarkson, 2007). Blackler et al. (2005) have also found that older adults are less likely to use complex devices intuitively, and operate them more slowly.

Use of technological products in older users is a complex issue mediated by technology prior knowledge, cognitive capabilities, technology anxiety, perceived technology self-efficacy and socio-demographic factors (Czaja et al., 2006). This chapter discusses several of these important factors of ageing that influence use of technological products in older adults.

3.2 Sensorimotor function and ageing

Ageing progressively impairs various cognitive skills and sensory-motor abilities. Some abilities decline more markedly than others, and some may remain intact till the late 70s (Mynatt, Essa, & Rogers, 2000; Salthouse, 2010). This decline is not constant and varies widely between individuals (Czaja & Lee, 2007; Gregor, Newell, & Zajicek, 2000). Baltes and Lindenberger (1997) found a strong correlation between visual acuity, auditory pure tone threshold and different measures of intellectual functioning. In other words, degraded sensory impairment implies degraded intellectual functioning (Li & Lindenberger, 2002). However, it is not clear which is the cause, and which is the effect.

3.2.1 Vision

Problems with vision start in the early forties and it deteriorates progressively as people grow older (Fisk, 2004; Fisk et al., 2009). One of the most noticeable declines in vision is the loss of ability to focus on close
objects (presbyopia), which is mostly caused by reduced reactivity of the lens. Among many others, some common ageing-related vision problems include: decline in visual acuity (the ability to see fine detail), contrast sensitivity, colour discrimination and detection, and glare sensitivity. Most of these problems are results of clouding of the lens. Reduced reactivity of the pupil over time degrades vision in dim light. Degradation in visual information processing reduces the ability to detect flicker, and creates difficulty in estimating depth and visual searching (Fozard & Gordon-Salant, 2001; Hawthorn, 2000, 2006). While older people seem to cope with age-related vision decline quite well, the middle-aged are more concerned about their vision-related problems (Kosnik, Winslow, Kline, Rasinski, & Sekuler, 1988).

3.2.2 Hearing

Decline in hearing is one of the most frequently noted problems of the ageing process. Older people with mild to moderate hearing problems have reported difficulties with speech comprehension especially under stressful conditions (Corso, 1977). Hearing declines with age, and around 20% of those aged between 45 and 54 have some hearing impairment. This rises to 75% for those between 75 and 79 years of age (Hawthorn, 2000). The most noticeable decline in hearing with age is an inability to detect tones over 2500 Hz (Schleber, 1992). Age-related cognitive decline further contributes to deterioration in speech understanding, particularly in difficult listening conditions. However, older people compensate for most of these declines by using their knowledge of language and available contextual cues (Fozard & Gordon-Salant, 2001).

3.2.3 Motor control

Response time on complex motor tasks lengthens with ageing. Proprioception, the ability to perceive (without visual monitoring) the position of body segments in space, also declines. There is a lack of substantial research data on the learning of new motor skills in older adults,
but the available information suggests that they do not learn as well as the young (Ketcham & Stelmach, 2001). Overall, fundamental neural events become slower for all cognitive and motor functions. Slowing of movement is evident, ability to reach and grasp diminishes, and older adults have difficulty in coping with the demands of repetitive speed, such as double clicking a mouse (Kroemer, 2006).

However, ageing does not diminish performance on all types of tasks. There is little effect of ageing on older adults’ ability to perform single, discrete actions that are planned in advance of the stimulus. On the other hand, negative effects of ageing become apparent when the task is complex, unfamiliar and uninteresting (Vercruyssen, 1997). Many researchers have found that older people are more concerned with accuracy than speed. They tend to slow down their movements to attain accuracy in tasks related to movement. This also explains why older people are slower than younger people (Goggin & Meeuwsen, 1992; Goggin & Stelmach, 1990; Larish & Stelmach, 1982).

In summary, ageing slows down visual processing and motor response speeds. Older people tend to compensate for this by trading speed for accuracy. However, expert skills acquired over a long period of time are unaffected. Older people also find it difficult to hear high-pitched sounds and to make sense of speech in a noisy environment.

### 3.3 Ageing and cognitive processing

It is generally agreed that old age causes a decline in cognitive skills which, in turn, affects the learning of new information. Some research points out that this decline is not global, as not all skills are affected by ageing (Bäckman, Small, & Wahlin, 2001). For example, crystallised memory (such as vocabulary) remains constant or improves with age. Fluid intelligence (such as problem-solving, learning, and pattern recognition abilities), on the other hand, declines markedly. Other researchers have shown that age-related memory impairment is a result of damage to some parts of the brain,
such as the hippocampus (Marighetto et al., 1999) or the frontal lobe (Rabbitt, 1997). These changes take place at a sub-clinical level and are part of the normal processes of ageing.

However, the brain compensates for this diffuse neuron loss by recruiting other unaffected parts of the brain. This recruitment is not universal, as it is only evident in high performing older people; lower performing adult brains do not show this flexibility (Cabeza, Anderson, Locantore, & McIntosh, 2002). This adaptability of the brain gives credence to the maxim ‘use it or lose it’ for successful ageing (Hawthorn, 2006).

To summarise, Salthouse (2004) suggests that cognitive processing speed affects almost all measures of performance in the aged. However, recent research challenges the idea that cognitive slowing is global and suggests that it depends more on the task being performed (Ratcliff, Thapar, & McKoon, 2003).

### 3.4 Memory and ageing

Memory is more than just a simple storage facility: it lies at the core of thinking and learning (Howard & Howard, 1997). It is also a very complex phenomenon, which is not yet completely understood. In general, literature suggests overall decline in memory performance with ageing (Howard & Howard, 1997; Old & Naveh-Benjamin, 2008). However, this decline is not linear and there is ample evidence that age-related memory impairment varies greatly between individuals.

Memory is broadly categorised into five major systems. Of these, four are particularly important for research that involves older people and interaction design: 1) working memory, 2) episodic memory, 3) semantic memory, and 4) procedural memory (Fisk & Rogers, 1997). Episodic, semantic and procedural memory systems all deal with long term storage of information and are hence clubbed under long-term memory. Working memory, on the other hand involves holding a limited amount of
information for a limited time for processing. Of these four memory systems, working and episodic memory are most affected by age-related degradation, while semantic and procedural memory are relatively un-affected (Howard & Howard, 1997).

Episodic memory deals with the ability to retain and consciously recollect information that is acquired at a particular place and time. Extensive literature on ageing shows that episodic memory performance declines with age (Fisk & Rogers, 1997). Episodic memory deficits lead to older adults’ difficulty in recalling events and faces. Source memory, another important aspect of episodic remembering, is also affected by ageing (Bäckman et al., 2001). Source memory refers to the specific conditions and context that was present when the memory was acquired. Its deficit leads to difficulty in recollecting where knowledge was acquired and can also lead to false memories resulting from a confusion of imagined and real experiences (Howard & Howard, 1997).

Semantic memory deals with facts about the world and knowledge of language, including the meanings of words, concepts and symbols and their associations. This system of memory, in general, is not affected by age. However, age-related deficit in information access makes the retrieval process slower (Bäckman et al., 2001). Both episodic and semantic memories are termed as ‘explicit’ or ‘declarative’ knowledge as they are involved with information, such as knowing that or remembering something.

Procedural memory is non-declarative, or implicit, knowledge. Procedural knowledge is not directly accessible to consciousness and its presence can only be demonstrated in action (e.g. driving or walking). Ageing only affects the speed of acquiring this knowledge. However, once the knowledge is acquired, there is no significant difference between the old and the young (Fisk & Rogers, 1997). Priming, like procedural memory, is referred to as ‘implicit’ and refers to the facilitation of the processing of a stimulus as a result of a recent encounter with the same or related stimulus (Schacter,
1987). In general, ageing-related deficits in implicit memory are relatively small.

Working memory operation can be broadly placed into two functional categories: one that deals with holding information in consciousness, and the other that is involved in processing this information while keeping task-relevant goals and strategies at a conscious level. In general, ageing has little impact on the amount of information held in consciousness. However, the information processing function deteriorates with ageing. Moreover, age-related working memory deficiencies become more prominent as the complexity of cognitive tasks increases, such as when a task requires the simultaneous storage and processing of information (Bäckman et al., 2001). However, manifestation of working memory deficiencies in ageing can be mediated by coping mechanisms adopted by older individuals (Brébion, Smith, & Ehrlich, 1997), especially when the task is simple.

One of the dominant theories of working memory was proposed by Baddeley and Hitch (1974). According to this theory working memory is not a unitary system; rather, it is a multiple component system that emphasises functional importance rather than just storage. This system (Figure 3.1 below) has three components (later expanded to four): the central executive (a limited capacity attentional controller or processing component); aided by subsystems, the phonological loop; the visuospatial sketchpad; and the most recent addition the episodic buffer (Baddeley, 2002).
The central executive is engaged in reasoning, decision-making and coordinating the activities of other subsidiary systems. It also plays a critical role in storing, coordinating and updating information in the long-term memory. Age related decline in working memory is mostly due to slowing down of the central executive component (Salthouse & Babcock, 1991).

Phonological loop is a temporary store for phonological information. Similarly, visuospatial sketchpad is a temporary store for visual and spatial information. The function of episodic buffer is to combine information from phonological loop, visuospatial sketchpad and long-term memory.

These four important memory systems give a clearer understanding of prior experience in the context of this study. Use of product interfaces involves both procedural (implicit, non-declarative) knowledge for knowing how to do something, and semantic (explicit, declarative) knowledge for understanding and interpreting a product’s interface features and functions. This also explains the findings of recent research that suggests that the self-
evaluative tools used to measure participants’ prior experience of the participants may not provide complete data (Lawry, 2012; O’Brien, 2010). A self-evaluative tool, because of its very nature is not effective in capturing non-declarative or procedural knowledge, and the central executive function, which plays a critical role in acquiring, storing and retrieving knowledge from long-term memory. Recent research on intuitive interaction (Blackler, Mahar, & Popovic, 2010; Reddy, Blackler, Popovic, & Mahar, 2010) also shows that, more than chronological age, domain-specific prior experience and central executive function is important for fast, intuitive and error-free use of product interfaces.

### 3.5 Attention and ageing

A variety of behavioural inefficiencies are attributed to age-related changes in attention. In general, attentional capacity is conceptualised as a limited supply of energy that supports cognitive processing. The central executive is thought to play a key role in directing and controlling attention (Baddeley, 2002; D.A. Norman & Shallice, 2000). ‘Attention’ is a term used to describe a variety of cognitive functions, and is usually defined in literature by its various functions. For example, ‘selective-attention’ is processing of one source of information at the expense of another; ‘divided-attention’ is simultaneous processing of two or more sources of information; ‘switching-attention’ is alternately processing one source then another; and ‘sustained-attention’ is maintaining a consistent focus on one source (McDowd & Shaw, 2000). However, these descriptions of different functions of attention are used to organise and present information in research literature. In reality, there are no clear boundaries between various functions of attention, a complex cognitive task, at a time, may employs more than one attentional function for its processing.

Age-related decline is most noticeable in selective-attention and divided-attention functions. Selective-attention, the ability to attend selectively to relevant information and ignore irrelevant information, is considered a
prerequisite for extracting relevant information from distracting or irrelevant detail (Kramer & Madden, 2008; McDowd & Shaw, 2000). Some researchers argue that age-related decline in selective-attention is due to the inability of older people to inhibit task irrelevant information (Hasher & Zacks, 1988; Morrison, 2005). This inability to suppress irrelevant information is also known to affect divided-attention in older adults.

Ageing shows one of the clearest declines in the ability of older people to divide their attention between two sources of information, to attend to one source of information while holding onto another, and to hold and respond to both the sources (Craik, 1977; McDowd & Craik, 1988). For example, when driving a car, divided-attention ability involves scanning the road for other vehicles and pedestrians and, at the same time, performing other unrelated tasks such as taking directions from a global position satellite navigation system or talking on a mobile phone. However, age-related decline in divided-attention is only apparent when the task is complex, and it is not evident when performing automatic tasks (Kramer & Madden, 2008). For example, performing a familiar divided-attention task such as driving a car and keeping it in the centre of the road while maintaining a set distance from other vehicles on the road, is not affected by ageing. However, when this familiar task is changed – as in a study conducted by Korteling (1994) where the polarity of the accelerator pedal was reversed so that faster became up - the divided-attention deficit is more prominent in older people. Interestingly, Korteling found that when the accelerator pedal polarity was reversed, the older people had difficulty with steering the car rather than the accelerator pedal. It was concluded that the complex task had overwhelmed cognitive resources, leaving little capacity to deal with the second, less complex task. Some researchers argue that this deficit in older people is a result of overall task complexity, rather than of divided attention per se (McDowd & Craik, 1988).
3.6 Ageing and technology adoption

A common belief is that older people are unwilling or reluctant to use contemporary technologies. Contrary to this assumption, available data suggests that older people are, in general, open to the use of technology (Czaja & Lee, 2007). However, they exhibit more anxiety about their ability and confidence in using these systems successfully; this in turn, hampers their adoption of new technologies (Marquié, Jourdan-Boddaert, & Huet, 2002).

The usage of new technologies by the present generation of older people is low, especially by those who are less educated and come from a lower income bracket (Tacken, Marcellini, Mollenkopf, Ruoppila, & Széman, 2005). Tacken et al. (2005) also suggest that age-related cognitive decline is a major contributing factor to the low use of technology by the older people. However, some researchers view new technology adoption by older people from a different perspective, suggesting that the low adoption and use of technology could be viewed more as the reaction of older people to generational changes in technology rather than to age-related declines. Furthermore, the way people handle current technology could be based on the kind of technology they were exposed to during their formative years from age 10-25 years (Docampo Rama et al., 2001). People who have experienced certain technology of consumer products in their formative years show similar technology usage behaviour in their later life (Sackmann & Weymann, 1994). This group of people can be identified as belonging to a certain 'technological generation' (Docampo Rama et al., 2001; Lim, 2009).

Docampo Rama (2001) and Czaja (2006) suggest that a group of people belonging to a certain technological generation will find using the devices from another generation to be very difficult. For example, the group who belong to the ‘electro-mechanical’ (1950s) generation will find it hard to use devices that are software-driven, such as videophones. However, it should be noted that the evolution of technology is a continuous process and
there are no true boundaries between generations. It is, therefore, possible for people to belong to more than one generation of interface styles. One of the implications of the cohort-specific (people belonging to a certain technology generation group) obsolescence is that as the present younger generation ages, it will have a very different pattern of prior experience with technology.

It is also observed that a digital divide exists for certain segments of the population, such as those belonging to minorities, those who are older and those who are less educated (Czaja et al., 2006). However, adoption of technology is a complex issue that cannot be explained by just socio-economic factors, attitudinal approach, age and education alone. There are other psychological factors, such as self-efficacy and technology anxiety that could influence the attitude of an individual towards technology (Czaja et al., 2006).

3.7 Prior experience and ageing

A recent study investigated effects of the different facets of technology prior experience on the usability of a ticket vending machine on older users (Hurtienne et al., 2010). The facets of technology experience investigated were exposure and competence at different levels of specificity. Exposure to technology is a measure for duration, intensity and diversity of technology use, and competence with technology is a measure for skill and knowledge required to interacting with the product. The levels of specificity can be best explained with the following example: the highest level of specificity would be where the participant had used that particular ticket vending machine; and the lowest level would be their exposure to vending machines and electronics in general. Overall, 58 older adults, with a mean age of 61.72, participated in this study. The outcome of this study suggests that a measure of competence with technology, compared to exposure, might be more predictive of usability of a product in older adults. A much more comprehensive study by O’Brien (2010) also supports Hurtienne et al.’s
(2010) finding. O’Brien (2010) investigated the role of prior experience in the use of technology in users of different ages and experience levels. Her research involved two experiments.

O’Brien’s first experiment was designed to investigate the role of prior knowledge in the use of everyday technologies and the differences in use among various age groups. Overall, 30 participants participated in this experiment. Participants were allocated into two age groups: ten in the 18 to 28 years age group, and twenty in the 65 to 75 year age group. The older age group was further split into two groups of ten each, one with low technology prior experience and the other with higher technology prior experience. Technology prior experience was decided by measuring breadth and depth of experience with representative everyday technologies. All groups reported their use of technologies over a period of 10 consecutive days. Results show that prior experience was often cited as the reason for successful use of technology. The most common approach for resolving problems in technology use was to use a combination of prior experience and the knowledge in the world (affordances). Older people also reported more problems than younger people due to insufficient knowledge.

O’Brien’s second experiment was designed to investigate younger and older adults’ interaction with three everyday technologies. The proceedings were video-recorded to enable assessments of age and experience differences. Overall, 36 participants participated in this study. As in the first experiment, 12 were allocated into the younger group, aged 18 to 28 years, and 24 into the older age group, aged 65 to 75 years. The older age group was further split into a ‘low tech’ and a ‘high tech’ group. All participants completed a technology prior experience, health, and demographic questionnaire. Results showed that participants who had reported higher relevant experience generally performed better. Interestingly, younger participants performed better on all technologies compared with the high-tech older age group. Although the younger group and the high-tech older group shared similar technology experience, the age differences were still significant.
Older group were also more variable in their performance. In other words, older participants with higher technology prior exposure performed much more slowly than younger participants with the same level of technology prior exposure.

Based on her study, O'Brien suggests that, apart from looking at exposure to technology, it would be better to look at technology elements that are specific to the product in use. This study, however, did not look at cognitive age differences. Similarly, other studies found that, although prior experience with related technology improved the performance of older adults, age-related differences in processing speed and memory are still important factors that influence the usability of a product (Blackler, Mahar, et al., 2010; Czaja & Sharit, 1993; Czaja et al., 2001; Reddy et al., 2010).

Researchers at Cambridge University conducted a series of experiments under the ‘inclusive design’ theme that looked at the role of prior experience and cognitive ability on usability of a product (Langdon et al., 2007, 2010; Lewis et al., 2007, 2008). Langdon et al. (2007) report results from a study that examined the relationship between prior experience, cognitive decline and age. Overall, 16 participants, between 23 and 84 years of age, participated in this study. Cognitive testing was done using a web-based Combined Cognitive Scales Intelligence assessment. It reported results in four broad sub-groups: Long-term memory, short term memory, perceptual and reasoning. For prior experience, a questionnaire was used to measure technology experience and frequency of use. Two products were used in the trials: a digital camera and a Ford Puma car. The outcome of this study suggests that, prior experience with related products is a strong predictor of usability of a product. Langdon et al. (2007) also report that combined cognitive score was negatively associated with time on task and errors.

In a more recent study, Langdon et al. (2010) report on two investigations, one using a microwave oven and the other a digital radio. Both these studies used measures similar to their earlier study (Langdon et al., 2007). The first
study, using the microwave involved 19 participants aged between 21 and 85. The result from this study suggests that age has more effect on use of the microwave than technology prior experience does. Cognitive capabilities also had a major effect on performance. The second study, with digital radios, used overall 42 participants in all, split into two age groups: 40 to 60 years olds, and 60 to 80 year olds. They were further split into three sub groups based on their score on the cognitive capabilities assessment. Since technology prior experience was not controlled in their earlier study, it was not clear if the performance differences were due to prior experience or cognitive abilities. For the study with the digital radio, it was decided to train all the participants in using a common base product to a criterion of low errors. For actual trials they used two different but functionally similar products. The result from this study shows a significant correlation of age and cognitive capability with time to complete the task. Learning of interfaces, measured as time on task, is also dependent on age and cognitive ability. Controlling technology prior experience did not bridge the age differences. It was concluded that although training helped participants build the necessary prior knowledge; actual transfer of this knowledge in using a product effectively was dependent on age and cognitive ability.

However, most of these studies discussed above are done with relatively small sample sizes (Langdon et al., 2010), and the measures used for the cognitive abilities appears to be a very generic web based questionnaire. Some recent research also questions reliability of technology prior experience measure used in these Cambridge University studies (Lawry, 2012).

Similar to the above research, another recent study (that also used microwave oven as its mediator product) had 32 participants across three age groups: 18 to 39, 40 to 56 and 57+ (Blackler, Mahar, et al., 2010; Blackler, Popovic, & Mahar, 2009). Two version of microwave were used: a commercial oven and a prototype running on touch screen. The second microwave was redesigned to be more intuitive to use than the existing
commercial oven. This study used measures to capture the technology familiarity and working memory capacity of the participants. The result from this study shows that central executive function has an effect on time to complete the task and intuitive use. Thus, it was concluded that central executive function has more impact than chronological age on use of interface. However, the research does not include old age (65+) group in reporting the results.

Another study, on the use of small multi-functional devices, found that both age and prior knowledge are important factors that influence use of complex product interfaces (Kang & Yoon, 2008). However, when the subjects were matched for prior knowledge, there were no significant age differences in task completion between young and old. Based on these results Kang and Yoon (2008) conclude that, rather than chronological age, prior knowledge should be kept in focus when developing interfaces for older people. However, this study looked at only two age groups: young (21 to 29) and, older (46 to 59).

The older age group in Kang and Yoon (2008) was more towards middle-age than old age. Recent research suggests significant age differences start showing only from age 65 onwards (Lawry, 2012; Reddy, Blackler, Popovic, & Mahar, 2011). Furthermore, Lawry (2012) found that younger people (<45 years), in general, have significantly higher levels of technology familiarity (exposure and competence) with contemporary products when compared to older adults. On the other hand, technology familiarity in middle-aged people (45-60 years) is more constrained to products that they use. In other words, middle-aged group’s exposure and competence with technology is confined to products that they own or use in the context of their work. In effect, when the young and middle-age groups are matched for technology prior experience, the age differences are minimal. However, the age differences start to show only when the 60 + year age groups is involved. Lawry (2012) found that old people (60 + years) do not exhibit high levels of familiarity, even with the products that they own and use.
All the literature reviewed here agrees that both domain-specific prior knowledge and cognitive abilities are important for successful use of complex technological product interfaces. However, depending on the sample size, age groups and measures used in a particular study, there appears to be some variation in identifying the most influential factor among prior knowledge, age or cognitive abilities. One of the reasons for these variations could be that all three factors are interrelated.

Prior experience is acquired knowledge, and efficiency in acquiring new experiences is based on existing knowledge. In other words, the greater the knowledge base of a person, the easier it is for them to understand and integrate new knowledge. However, due to generational effect (Section 3.6), older people tend to have a low knowledge base for contemporary technologies (Docampo Rama et al., 2001). Moreover, the knowledge thus acquired, both explicit and implicit, is stored in the long-term memory. Use of prior experiences involves procedural memory (implicit) to recollect the process needed to accomplish a task, and semantic memory (explicit) to understand how a task needs to be performed (Lim, 2009). However, working memory facilitates both acquiring and using of knowledge. As discussed in the Section 3.4, both procedural memory and working memory are affected by the process of ageing. This could be one of the reasons why older people, although they are exposed to relevant technologies, find it difficult to use new technological products intuitively.

In summary, age, cognitive abilities and generational (or cohort) effect are some of the important factors that influence prior knowledge of older people. This prior knowledge, in turn, affects the process of acquiring new knowledge. In other words, all of these factors - prior knowledge, age, and cognitive ability - are interdependent.

**3.8 Anxiety, stress and interaction**

There are many definitions of ‘stress’ or ‘anxiety’. Staal (2004), based on his literature review on stress, cognition and human performance, suggests the
simple and coherent definition first proposed by McGrath (1976) who ‘conceptualized stress as the interaction between three elements: perceived demand, perceived ability to cope, and the perception of the importance of being able to cope with the demand.’ (Staal, 2004, p. 2). In general when a stressful situation or stimulus is perceived as threatening or dangerous an anxiety reaction is elicited (Eysenck, Derakshan, Santos, & Calvo, 2007; Spielberger, 1979). The condition of anxiety is categorised under two states:

1. State anxiety: a temporary form of anxiety related to a particular situation or condition that a person is currently in, for example, test anxiety is a state anxiety.

2. Trait anxiety: a chronic/generalised condition of anxiety (Spielberger, 1979)

Literature on the impact of anxiety on foreign language acquisition adds a new dimension to this discussion. Onwuegbuzie (2000) argues that anxiety exhibited in some individuals during foreign language learning is neither state-anxiety nor trait-anxiety. Rather, it is described as situation-specific anxiety (Horwitz, Horwitz, & Cope, 1986). Moreover, situation-specific anxiety exhibits physiological signs that are similar to state anxiety, such as perspiration, sweaty palms, dry mouth, muscle contraction and tension, and increase in heart rate. Individuals who have the highest levels of situation-specific anxiety tended to have at least one of the following characteristics: older, high academic achievers, have low prior knowledge and low expectations of the overall task-specific skills (Onwuegbuzie, Bailey, & Daley, 1999). Similarly, research on computer-anxious people found that they have lower expectations of performance on task, less computer related experience, low mechanical interest and higher levels of math anxiety (Glass & Knight, 1988). Mahar et al. (1997) also found that computer-anxious people took more time to complete simple computer tasks. However, no relationship was found between error rate and computer anxiety.
Although most research considers computer anxiety as state anxiety, there are a few studies that consider that computer anxiety is based on trait anxiety. These studies argue that positive conditioning can alleviate state anxiety and anxiety that is triggered by specific situations. However, they suggest that extreme computer anxiety is much more complex and that there is no quick-fix solution for resolving it (Beckers, Wicherts, & Schmidt, 2007).

3.8.1 Anxiety and cognitive performance

Many studies have shown that anxiety impairs cognitive functioning by reducing the amount of resources available for task accomplishment (Eysenck & Calvo, 1992; Eysenck & Derakshan, 2011; Eysenck et al., 2007; Wetherell, 2002). People in an anxious state worry about threats to their current goal and try to develop effective strategies to reduce anxiety to achieve the goal. These worrisome thoughts interfere with their attention to task-relevant information, thus competing with cognitive resources available for task-related information processing activities (Eysenck & Calvo, 1992; Eysenck et al., 2007). While this interference of worrisome thoughts with the cognitive process results in the individual taking longer to accomplish a task, it does not necessarily result in more errors (Darke, 1988). A brief look at basic theories of anxiety gives a better understanding of its impact on performance.

Conditions of anxiety and danger produce stressful circumstances that increase physiological arousal. Razmjoj (1996) defines arousal as ‘a hypothetical construct that represents the level of central nervous system activity along a behavioural continuum ranging from sleep to alertness’ (p. 530). An optimal level of arousal is needed to perform any goal-oriented tasks successfully. Researchers have found that there is a strong relationship between the arousal state and a person’s performance. The cornerstone of this anxiety-performance research for many decades has been the inverted-U hypothesis. It originated from a study by Yerkes and Dodson (1908), cited in Hardy and Parfitt (1991). The study, of habit
strength formation in mice under different conditions of punishment stimuli, states that for any given task, optimal performance is achieved at some intermediate level of arousal. In other words, performance is predicted to be poor at low levels of arousal, good at moderate levels, and progressively worse as arousal increases beyond this optimal level.

However, the inverted-U hypothesis has been criticised by many for its lack of rigour in terms of empirical support. Fazey and Hardy (1988) suggest that the inverted-U should not have a symmetrical shape as it is usually presented. They suggest a ‘catastrophe model’ which states that, when performers ‘go over the top’, performance appears to drop dramatically rather than gradually. Once this happens, it is very difficult to achieve even a mediocre level of performance (Hardy & Parfitt, 1991).

Stress impacts both physiological and cognitive functioning of a person. People under stress seem to be less capable of using working memory effectively (Eysenck et al., 2007; Wickens, Lee, Liu, & Becker, 2004). Almost all functions of working memory - processing, storing and rehearsing - are affected by stressful conditions. However, long-term memory is relatively unaffected by these conditions (Wickens et al., 2004). This causes a person under extreme stress to access most available thoughts/actions and to linger on them due to the unavailability of the information processing function of working memory. This could impact effective accomplishment of tasks that involve the central executive, processing component of working memory.

One of the dominant theories from recent research on effects of anxiety on cognitive functions is Attentional Control Theory proposed by Eysenck, et al. (2007). Eysenck, et al. (2007) suggests that anxiety interferes with the cognitive processing centre of the central executive component (Baddeley, 2007), more specifically, attentional control resources of the working memory system (Eysenck & Derakshan, 2011). According to Attentional Control Theory, anxiety adversely effects functioning efficiency of the goal-
directed attentional system and increases the influence of the stimulus-directed attentional system. The goal-directed (top-down processing) attentional system is driven by expectation, prior experience, knowledge and current goal, while the stimulus-driven (bottom-up processing) attentional system is more influenced by unexpected, conspicuous stimuli (Corbetta & Shulman, 2002). In other words, anxiety increases the allocation of attentional resources to threat-related stimuli at the expense of reduced focus on the current goal.

The core assumption of Attentional Control Theory is that anxiety impairs processing efficiency more than performance effectiveness (Eysenck et al., 2007). For example, in a typical usability study, response accuracy is a measure of performance effectiveness and response time is a measure of processing efficiency. In effect, what this theory suggests is that high-anxiety individuals, when compared with low-anxiety individuals, will likely take more time to complete a task; however, they may not necessarily make more errors. In other words, high anxious individuals, under stressful conditions, trade time for accuracy in achieving their goal. They also use increased effort and working memory resources.

Overall, Attentional Control Theory makes various predictions of the effects of anxiety on the goal-directed attentional system. Some of these effects are: a) reduced ability to inhibit incorrect prepotent responses, b) increased susceptibility to distraction, c) impaired performance of secondary tasks in dual-task situations, and d) impaired task-switching performance. (Eysenck et al., 2007, p. 348). On the other hand, some have found that high trait anxious individuals’ performance was comparable to, or even superior to that of low anxious individuals (Hayes, MacLeod, & Hammond, 2009). Eysenck, et al. (2007) suggests that high anxious individuals perform by increasing effort and by using processing resources in a manner that can overcome functional restrictions resulting from worrisome thoughts. Moreover, Attentional Control Theory also contends that when the task is
demanding and task goals are clear, high anxious individuals exhibit a high level of motivation.

### 3.8.2 Older adults and anxiety

Older people can experience more anxiety when it comes to interacting with new technologies (Czaja et al., 2006; Eisma et al., 2004). This may stem from an assumption that it requires considerable effort to learn to use them (Eisma et al., 2003). Ageing also diminishes attention capacity (Craik, 1986), in particular, the ability to inhibit irrelevant information (Hasher & Zacks, 1988) and dual-task performance (Stawski, Sliwinski, & Smyth, 2006). An anxious state interferes with attentional resources available for task-relevant processing activity (Eysenck et al., 2007). With age-related decline in attentional resources, the compensatory mechanisms of using more effort and resources in highly anxious individuals could result in substantial impairment in the performance of older adults. Compounding this, research also suggests that higher anxiety in older adults results in poorer performance on tasks that require divided attentional resources (Hogan, 2003).

On the brighter side, greater anxiety in older adults does not seem to have a significant effect on performance when it is measured as rate of errors in accomplishing a cognitive task. However, older adults did take more time to complete the task compared with younger ones (Delgoulet & Marquié, 2002). On the other hand, this study involved participants from only younger and middle age group of ages, 25 to 49 years.

### 3.9 Perceived self-efficacy

Self-efficacy can be defined as a judgement of ‘how well one can execute courses of action required to deal with prospective situations’ (Bandura, 1982, p. 122). In general, individuals with high perceived self-efficacy are determined and show more effort across a broader range of tasks than people with a lower level of self-efficacy. Bandura (1986) also suggests that
decreased levels of self-efficacy, resulting from low levels of exposure to related stimulus, is also associated with higher levels of anxiety. In other words, self-efficacy beliefs can be influenced and manipulated by many factors. People who are younger and better educated or who have higher levels of crystallised and fluid intelligence have higher computer self-efficacy and lower levels of computer anxiety. These people also tend to use more types of technologies (Czaja et al., 2006).

Computer self-efficacy is an important predictor of general use of technology. People with lower computer self-efficacy may be less likely to engage with technology in general (Bandura, Freeman, & Lightsey, 1999). The effects of computer self-efficacy are mediated by computer anxiety, which, in turn, is linked to breadth of computer experience.

However, some researchers found no significant relationship between experience and computer anxiety (Bozionelos, 2001; Mahar et al., 1997; Wilfong, 2006). Mahar et al. feel that the relationship between computer anxiety and computer experience is much more complex than there simply being a general reduction in anxiety with experience. Furthermore, the research of Bozionelos (2001) and Wilfong (2006) suggests that more than computer experience, low perceived self-efficacy has a significant relationship to computer anxiety.

**3.10 Summary**

Age-related declines in cognitive and sensory-motor function occur slowly and at varied intensities from individual to individual. In other words, compared to the younger population, variability in older adults is significantly larger (Fisk, 2004; Zajicek, 2001). Central executive function, a component of working memory, is most affected by the process of ageing (Bäckman et al., 2001). Central executive also facilitates the acquisition and use of new knowledge; age-related decline in this function not only slows down the acquisition of new knowledge, but also slows the use of existing knowledge on demand (Czaja et al., 2006). This could be one of the reasons...
why some older adults, even with high domain-specific prior knowledge, find it difficult to use contemporary technological products intuitively.

People with low technology self-efficacy exhibit higher levels of technology anxiety and may be less likely to engage with technology in general. This, in turn, may result in low domain-specific technology prior experience. Thus, technology self-efficacy is mediated by technology anxiety; which in turn, is linked to prior experience (Bandura et al., 1999; Czaja et al., 2006).

Chapter 4 discusses the literature that focuses on issues and strategies that could help in the development of interfaces that are more intuitive for older people. It also explores factors that could interfere with intuitive use by older people.
Chapter 4

Facilitating Intuitive Interaction for Older Adults
4.1 Introduction

Chapters 2 and 3 have discussed relevant literature on intuitive interaction frameworks, some methods of investigating prior knowledge of the target users, and issues related to the use of technological products in older users. In summary, the literature review so far has looked at different issues that contribute to older people’s problems with the use of contemporary technological products. It has identified complex interrelationships between the use of technological products in older people and domain-specific prior experience, age, cognitive aspects of ageing, and technology self-efficacy.

Figure 4.1 illustrates this relationship in a succinct format: Domain-specific prior knowledge is the key to intuitive interaction; age-related cognitive decline slows down the acquisitions of new experiences, resulting in older people having low prior experience with contemporary technologies; low prior experience with contemporary technologies, in turn, could result in low perceived technology self-efficacy; low technology self-efficacy could result in technology anxiety; and anxiety could interfere with intuitive use.

![Figure 4.1: Summary of interrelationships from the literature review](image.png)
This chapter focuses on literature that discusses issues and strategies that could help in developing interfaces that are more intuitive for older people. As summarised above, matching prior knowledge of the users to the interface is the key to the perception of intuitiveness of a product interface. One of the reasons older people have trouble using contemporary products intuitively is lack of domain-specific prior knowledge. This chapter discusses research that suggests redundancy as one of the strategies to counter low domain-specific prior knowledge in older people. It also discusses other important issues that could interfere with intuitive use in older people, such as anxiety resulting from interaction with complex interface structure and perceived low self-efficacy.

4.2 **Redundancy in interface design**

Some research hypothesises that redundancy in interfaces might help older people and people with low prior knowledge (Blackler, 2008; Wiedenbeck, 1999). It is also hypothesised that redundancy could help in intuitive use of an interface (Blackler, 2006). ‘Redundancy’ refers to a repetition of content in a different format. The repetition has to be in an alternative physical form; for example, voice and text or picture and text (Wickens et al., 2004). Some interaction design research also suggests that a redundant textual description that restates what is shown in a diagram is very beneficial for novices or learners with no prior knowledge. Furthermore, it could also help in making products more intuitive for people with degraded cognitive ability and people with low prior experience (Gould & Schaefer, 2005).

Redundancy in interface design is often recommended in the user interface field for its effectiveness in message comprehension and reducing the ambiguity of an icons-only interface (Barfield & Furness, 1995; Cooper, Reimann, & Cronin, 2007; Shneiderman & Plaisant, 2005). The use of term icons in the computing field refers to image, picture or symbol that represent a concept (Yvonne, 1989). The ambiguity in interpretation of icons or symbols often results because, as for verbal language, there are no
fixed syntactic and semantic rules that help in interpreting with certainty. For example, the meaning of a word is listed in a dictionary and this helps to establish a common understanding of that word in a given context and language. However, symbols do not yet have a standardised lexicon and are usually interpreted individually based on prior knowledge and the context of use (Yvonne, 1989). On the other hand, the advantages of symbols are that they are much easier to learn and remember because of their strong visual and spatial qualities. Most of the research supports the notion that symbols-only interface are more efficient once users learn the system (Camacho, Steiner, & Berson, 1990; Cooper et al., 2007; Mertens, Koch-Körfges, & Schlick, 2011; Schröder & Ziefle, 2008a, 2008b; Yvonne, 1989).

There is also some research that investigated differences between icon and text or alphanumeric-based interfaces. One such study on use of a purely icon-based menu in mobile devices suggests that participants used a words-only menu much faster and efficiently compared to an icons-only interface (Schröder & Ziefle, 2008b). Overall, 40 participants between ages 21 to 32 years, participated in this study. However, this research also shows that participants found an icons-only interface much easier to learn compared with a text-only interface. Based on this finding, it is suggested that if design is based on user-centric design principles, there is a lot of potential for developing icons-only based interfaces for mobile devices (Schröder & Ziefle, 2008b).

In a related study, the same research team investigated age differences in the speed and accuracy of recognising icons of different levels of complexity and concreteness on mobile devices. Overall, 20 participants in two age groups, 19 to 29 years and 50 to 65 years, participated in this study. They found that, apart from slower reaction times in older participants, there were no differences between ages in terms of their accuracy in recognition of icons of between different levels of complexity and concreteness of icons (Schröder & Ziefle, 2008a).
Similarly, another study investigated the effects of the amount of information presented in textual and iconic displays of information and its impact on how efficiently (in this case) pilots can utilise that data. The study found that, when the data comprised of two to four bits of information, there were no time differences between iconic and textual presentation of the data. However, when the quantity of the data presented was increased beyond eight bits of information, participants performed better on the icon-based display than the text-based display of the information (Steiner & Camacho, 1989).

In a related study, it was reported that, not only were icons better for display of a larger number of interface elements, they also produced faster reaction times in terms of search and selection times (Camacho et al., 1990). Camacho et al. (1990) conclude that this performance advantage of icon-based interfaces is because of their physically more distinct appearance compared with text-based interfaces. In addition, Camacho et al. (1990) also report that that text-based interface produced fewer errors compared to icon-based interface display. They attribute this to the ambiguity that is inherent in the interpretation of purely icon-based information.

One of the more comprehensive studies on this topic investigated the learning of a software application whose interface had three levels; text-only buttons, icons-only buttons, and a fully redundant combination of icons and text buttons (Wiedenbeck, 1999). The objective of this study was to evaluate learning of the system by novice computer users, and also measure their attitude towards the system. In total, 60 people participated in this study and their average age was 21.5 years. Participants were required to work on four blocks of tasks per session, and two sessions were scheduled one week apart. Participants worked on the same tasks in both sessions to measure the learnability of the system. Results suggest that participants’ learning was better aided by a text-only or text and icons interface compared to an icons-only interface. Although participants initially performed very poorly on the icons-only interface, they caught up with the other two interface groups by
the end of the second session. Based on these findings Wiedenbeck (1999) suggests that a text-only or redundant interface might be better for initial learning. However, in terms of participants’ attitude towards the type of interface, they were less favourably disposed towards the text-only interface.

Redundancy in the context of information communication is also recommended for minimising ambiguity and individual differences in comprehension (Wickens & Hollands, 2000; Wickens et al., 2004). Furthermore, research from the field of instructional design suggests that redundancy of graphics and words is most beneficial in accommodating individual differences in cognitive abilities (Tindall-Ford, Chandler, & Sweller, 1997). On the other hand, some studies discovered that older users face difficulties in using interfaces that use graphics extensively (Gould & Schaefer, 2005). Graphics-intensive interfaces can increase extraneous cognitive load and can hamper learning of their functionality (Feinberg & Murphy, 2000; Sweller, 1994). It is suggested that using descriptive language to define the function of a button could help in using an interface intuitively (Gould & Schaefer, 2005).

There is a considerable amount of research in the field of educational technology that suggests the use of multimodal representation to reduce the cognitive load for the learner. Cognitive Load Theory (Sweller, 1999) is one such theory that is used extensively to inform the design of product interfaces. This theory focuses on efficient use of available cognitive processing for learning. Cognitive load can be described as the amount of working memory resources used at any point during the learning process. Sweller (2002) suggests that if information is presented in two modalities - for example, auditory and visual - demand on working memory is reduced. Research in cognitive psychology also indicates that more working memory is available when dual modalities (auditory and visual) are used (Penney, 1989).
On the other hand, redundancy could be detrimental to users with high prior knowledge (Vetere & Howard, 2000). Sweller (2002) terms this as the ‘redundancy effect’, which states that if one form of information representation is intelligible by itself, repeating it in another form will increase cognitive processing load. For example, a graphical interface with redundancy (Figure 4.2) is helpful for novice users to learn the function of this control. However, for expert users, both forms of representation are intelligible; hence a redundancy effect may occur.

![Start]

Figure 4.2: Graphical representation of start function

In summary, some research indicates the importance of redundancy in interface design to address low prior knowledge and age-related cognitive decline, and some highlights negative aspects of redundancy. There is also a considerable amount of research on icon-based versus text-based interfaces, which suggests that, once learnt, icon-based interfaces are much more effective than text-based interfaces. Moreover, it is suggested that text-only or redundant interfaces could be beneficial for initial learning. However, there is not much research that looks at redundancy in interface and its effect on older users and users with varied prior experience with similar technologies.

4.2.1 About redundancy and representation

Semiotics, in short, can be defined as a ‘study of sign’ (Chandler, 2002). A ‘sign’ is defined as ‘something that represents or stands for something else’. All signs are interpreted based on the prior experience or convention. ‘Convention’ means ‘as convened, agreed upon, and accordingly shared in a given social context and culture’ (Nadin, 1988). A sign will acquire a
meaning only when someone interprets it as signifying something other than itself (Chandler, 2002).

There are three types of signs: 1) Iconic representation, by direct relationship, 2) Indexic representation, by association, and 3) Symbolic representation, by convention. Iconic and indexic representations are not possible for abstract concepts. For example, a power switch can be represented indexically as 1/0; however, the symbols 1 and 0 cannot be deciphered without the knowledge of the binary system. A simple means of understanding iconic and indexic representations is to consider that the iconic representation of a tree, for example, would be a picture of a tree, and an indexic representation of a tree could be a leaf or a branch.

In this study, the terms ‘text/words’ and ‘symbols/icons’ are used in their colloquial sense. However, from a semiotics point of view, both ‘text/words’ and ‘symbol’ are symbolic representations. As both are based on conventions, one is based on verbal language and the other on visual language.

4.3 **Complexity in contemporary product interfaces**

There is a gradual shift in most consumer products towards a touch-based interface paradigm. If this trend continues, it will not be long before most of the technology older people encounter in their day-to-day activities will be based on this interface paradigm. On a brighter note, recent research suggests that touch-based products are much easier to learn and older users could successfully use them regardless of their age-related cognitive or physical deficiencies (Häikiö et al., 2007; Isomursu et al., 2008; Taveira & Choi, 2009). Unlike input devices such as the mouse or track ball, interaction with touch-based interfaces is not limited by many age-related ailments such as arthritis and tremors. For example, Murata and Iwase (2005) found that the pointing time of a mouse was longer for older adults compared to younger age groups, whereas there were no significant pointing time differences when a touch-based interface was used. Interestingly,
Umemuro’s (2004) research on older people’s aptitudes to computer found that the anxiety factor declined significantly in the touch screen condition. However, further research needs to be done in this regard to clearly establish which types of input devices are optimal for older people (Czaja & Lee, 2009).

On the other hand, this shift to touch screen has also resulted in smaller screen sizes with little or no tactile feedback (Ziefle, 2010). In addition, with increased functionality and small screen sizes, it has become necessary either to decrease the size of interface elements so as to fit them on the small screen, or to resort to some amount of nesting of the interface to fit all the functions of the device on the screen. Decreasing the size of text and icons will result in visibility and readability issues, especially for older people. Then again, multiscrreen design, if its structure is too deep or complex, could increase the cognitive load on the users.

**4.4 Breadth versus depth in interface design structure**

Fundamental characteristics of menu structures have been well researched over the past couple of decades. In particular, tradeoffs between breadth (the number of options in a level) and depth (the number of levels) in menu structures have been extensively empirically investigated and analysed; for example: (Detweiler, Hess, & Ellis, 1996; Geven, Sefelin, & Tscheligi, 2006; Kiger, 1984; Landauer & Nachbar, 1985; Miller, 1981; Tullis, 1985; Zaphiris, Kurniawan, & Ellis, 2003).

A flat/broad interface is one that has only one level of menu with all the options arranged in a grid fashion, as shown in (Figure 4.3) below.
Figure 4.3: One possible arrangement of controls in a broad/flat interface one-level menu system

A nested/multi-layered interface has more than one level of menu. In a nested or multi-layered interface, menu options for the second level onwards are only displayed when one of the menu options in the first level is activated, as shown in (Figure 4.4).

Figure 4.4: One possible pop-out arrangement of controls in a nested/multi-layered 2-choices and 3-levels menu system

One of the early studies by Miller (1981), investigating differences in breadth versus depth of menu structure, shows some very interesting results. His study involved participants finding target words in one of the four semantic hierarchical tree structure menus. The dependent variables were target acquisition time and accuracy. The four different tree structures
contained a total of 64 different target words. The four different structures were: 1) Six levels of menus with two choices at each level, 2) Three levels with four choices at each level, 3) Two levels with eight choices, and, 4) One level with 64 choices. The time to acquire the target word produced a U-shaped function with extremes at 'one level with 64 choices', and 'six levels with two choices'; the, minimum or most optimal configuration was 'two levels with eight choices'.

Kiger (1984), as an extension to Miller’s study, investigated five different menu structures with the deepest at six levels with two choices. At the other end of the continuum there were three broad menu structures with just two levels with a different number of choices per menu. Kiger (1984) found that, similar to Miller’s (1981) study, broad menu structures resulted in shorter times and better accuracy.

Menu structure on mobile devices presents a different set of problems. Their screen sizes are often smaller and they usually use touch or pen-based interfaces. A study of preferences for menu structure of mobile devices found that participants preferred a layered rather than broad menu structure (Geven et al., 2006). More specifically, they preferred a structured hierarchy with four to eight items per level.

Research suggests that older people encounter more difficulties when using interfaces that use nested/multi-layered structures compared with flat/broad interface structure (Detweiler et al., 1996; Docampo Rama, 2001; Lim, 2009). They are also much slower using nested interfaces and tend to prefer shallower interfaces that offer better spatial orientation (Zaphiris et al., 2003). A nested interface, by its very nature, offers very few cues to the spatial location of different nested functions. Therefore, these types of interfaces impose a greater demand on the user’s working memory. In general, working memory function deteriorates with ageing. Moreover, age-related working memory deficiencies become more prominent as the complexity of cognitive tasks increases, such as when a task requires the
simultaneous storage and processing of information (Bäckman et al., 2001). Research suggests that broad or flat structured interfaces rely much less on cognitive abilities and, hence, may be much more beneficial for older users (Detweiler et al., 1996; Docampo Rama et al., 2001).

### 4.4.1 Anxiety, stress and intuitive interaction

Although anxiety and stress are known to interfere with intuitive thinking (Bastick, 2003), there is no research available that clearly points to the impact of anxiety on intuitive interaction. Blackler’s (2006, 2008) research investigating the hypothesis that intuitive use of products is based on prior experience with similar products did attempt, in Experiment 1, to use the presence of anxiety in the participants as an indication of non-intuitive use. However, it was noted in the study that the psychophysiological tools used to measure heart rate and electrodermal activity (to indicate when participants were anxious) did not provide useful data due to latency issues. These instruments take several seconds to indicate the presence of anxiety in a participant; during these few seconds, a participant would have performed more than one action, thus making it difficult for researchers to pinpoint which actions had triggered anxious moments and which were performed in anxious states. Hence, for the subsequent two experiments, the data on anxiety was garnered through retrospective interviews. During these interviews, when participants were asked if they felt anxious at any time during the test, the majority of responses were negative, and no significant relationships were found between self-reported anxiety and time taken to do tasks or percentage of intuitive uses.

However, it was noted in the study that there were occasions when participants were ‘frustrated’. There were also instances when, towards the end of the session, it was observed that the participants were making mistakes with features they had used correctly earlier. While causes of these frustrating moments were not ascertained, it was noted that they could be a result of anxiety or fatigue interfering with their intuition (Blackler, 2006, 2008). Overall, the outcomes of these experiments are inconclusive in terms
of establishing a clear relationship between anxiety and intuitive use. There is no other data available that provides insight into the likely impact of anxiety on intuitive interaction.

4.5 Summary

This chapter discussed issues and strategies that could help in developing interfaces that are more intuitive for older people and some factors that could interfere with intuitive use in older adults. Literature reviewed suggests that matching prior knowledge of the users to the interface is the key to its intuitive use. However, older people have trouble using contemporary product interfaces intuitively due to lack of domain-specific prior knowledge.

Some research suggests that exploiting redundancy in interface design could help in making products more intuitive for older people and people with low prior experience (Blackler, 2008; Gould & Schaefer, 2005). Other related studies show that text and redundancy-based interfaces are easier to learn, and that symbols-based interfaces are more efficient to use once they are learnt (Camacho et al., 1990; Wiedenbeck, 1999). However, these studies do not include old people in their investigation.

Use of technologically complex products in older people is mediated by, among other things, technology self-efficacy, technology anxiety, cognitive capability, education, and domain-specific prior experience (Czaja et al., 2006). Moreover, low technology self-efficacy leads to technology anxiety (Czaja et al., 2006), and anxious conditions are not conducive to intuitive thinking (Bastick, 2003). However, there is currently no data available on the impact of anxiety on intuitive use of a product.

In conclusion, there is lack a of research on developing interface design for older adults (Hawthorn, 2001). Apart from the preliminary investigations conducted by Blacker (2008) and Hurtienne et al. (2010), there is no empirical research available on designing to facilitate intuitive interaction.
for older adults. However, there is a large body of literature available on the impacts of ageing on cognitive and perceptual abilities and psychomotor skills. As Hawthorn (2001, 2006) points out, most of these studies originate from experimental studies conducted under fairly artificial conditions that are designed to address theoretical issues rather than people’s performance in real world situations.

Chapter 5 discusses, methodological issues related to researching with older participants. It will also present the research plan for this study, hypotheses drawn from the literature reviewed, and the design of the two experiments that investigate these hypotheses.
Chapter 5

Research Plan and Methodology
5.1 Introduction

This chapter discusses issues related to experimental design when older participants are involved. It also presents data collection methods employed in this study. It further lists hypotheses drawn from the literature reviewed and presents the design of two experiments that investigate these hypotheses. Finally, a detailed explanation of the methodology used for these investigations is given.

5.2 Methodological issues with older users as research participants

Age-related disabilities occur slowly and at varied intensities from individual to individual. This results in greater variability in abilities among older adults than among younger people. Thus, the standard practice in user research of assuming homogeneity in a certain demographic group may not work with older adults (Fisk, 2004; Fisk et al., 2009). Older users do not have a static set of user requirements (Zajicek, 2001). Requirements differ between individuals and even within an individual from time to time, based on the state of that individual's health. For example, some older adults may have severe visual, physical and cognitive impairment, while others from the same age group may have almost perfect physical and cognitive abilities.

Designing experiments for such a wide variety of users with different capabilities is challenging and calls for re-examination of existing experimental design methods to better address this dynamic diversity (Dickinson, Eisma, Sme, & Gregor, 2002). In general, research suggests that studies on ageing are particularly subject to confounding effects, and it should be approached with caution (Rybash, Roodin, & Hoyer, 1995).

5.2.1 Cohort versus longitudinal studies

Most of the studies involving older people are cross-sectional experimental designs that compare two or more age groups at any point in time. An often
cited reason for this preference is that cross-sectional studies are considerably more efficient and less expensive than longitudinal studies. However, a number of researchers consider cross-sectional studies inferior to longitudinal studies (Salthouse, 2000). The basic problem with cross-sectional studies is that the differences in age groups, among other issues, could be a result of better education, of skill acquired with changing patterns of work over time (for example, from more physical to cognitive work), and of changes in nutrition and quality of living.

Longitudinal studies, on the other hand, follow the performance of the same set of participants over time. One of the advantages of this method is that it counters the ‘cohort effect’ of cross-sectional studies. For example, to make inferences about age-related changes from cross-sectional data, researchers must assume that current young adults will resemble the older adults when they reach that age, or that current older adults resembled current younger adults when they were young (Salthouse, 2000). These assumptions could be wrong because, over time many factors - such as changes in technology, education and culture - have a significant influence on participants. However, on the negative side, longitudinal studies are inherently time consuming; hence, very few studies are conducted in this manner. Rybash, Roodin, and Hoyer (1995) also observe that longitudinal studies show a smaller effect of ageing. This could be due to training, as the participant follows the same set of tasks over time. Moreover, elderly participants with impaired cognitive abilities may drop out midway through the study. Rybash et al. (1995) suggest that, unless the effects of inadvertent training over time and the dropping out in the middle of the study are taken into consideration, this method of research might not provide a true picture.

Overall, longitudinal studies are time consuming, resource intensive and tend to overstate the abilities of older groups. Although cross-sectional studies are more efficient, they may exaggerate the decline in cognitive and physical function of ageing (Rybash et al., 1995; Salthouse, 2010). This is because it is not possible to match the capabilities of participants from
different cohorts in cross-sectional studies. In longitudinal studies, on the other hand, participants are often selected with matching capabilities and the differences are studied over a period of time. As participants are often from different time periods, it is not possible to gauge whether the cause of a participant’s physical or cognitive capability is age-related or birth related.

However, the selection of experimental design is also dictated by the nature of the research. Studies such as this that involve looking at the differences between cohorts/generations can only use cross-sectional studies. On the other hand, it is important to understand that cross-sectional studies could exaggerate age differences (Salthouse, 2010).

5.2.2 Participant sample

A primary objective in recruiting participants for most studies is to have an ideal sample that is fully representative of the general population. However, ensuring ideal coverage of relevant groups would involve participation of all targeted individuals. In practice, it is not feasible to achieve this, especially in a study such as this that exclusively relied on volunteer participation. In this regard, furthermore, research points to some important issues related to the recruiting of older participants that need attention (Salthouse, 2000). Unlike the young population who are relatively easily recruited in and around the university or other learning institutions, older people prefer to live in the suburbs or more isolated areas (Eisma et al., 2004). Some prefer to spend most of their time in the home for various reasons and it is very hard to motivate this group of older participants to volunteer for research studies (Eisma et al., 2004).

At the other end of the spectrum, there are older people who are more motivated and mobile and are generally more open to participating in research studies. This difference in participants’ motivation could affect the representativeness of a sample. Hawthorn (2006) argues that older people participate in studies because they are able to, choose to, and are motivated to. Essentially, these motivated groups are survivors and, therefore
examining the performance of these groups may understate the problems of ageing.

To truly understand problems related to ageing, research should be designed to include groups that are unwilling to participate. One way to reach older people who are unwilling to go out or lack mobility is to conduct mobile studies. However, it is very hard to control experimental conditions in a mobile study. For example, simple things such as distraction from other members at the location, noise level, lighting conditions, temperature, seating comfort and so on might vary from one participant location to another. Another way to address this issue is to recruit participants from different contexts such as sports clubs, old age homes and through neighbourhood networks. This will ensure a reasonable representative sample of the older population, even if not a perfect one.

Although it is not feasible to achieve an ideal sample, there are relatively simple means by which one can determine the representativeness of a sample. This can be done by administering one or more standardised tests to all the members of the sample and then referring to the published norms to determine the relative position of each age group (Salthouse, 2000). This is especially important for very old participants where age-related cognitive deficiency is within the expected range, to ensure equivalence between different groups in the study (Dickinson, Arnott, & Prior, 2007). This study used cognitive measures to de-select participants who did not fit the expected profile of the population.

**Control of extraneous variables**

In studies that use cross-sectional experimental designs, it is very important to match participants closely to keep extraneous variables to a minimum. In general, most cross-sectional studies use screening instruments relevant to the experiment, to match participants in a group. However, some research points out that, when participants are older, these instruments may not be reliable (Hawthorn, 2006). Hawthorn (2006), for example, suggests that
standard psychological tests that are administered to gauge the effects of ageing on cognitive processes may not give a clear picture. Many of these instruments rely on atypical, simplified, stand-alone tasks to be performed in an unfamiliar environment. Most of these tasks, from the perspective of the participant, do not have a meaningful context. In addition, without real-life motivation or context the true performance of participants may not emerge. However, there are some studies that show good correlation between laboratory-based tests and tasks performed in an everyday environment (Diehl, Willis, & Schaeie, 1995). Although Hawthorn’s observation is well argued and supported, it does not provide a feasible alternative solution to this problem. It may be safe to conclude that, for the time being, it is prudent to use time-tested laboratory based screening tools to screen participants in a group.

No matter what kind of screening instruments are used, it is not practical to have an ideal participants match between groups. Even a simple match, such as age, is not as straightforward as it appears; it is possible to have two individuals share the same chronological age, but have different rates of age-related cognitive and psychological decline (Charness, 1988). Some research states that studies which are looking at cognitive and memory function of ageing should take into consideration the educational level of the participants (Perlmutter & Hall, 1985; Rybash et al., 1995). Research suggests that high levels of education predict a slower rate of intellectual decline in older adults (Schaie, 1989). Also, individuals who held a job that involved complex work are more likely to maintain cognitive functioning into old age (Schaie, 1996). However, some challenge these findings (Rabbitt, Chetwynd, & McInnes, 2003). They argue that these studies used scores from vocabulary tests as an indicator of fluid intelligence, and proved that vocabulary remains more or less unchanged as people age and is not related to age-related decline in fluid intelligence. Moreover, fluid intelligence declines sharply over the period of 42 to 92 years of age, irrespective of socioeconomic advantage. Overall, these studies suggest that participants should be matched for their level of education and that it may
be also beneficial to consider the cognitively challenging activities pursued by participants after the period of their formal education.

Knowledge and skills acquired through education, lifestyle, work-related and other leisurely activities all contribute to how an individual approaches a technologically challenging task. Research suggests that people who have expertise in an area retain their performance in that area as they age (Charness, 1988). However, they show decline typical to that of the general population in areas that are not related to their expertise. If technology or computers are involved in the study, it is imperative that participants’ expertise in technology should be considered (Hawthorn, 2006). It is important that attention is paid to prior experience with technology when selecting participants. The selection should represent present cohort abilities. It may also be best to recruit participants from non-technical backgrounds.

To summarise, matching older participants between-groups is much more complex than it appears. Although many issues that are important for matching subjects in cross-sectional studies were raised in this section, it may not be practical to implement some of them. For example, some researchers argue that it is not possible to get a clear picture of an individual’s cognitive performance when laboratory based instruments are used. However, it is not practical to measure the cognitive performance of individuals by using real-life tasks that they find motivating, especially when using cross-sectional experimental design. This is mostly because finding a group of individuals across different age groups, who share similar interests in a specific activity, is very unlikely. This makes matching participants between-groups almost impossible. This is one of the main reasons why this study did not use matched subject design.

5.2.3 Experimental procedure

How, when, and where an experiment is conducted could influence the outcome of that experiment. Jacoby, Toth & Yonelinas (1993) suggest that
tasks related to memory function can be influenced by familiarity with that task, leading to repeated priming (see Section 3.4) and deliberate remembering. Moreover, they state that the context under which task-related memory is acquired has an impact on its recollection. Deliberate or self-initiated recall is more effortful, and older people have reduced resources to carry out such a process. Therefore, older people are more dependent on contextual cues for remembering (McDowd & Shaw, 2000). It is possible that the laboratory environment may not provide the necessary contextual cues for recollection of information learnt in a different environment. However, if a study is only interested in age differences in a controlled laboratory based study, this should not be a major concern.

Research also suggests that the time of the experiment can have an impact on participants. Substantial literature suggests a circadian arousal pattern has an impact on the performance of participants on cognitive tasks. Zacks, Hasher & Li (2000) suggest that the peak functioning time for young adults tends to be midday and later, whereas the peak time for older adults centres around early to midmorning. For this study, apart from a few exceptions, trials for both the experiments were scheduled between 10 am and 2pm.

Self-efficacy plays an influential role in experiments involving memory and cognitive performance. The concept of self-efficacy refers to a person’s belief in his/her ability to perform a given task successfully (Bandura, 1986). However, self-efficacy beliefs can be manipulated in experimental setup by low or high self-efficacy instruction. For example, Wood and Bandura (1989) conducted a study where they took two groups of students who were initially performing at the same level and gave them two sets of instruction - high versus low-self-efficacy. Performance of the group that was given high self-efficacy instruction improved, while the performance of the group that was given low self-efficacy instruction declined considerably. Research suggests that stereotyping and self-efficacy can influence performance of a participant (McDowd & Shaw, 2000). The way the experiment is set up, the behaviour of the researcher, and the instructions given by the researcher
can alter the participant’s perception of self. Both the experiments in this study were conducted in a controlled environment with a procedure script that was strictly followed for all participants. Even the type of chair and tables, their position with respect to the light, and the lab temperature were kept constant.

5.3 Data collection methods

5.3.1 Observation

Observation is a very valuable data collection method, as it is often noticed that what people say during delivery of verbal protocol does not match their actions (Wickens et al., 2004). Wickens further states that, in verbal protocol delivery, people may distort description of their actions to avoid looking incompetent or confused. Most importantly, when people intuitively do certain tasks, they sometimes do not report their actions (Blackler, 2008). In these situations, observation is a very effective data collection tool. However, an observation does not provide insight into people’s thoughts, goals and intentions (Stanton & Barber, 1996; Wickens et al., 2004). Although limited at times, concurrent verbal protocol is still effective in obtaining this insight.

5.3.2 Concurrent verbal protocol

Concurrent verbal protocol, or think-aloud protocol, is used extensively in human-computer interaction studies. It was also found very useful in investigating design activity (Cross, Christiaans, & Dorst, 1996). Participants are required to think out loud or verbalise their thoughts as they perform a given task. This allows researchers to gain an insight into users’ thought processes, decisions and strategies during task performance (Wickens et al., 2004). Wickens (2004) further elaborates that there are three types of verbal protocol: concurrent (think-aloud while performing a task), retrospective (verbalisation after task performance), and prospective (users
are given a hypothetical task and asked to think aloud when imagining performing this task).

In concurrent verbal protocol, it is important that participant reporting consists of straightforward verbalisations of on-going thought as it happens, without elaboration, rationalisation or explanation. If this protocol is used as stated, most research on verbalisation of on-going thought suggests that the verbalisations are accurate and reasonably complete, with little reactive effect beyond some slowing of performance. However, some research points out that concurrent protocols might have an impact on performance as they divert some of the limited resource of working memory (Wickens et al., 2004). This might be of a concern if participants are older as the processing capacity of working memory declines with ageing and this has a substantial impact on performing tasks that require simultaneous processing (Fisk & Rogers, 1997). Concurrent protocol might interfere with older participants’ completion of a task, especially when the task gets difficult (Dickinson et al., 2002). Moreover, there is a possibility that concurrent protocol may change participants’ behaviour and cognitive performance (Cross et al., 1996).

Retrospective reports are less likely to burden working memory. However, participants tend to rationalise their actions during retrospective interviews (Gilhooly & Green, 1996). Although rationalisation provides better insight into a participant’s actions, it is quite unreliable. Ericsson and Simon (1993), in their milestone work on protocol analysis, warn against all retrospectively collected data as it could be subjected to forgetting and fabrication.

Experiment 1 of this study used concurrent verbal protocol, but it did not produce reliable data. Older people found it difficult to deliver the protocol when the task became difficult or when they are trying to recover from an error. Moreover, some older people tend to talk a lot and some, very little. As time on task was one of the dependent variables, extreme variations in
the protocol delivery times lead to unusable data. For the second experiment concurrent verbal protocol was not used.

5.3.3 Questionnaires

Questionnaires are an often used technique for collecting demographic data and users' opinions. They are also very useful to measure variables in applied research (Wickens et al., 2004). Like interviews, questions in a questionnaire can be open-ended or structured. Open-ended questions are useful in collecting qualitative data; and for quantitative data, a more structured approach, such as a numerical rating scale, is preferred (Wickens et al., 2004).

Sharp et al. (2007) have some useful guidelines for designing rating scales. The points on the scale should be decided by the depth and type of the response expected from the participants: Small range, such as 1 to 3, for very limited response such as ‘yes, no, may be’; a medium range, such as 1 to 5, for judgement responses such as ‘strongly agree to strongly disagree’; and long-range, such as 1 to 7-9, when seeking subtle judgements such as experiences.

Motivation of a participant is an important factor for reliability of data collected through questionnaires. The problem is, most people are not motivated enough to voluntarily complete a questionnaire (Wickens et al., 2004). The best approach is to assist with the completion of the questionnaire and to keep it simple and short. In this study, all the participants, for both the experiments, received assistance in completing the questionnaires. It was ensured sure that all understood the terms used and the intent of the questionnaire before they started filling it out.

5.4 Performance measures

Performance indicators for usability studies are usually based on the objective or requirements of that study (Martin, 2001). The primary aim of
this study was to facilitate intuitive use of a complex product interface. There were two basic performance indicators for the experiments: 1) Actions that took participants closer to the objective, namely, percentage of intuitive use; 2) Actions that took them away from the objective, for example, errors and, to a certain extent recovery from errors.

Time on task was also used as an indicator as it is an accepted measure of efficient use of a product (Frøkjær, Hertzum, & Hornbæk, 2000). However, it is well established that normal ageing slows down both cognitive processes and motor response times (Fisk et al., 2009; Salthouse, 1996, 2010). Despite this fact, time on task was used as an indicator because it provided data on variability within age groups. In this study the measure of time has established that age-related slowing is not universal and varies from individual to individual.

5.5 Programme of research and investigation

5.5.1 Research overview

The main aim of this research was to develop an approach that will help designers create interfaces that are more intuitive for older adults to use. This study started with two objectives: 1) to identify and investigate one of the possible approaches to developing intuitive interfaces for older adults; 2) to identify issues that could interfere with intuitive use by older adults. Finally, based on the outcome of these investigations, the study aimed to suggest a strategy that will help designers in developing interfaces that are more intuitive for older adults to use.

The literature reviewed covered existing research on intuitive interaction for older adults, drawing resources from, psychology, ergonomics, design (product, interaction and interface), human-computer interaction (HCI), gerontontology, the cognitive sciences and other fields. The literature review suggests that domain-specific prior experience and competence with technologies is the backbone for intuitive use of product interfaces. One of
the important reasons why older people have difficulties in using contemporary technological products is that they lack the necessary prior experience.

Some research suggests that building redundancy into interfaces could address the lack of prior experience and variability in older people’s abilities. Although there is some research that looks at the impact of redundancy in interface on usability of product interfaces, it was mostly conducted with younger participants. Currently, there is no report of research that investigated the impact of redundancy in interface design for intuitive use on older people.

Domain-specific prior experience, technology self-efficacy, technology anxiety, cognitive abilities and education are mediating factors in use of technological products. All these factors are interrelated; for example, low prior experience causes low self-efficacy which, in turn, results in technology anxiety. Also, age-related cognitive decline slows down the process of acquiring new knowledge; this is one of the contributing factors of low prior experience in older people.

For all of these reasons, when interacting with contemporary technological products with complex interface structures, older people generally suffer from technology anxiety more often than younger people, and anxious conditions are not conducive to intuitive process. However, the effect of anxiety on intuitive use of contemporary products with complex interface structures has not been investigated.

5.5.2 Hypotheses and research plan

Two objectives were set for this study: 1) to identify and investigate possible strategy to develop interfaces that are intuitive to use for older people and 2) to investigate factors that could interfere with intuitive use in older people. Based on the gaps identified in the literature reviewed, the following hypotheses were formulated to address the objectives.
1. That redundancy in interface design helps older users and users with low domain-specific prior experience in using complex technological product interfaces more quickly, more intuitively and with fewer errors.

2. That, with respect to complex interfaces, age and anxiety:

   a. Complex/nested interface structure has adverse effects on time to complete a task and on the percentage of intuitive uses and errors for older participants and participants with low domain-specific prior experience, when compared with younger participants.

   b. Participants who score poorly on the Technology Prior Experience Questionnaire will also score poorly on the Self-efficacy Questionnaire and report high anxiety on the State-Trait Anxiety Inventory (STAI) Questionnaire.

   c. Anxiety, induced by stressful condition has an adverse impact on time to complete the task and the percentage of intuitive uses and errors for both younger and older participants.

Figure 5.1 shows how this research was planned to address the overall aim of this study. Two experiments were designed to investigate the two hypotheses listed above. The outcome of this research will help in formulation of a strategy for developing intuitive interfaces for older people. The strategy will not impose a new rigid design process; rather, it will help designers contextualise the research findings to their design needs, knowledge, and preferred development methods and processes.
5.5.3 Experiments

In total, two experiments were planned for this study to investigate the hypotheses formulated based on the gaps found in the literature. Participants between 18 to 84 years of age participated in both the experiments, and were placed in groups for statistical analysis of age differences.

For Experiment 1, participants were placed in three age groups: young (18 to 39 years), middle-aged (40 to 65 years) and old (65+ years). However, the outcome of Experiment 1 has indicates that older people are more diverse in their capabilities than younger people. To minimise this variability within an age group, age groups were increased from three to five for Experiment 2: young (17 to 34 years), older young (35 to 49 years), middle-aged (59 to 64 years), old (65 to 72 years) and older old (73+).

In general, data from Experiment 1 indicates that increasing the number of age groups beyond five would address the variability within an age group.
much more effectively, especially for participants above 65 years of age. However, from a statistical power point of view, this would have also necessitated an increase in number of participants in each group to sizes that were not feasible for the given time span of this study.

**Pilot study**

Pilot studies were conducted for both the experiments, with participants representing three age groups: young (20 to 39 years), middle-aged (41 to 60 years) and old (61+). The objectives of these studies were to test the experiment protocol, data collection methods and mediator devices used in the experiments. The pilot studies were also used to evaluate different software systems used in observation and analysis of the research data.

The following observations were also made during these studies that helped refine the experimental design: Older participants tend to blame themselves, even for mistakes that are obviously not their fault; and this, in turn, leaves them a little distressed. A debriefing interview was introduced mostly to chat, so as to make them feel comfortable before administering post-task questionnaires.

Overall, these pilot studies helped immensely in fine-tuning the experiment protocol to work with the very diverse group of participants involved in the experiments and to reduce extraneous variables. However, since the test parameters and procedure were fine-tuned after each trial, the data from the pilot studies were not included in the final data analysis of the experiments. Overall, 23 participants, 11 for Experiment 1 and 12 for Experiment 2, were involved in the pilot studies.

**Experiment 1**

This experiment was designed to investigate if redundancy in interface design facilitates intuitive use in older users and users with low technological prior experience. The design of the experiment was based on
previous studies that investigated intuitive use (Blackler, Popovic, & Mahar, 2004).

Research suggests that redundancy in interfaces might help older users and users with low prior knowledge in using technological products more intuitively (Blackler, 2008; Gould & Schaefer, 2005). Research also suggests that redundancy of graphics and words is beneficial in accommodating individual differences in cognitive abilities (Tindall-Ford et al., 1997). However, some research suggests that older users have difficulty assessing the functionality of interfaces that use graphics extensively (Gould & Schaefer, 2005). It has also been observed that graphics-based interfaces can increase extraneous cognitive load and can have an adverse impact on the learning of interface functionality (Feinberg & Murphy, 2000; Sweller, 1994).

Some studies also report that text and redundancy-based interfaces are easier to learn, and symbols-based interfaces are more efficient to use once they are learnt (Camacho et al., 1990; Wiedenbeck, 1999). However, these studies do not include older participants in their investigation.

**Experiment 2**

This experiment investigated the impact of anxiety, complexity in interface structure (nested versus flat) and age on intuitive interaction. There is some research which indicates that older people can experience more anxiety when it comes to interacting with new technologies (Eisma et al., 2003). It was further established by Bastick (2003) that stress, anxiety and oppressive environments are not conducive to intuitive thinking. However, what is not well understood is the impact of these conditions on intuitive use of a product.

Earlier studies on intuitive interaction with complex artifacts by Blackler (2006) found no significant differences in intuitive use between those who are anxious and those who are not. However, these experiments were not specifically designed to look at the impact of anxiety on intuitive interaction.
Moreover, the experiment protocol used by Blackler (2006) was carefully designed to remove uncertainty and anxiety for participants, and this is not possible in a real world situation.

Research also suggests that older people encounter more difficulties when using interfaces that use complex (nested) interface structures compared with simple (flat) interface structures (Detweiler et al., 1996; Docadopto Rama, 2001). Despite this a gradual move in product interface interaction towards touch-based input systems with small screens has necessitated extensive use of multi-layered interface structures.

5.6 Methodology

Both experiments used similar methods of data collection and analysis. In this section common methods and tools employed for both the experiments are described and discussed. In the next two chapters, specific variations between the two experiments are discussed.

5.6.1 Data collection methods

The data collection methods used for this study included: concurrent verbal protocol, observation of task performance, and questionnaires. Both experiments were conducted in the Queensland University of Technology's, People and Systems Laboratory, and an audio-visual recording of each experiment was made. Noldus Observer (observational software) was used to assist coding and analysis of the captured data.

**Concurrent verbal protocol, observation of task performance**

As discussed in Section 5.3.2, both concurrent verbal protocol and observation of task is essential for extracting quantitative data on intuitive use. Two cameras were used to record the experiment (Figure 6.3). The audio-visual recording was subsequently coded and analysed using Noldus Observer (Noldus, Trienes, Hendriksen, Jansen, & Jansen, 2000).
Rating scale questionnaire
The Technology Prior Experience Questionnaire, based on Blackler’s (2008) Technology Familiarity Questionnaire, was developed specifically for both the experiments.

A General and Specific Self-efficacy Questionnaire were used for Experiment 2. This questionnaire was based on 10 well tested questions to measure perceived general self-efficacy (GSE), as suggested by Schwarzer and Jerusalem (1995). For specific self-efficacy, eight questions as suggested by Cassidy and Eachus (2002), were used. Implementation of the questionnaire were based on the suggestions made by Sharp et al. (2007).

Cognitive measures tasks
As discussed in the Section 5.2.2, to better involve participants in the task an interactive software application (CogLab) was used in this study for cognitive measures. CogLab is proprietary software developed by Assoc. Prof. Doug Mahar, and administers various instruments that measure different aspects of working memory.

5.6.2 Mediator products
A mediator product is a device or instrument used to investigate various variables set for an experiment. For both experiments meditator products were carefully designed and developed specifically for the task. Experiment 1 used a commercially available body fat analyser as a mediator product. For Experiment 2, an iOS application that manifests as a simple role-playing game was used on iPad platform.

The decision to use these products was primarily based on the assumption that they provide enough interest for both younger and older participants. Some research suggests that mediator products used in studies that include older people should be perceived as useful in sufficiently motivating them to engage with the experiment (Hawthorn, 2007). Hawthorn (2007) also notes that older people find it difficult to work with low-fidelity prototypes and
suggests making testing environments as realistic as possible. Hence, all the interfaces used for these experiment used high-fidelity prototypes, and had functions that participants would find useful to motivate them to be better involved (Turner, Turner, & Van de Walle, 2007). Three pilot studies were conducted for both the experiments to make sure that the software was engaging for both the old and young and most importantly, to make certain that it was not too difficult for the older participants to use and not too easy for younger participants.

Overall, both these mediator products were unique in terms of functionality and features. This uniqueness minimised the possibility of direct transfer of knowledge that could occur if an off-the-shelf product was used. In other words, if some of the participants had encountered the product before the experiment this could have skewed the data.

5.7 Summary

Studies on ageing with different capabilities are challenging (Dickinson et al., 2002). They are particularly subjected to confounding effects (Rybash et al., 1995). Experiments related to ageing research should be designed to include groups that closely represent the population. If technology or computers are involved in the study, it is important that participants’ prior experience with technology should be considered (Hawthorn, 2006). Overall, participants should represent present cohort abilities. For optimal results, it may be best to use a combination of observations, concurrent and retrospective protocols. Concurrent protocol was used to give an insight into actions; observations were used to support concurrent protocol; and retrospective protocol was used for clarification of observations made during the interaction. However, concurrent verbal protocol imposes an additional burden on the limited working memory of older people.

The experiments for this study were carefully designed, taking into consideration all the limitations and advantages of the different investigation methods discussed in this chapter. Two experiments were
planned: one to investigate redundancy in interface as one of the strategies to facilitate intuitive interaction for older people; another to, investigate the impact of factors such as anxiety, self-efficacy, and complexity of interface structure on intuitive use by older and younger people. Chapter 6 presents and discusses the outcomes of Experiment 1.
Chapter 6

Experiment 1: Redundancy and Intuitive Use
6.1 Introduction

Chapter 5 discussed the overall research plan and methods employed for this empirical study. This chapter presents Experiment 1, which was designed to investigate if redundancy in an interface design has any impact on intuitive use of complex interfaces by older people and people with low domain-specific prior experience. The outcomes of this experiment are discussed from both interface design and cognitive processing perspectives.

6.2 Method

6.2.1 Experiment design

The objective of this experiment was to investigate redundancy in interface design as a possible strategy to counter low domain-specific prior experience in older adults in relation to younger adults. The following hypothesis was formulated based on the literature reviewed:

That redundancy will help older users and users with low domain-specific prior experience in using complex technological product interfaces, faster, more intuitively and with fewer errors.

This experiment used a cross-sectional, between-groups design. The design of the experiment was based on the literature reviewed in Chapter 6 and studies investigating intuitive use conducted previously (Blackler, 2008). The Independent Variables (IVs) for this experiment were interface design and age. Table 6.1 shows IVs and their levels. The Dependant Variables (DV) were the time taken to complete a set task, percentage of intuitive uses, percentage of errors observed and help received to recover from errors.
Table 6.1: Independent Variable for Experiment 1

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Levels of Independent variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface design</td>
<td>Words-only</td>
</tr>
<tr>
<td></td>
<td>Symbols-only</td>
</tr>
<tr>
<td></td>
<td>Redundant (Words and symbols)</td>
</tr>
<tr>
<td>Age</td>
<td>Young (18 to 39 years)</td>
</tr>
<tr>
<td></td>
<td>Middle-aged (40 to 64 years)</td>
</tr>
<tr>
<td></td>
<td>Old (75+ years)</td>
</tr>
</tbody>
</table>

In addition, the experiment was also designed to investigate effects of age related cognitive decline on different DVs. Linear regression model was used to explain the relationship between cognitive data and different DVs.

**Participants**

Participants for this experiment were recruited from different sources to maintain a good sample of the general population. Individuals from various organisations (sports clubs, educational institutes, recreational facilities and retirement resorts) were asked if they could volunteer to take part in this study. Overall 50 participants participated in this study; 40% were males, and 60% females, and ages ranged from 18 to 83 years (M = 51, SD = 21). Table 6.2 shows the distribution of participants against IVs. Based on their below normal cognitive measures score three older participants were replaced as they were suspected to be suffering from severe cognitive decline. All participants were screened for visual acuity using the Snellen Chart at the beginning of the session.
Table 6.2: Description of participants demographics and independent variables

<table>
<thead>
<tr>
<th>Interface</th>
<th>Age groups</th>
<th>Gender</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Symbols</td>
<td>18 to 39 years</td>
<td>Female</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>40 to 64 years</td>
<td>Female</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>65+ years</td>
<td>Female</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>2</td>
</tr>
<tr>
<td>Words</td>
<td>18 to 39 years</td>
<td>Female</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>40 to 64 years</td>
<td>Female</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>65+ years</td>
<td>Female</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>2</td>
</tr>
<tr>
<td>Redundant</td>
<td>18 to 39 years</td>
<td>Female</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>40 to 64 years</td>
<td>Female</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>65+ years</td>
<td>Female</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Male</td>
<td>3</td>
</tr>
</tbody>
</table>

6.2.2 Apparatus and measures

Technology Prior Experience Questionnaire

The Technology Prior Experience Questionnaire was a three-part questionnaire developed to capture participants’ exposure to, and competence with, technologies similar to the mediator product used for this experiment (Appendix 1). The first part of the questionnaire was designed to capture technology exposure and frequency; the second part was developed for technology competence; and the third part was specific to the
interface used for the mediator product. The parts were administered at two different stages to avoid the priming effect. Priming is the implicit memory effect in which prior exposure to a stimulus influences the retrieval/recognition accuracy of subsequent stimulus (Neely, 1991). The first part of the questionnaire, the technology exposure questionnaire, was administered before the trial. This part of the questionnaire contained questions that were not directly related to the functions and the features of the mediator product. The second and the third parts, the technology competence questionnaire, were administered after the trials as these parts had questions that were directly related to the mediator product’s features and functions.

**Lifestyle questionnaire**

This was a short questionnaire that was used to capture activities and hobbies of the participants. Some research suggests that the lifestyle of a person influences age-related cognitive decline (Hawthorn, 2006) (Appendix 1).

**STAI Questionnaire**

The State-Trait Anxiety Inventory (STAI) is a self-evaluation questionnaire administered to measure the level of state and trait anxiety (Spielberger, 1979). A short form six-question version of the questionnaire was used to measure the participants’ current state of anxiety (Marteau & Bekker, 1992) (Appendix 2). The STAI Questionnaire was used in this experiment to screen for high anxiety participants.

**Cognitive measures instrument**

The cognitive measures instrument (CogLab) software was used to administer five instruments discussed below to measure different components of working memory.

The Corsi-span Test measures visual sketchpad capacity. It used a standard Corsi Span task where participants viewed sets of squares, at the rate of one
per second, on the screen. Subsequently they recalled their locations by touching the LCD screen (touch sensitive) in the sequence they viewed them. The number of squares presented was varied using a staircase procedure to find the participants’ visual span. A staircase method is efficient at estimating a threshold. The trials start at an average level of performance and the level is either lowered, if the response is incorrect, or raised, if it is correct. This process is repeated till a threshold can be estimated.

The Digit-span Test measures phonological loop capacity. Digit Span was measured by presenting lists of digits one at a time, at the rate of one per second, on the screen. Participants recalled the lists by touching on a number pad on the screen. Again a staircase procedure was used to vary the list length.

The Visual Transform Task measures central executive capacity to hold and manipulate spatial information. In this task participants viewed, for 3 seconds, a pattern of 4 red dots on a circle made of 9 white dots. Participants were required to remember the pattern of 4 red dots and move them 4 positions in a clockwise direction. This task consisted of four trials, with first trial used as an example. The measure was number of correct responses.

The Phonological Transform Task measures central executive capacity to hold and manipulate phonological information. In this task participants viewed a set of 4 numbers for 3 seconds. They were then required to remember the 4 numbers and move each one of them forward by 4 places (For example, 5 would become 9) and enter them in the correct sequence using a keypad on the screen. Similar to visual transform task, there were total of four trials and the first one was used as an example.

The Go/No-Go Task was used to measure sustained attention and response inhibition, two of the central executive functions. This instrument was also used to capture choice reaction time of the participants. In the Go/No-go Task (Nielson, Langenecker, & Garavan, 2002), participants viewed
individual letters serially on the screen and were required to respond to stipulated targets. There were 3 sets of trials in this task, with each set comprising of 63 trials. In the first set, participants were required to respond by clicking a ‘target present’ button on the screen whenever they saw specific letters (X,Y and Z). In the second set, they were only required to respond to alternating target letters X and Y. For example, if they clicked on X in one instance, they should only have responded when they saw Y in subsequent instances (X, Y, X, Y). In the third set, participants were required to respond to three alternating target letters. For example, if they responded to X at one point they should then only have responded if they saw Y or Z in the next instance (X, Y, X, Z, Y, Z).

**Mediator product**

This experiment used a commercially available body fat analyser as a mediator product. Body fat analysers are common devices that come in different packages. Most consumer units are standalone devices that are used by holding them in both hands; at times, they are also incorporated into the bathroom scales. Health screening clinics often use more elaborate and reliable versions of this device.

This device was selected after carefully reviewing other over-the-counter health monitoring devices, including blood pressure, glucose and cholesterol monitors. For the actual experiment, a virtual version of the product was used, as it was not possible to modify the physical device to test the levels of the type of Interface independent variable. The virtual product was an Adobe Flash-based application that was used on a touch sensitive LCD monitor. The virtual product application had a back-end administration interface that allowed the researcher to setup the mediator product based on the participant’s device-related information. The setup function was used to alter the default numbers shown on the device for age, height and weight. This was done to make sure that - no matter what the age, weight or height of the participant – they were always required to perform the same number of actions to complete the tasks on the device. For example, if the
participant’s age was 83, they would see the default number on the device’s display as 68 years (15 less than the participant’s age). If a participant’s age was 45 years, they would see 30 years as the default value on the device display. This was done to ensure that all participants were required to perform the same number of actions to complete the task to avoid influencing the DV time on task.

Figure 6.1 illustrates the mediator product body fat analyser with modified interface and controls to represent one of the experiment’s IV’s level, redundant interface. Figure 6.2 shows the other two independent variable levels, symbols-only and word-only interfaces.

Figure 6.1: Device with redundant (both words and symbols) interface

Figure 6.2: Symbols-only and words only interfaces
Task sheets

Two task sheets were prepared for the two task scenarios that participants were required to complete on the mediator product (Appendix 3).

6.3 Procedure

This experiment was conducted in a controlled laboratory setting. The whole experiment was scripted (Appendix 3) to ensure consistency among the participants. Participants within an age group were randomly assigned to one of the three levels of the IV interface design.

Two cameras were used to record the experiment for later analysis using Noldus Observer software (Figure 6.3a). One camera was positioned to record participant’s facial expressions and body language (Figure 6.3b); the second camera was positioned to record the tasks performed by the participant on the screen (Figure 6.3c).

Figure 6.3: Experiment setup with virtual device on touch screen monitor (a) overall setup (b) face camera view and (c) screen camera view
Participants were first given an information package that explained what the experiment was about, and what it meant to participate in it. Once they understood the content of the package and had no doubts about their participation in the experiment, they were asked to sign the consent form (Appendix 5). Then they were shown around the laboratory and the experiment setup was explained. Participants were also informed that they could cease involvement at any time and request to delete all the records of their participation.

Once the participants had settled down, they were asked to complete the first part of the technology prior experience and lifestyle questionnaire. Participants were assisted in understanding and filling in the questionnaires (Figure 6.4). This was done to make sure there were no inconsistencies in interpretation of the instructions and responses.

![Participant receiving guidance filling in Technology Prior Experience Questionnaire](image)

**Figure 6.4: Participant receiving guidance filling in Technology Prior Experience Questionnaire**

As most participants were not familiar with touch sensitive LCD monitors, they were asked to perform two mini tasks on a calculator application on the screen. These calculator tasks were designed to familiarise participants
with the touch sensitive LCD monitor and with delivering concurrent verbal protocol (Appendix 3).

After the familiarisation session, participants were given the STAI Questionnaire followed by a task sheet for Task 1. Once it was ensured that they understood what they were expected to do, they were asked to start on the Task 1. Task 1 involved switching on the device, inputting the necessary details (age, gender, weight and height), and saving the data, and then instructing the device to measure and display body fat mass and volume. Participants were informed that, if they were not comfortable to divulge their personal information, they could provide false (but realistic) data and should then use this data throughout the experiment.

Soon after completing the Task 1, participants were asked to fill in the STAI Questionnaire for the second time to record post-task anxiety level. Following this, they were given the Task 2 sheet. Once they acknowledged that they understood it, they were asked to start on Task 2, which involved switching the device on, recalling saved data, updating the data and instructing the device to measure and display the body fat mass and volume. Soon after Task 2, they were asked to fill in the STAI for post-task anxiety level for the third and final time.

Once they had filled in the third STAI, participants were asked to fill in the second and third parts of the Technology Prior Experience Questionnaire. Soon after, they were asked to complete five cognitive measure tasks using the CogLab application (Figure 6.5). The sequence of the cognitive tasks was changed for every participant to avoid a sequencing effect. The whole experiment took roughly 90 minutes of participants’ time.
6.4 Data analysis

The dependent variables *time on task, percentage of intuitive uses, errors* and *error recovery* were central to this experiment. *Time on task* is an important indicator of intuitive use. ‘Intuitive interaction’ is defined as fast and generally non-conscious (Blackler, 2008). *Time on task and errors* were relatively easy variables to measure. On the other hand, collecting data on actions that are non-conscious was much more challenging. As intuitive use is non-conscious process, often participants do not verbalise intuitive actions during concurrent protocol delivery. Data on intuitive use was acquired based on observations, in conjunction with concurrent verbal protocol using Noldus Observer software. When participants performed an action quickly, with ease, and did not verbalise while performing the action, or at times verbalised after performing the action that interaction was coded as an *intuitive use*.

The coding scheme had an element of subjectivity. As younger participants, in general, have faster reaction times than older participants, there is a chance that they may appear to be using an interface more intuitively. To minimise the probability of wrong coding, all videos were coded by two independent raters to validate the data.
6.4.1 Coding scheme

Some of the terms used in this study are not well known or, at times, are used in a different context. To avoid confusion, experiment-specific terms - function, feature, actions, events and tasks - are defined in (Table 6.3) below.

Table 6.3: Definitions of specific terms used in experiment

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Function</td>
<td>Function of a control (for example, increase or decrease)</td>
</tr>
<tr>
<td>Feature</td>
<td>Representation that defines a function (for example, arrow or word ‘up’ to define increase function)</td>
</tr>
<tr>
<td>Actions</td>
<td>Single response (for example, clicking ok button)</td>
</tr>
<tr>
<td>Event</td>
<td>Group of actions (for example, increasing weight involves clicking up/down buttons and ok button)</td>
</tr>
<tr>
<td>Task</td>
<td>Group of events</td>
</tr>
</tbody>
</table>

The basic objective of coding was to extract as much detail as possible from the observational data. Unlike previous related studies (Blackler, Popovic, et al., 2010) in which features and functions were coded, in this experiment, only events were coded. In total, eight events were used for both the tasks (Table 6.4). Each event needed one or more actions to complete it. For example, inputting a participant’s age is an event and this event needs the following actions: pressing up or down arrow, and pressing the OK button.
<table>
<thead>
<tr>
<th>Event</th>
<th>Occurrences in Task 1 and 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switching on the unit</td>
<td>Task 1 and 2</td>
</tr>
<tr>
<td>User selection</td>
<td>Task 1: New user</td>
</tr>
<tr>
<td></td>
<td>Task 2: Existing user</td>
</tr>
<tr>
<td>Tab navigation</td>
<td>Task 1 and 2</td>
</tr>
<tr>
<td>User data input</td>
<td>Task 1: Age, gender, height and weight</td>
</tr>
<tr>
<td></td>
<td>Task 2: Weight</td>
</tr>
<tr>
<td>Saving user data</td>
<td>Tasks 1 and 2</td>
</tr>
<tr>
<td>Edit user data</td>
<td>Task 2</td>
</tr>
<tr>
<td>Initiating the measurement</td>
<td>Tasks 1 and 2</td>
</tr>
<tr>
<td>Switching the unit off</td>
<td>Tasks 1 and 2</td>
</tr>
</tbody>
</table>

### 6.4.2 Coding heuristics

The coding heuristics were based on the earlier study of intuitive interaction (Blackler, Popovic, et al., 2010). There are altogether seven codes used for coding the tasks in this experiment. These codes are listed in Table 6.5, with their descriptions and examples. Some of these codes have modifiers attached. Modifiers provide further granularity to the coding data. For example, if a participant had made an error (which is coded error) but had subsequently used a trial and error strategy to execute that event successfully, that completed event is coded as correct non-intuitive use with modifier trial and error.
Table 6.5 Coding Scheme

<table>
<thead>
<tr>
<th>No</th>
<th>Code</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Task start</td>
<td>Task starts when the user switches the device on</td>
<td>Switching on the device</td>
</tr>
<tr>
<td>2</td>
<td>Task stop</td>
<td>Task ends when the user switches the device off</td>
<td>Switching off the device</td>
</tr>
<tr>
<td>3</td>
<td>Intuitive</td>
<td>Successful completion of an event intuitively</td>
<td>Switching off the device without hesitation or evidence of reasoning</td>
</tr>
<tr>
<td></td>
<td>correct use</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Correct use</td>
<td>Successful completion of an event with reasoning</td>
<td>Wondering which buttons change user data and making a right choice based on the reasoning</td>
</tr>
<tr>
<td>5</td>
<td>Error</td>
<td>Unable to complete an event or using a wrong function</td>
<td>Using horizontal navigating (instead of up/down) buttons to change user data</td>
</tr>
<tr>
<td>6</td>
<td>Help (clue)</td>
<td>Indirect help; asking user to try again by going back or by repeating the step (provided after at least 30 seconds from the point of error)</td>
<td>Trying to edit user data by tapping display area instead of using buttons on the control panel; help Clue: asking them to look at the control panel</td>
</tr>
<tr>
<td>7</td>
<td>Help (explicit)</td>
<td>Direct help: giving the participant a direct clue that will help them finish the event (provided after at least 2 minutes from the initial help/clue)</td>
<td>Trying to enter user data edit-mode by tapping display area instead of using buttons on the control panel. Help Explicit: asking them to try direction buttons.</td>
</tr>
</tbody>
</table>

Of the seven codes listed in Table 6.5 two were used to code duration of the tasks. These are simple codes whose operation is very similar to that of a stopwatch. However, other codes are a bit more complex and need explanation, especially the code intuitive use.

**Intuitive use:** As intuitive process does not involve conscious reasoning, it is one of the most difficult codes to operationalise (Blackler, 2008; Hurtienne, 2009). Blackler (2010), based on her work on the nature of intuitive interaction, suggests that an intuitive use can be recognised by five
indicators: 1) Lack of evidence of conscious reasoning (An intuitive use is often based on very fast decision making with no evidence of reasoning. There is often a lack of verbalisation and, at times, verbalisation follows an action.); 2) Expectation (Participants with very specific prior knowledge about the event are certain about the outcome of their actions.); 3) Subjective certainty of correctness (Confidence of participants executing an event.); 4) Response latency (When a participant executes an event quickly without hesitation.); and, 5) Prior knowledge (When participants indicate their earlier encounter with a similar event). All of this information was extracted from audio video recording of the concurrent verbal protocol.

An event was coded as intuitive use only when a participant showed two or more of the above indicators (Blackler, 2008). The most certain way of recognising an intuitive use is when an event is executed quickly without hesitation, and when verbalisation follows the action. However, in a study such as this where participants with very diverse sensorimotor and cognitive abilities are involved, it becomes difficult to establish a baseline for both of these indicators.

It is well established that ageing slows down motor responses and this slowdown is not linear (Fisk, 2004; Fisk et al, 2009). In other words, two people might share the same chronological age but may have very different reaction times. Moreover, the concurrent verbal protocol does not provide indicator data as many older people found it very difficult to deliver concurrent verbal protocol when the task became difficult.

These issues were resolved by establishing a baseline response time for each participant. Each participant’s observational data was coded multiple times until the differences between correct non-intuitive use and intuitive use was clearly recognisable. To further minimise coding errors, two independent experienced raters coded the audio-visual recording.

**Correct use:** Participant completed an event successfully with the use of reasoning or when they had learnt from earlier error. Use of reasoning is
indicated by: hesitation in action, latency between the exposure to the event and response, and verbalisation preceding the response.

**Error:** This code is used when a participant is unable to complete an activity. Indicated by their using a wrong function or overlooking it.

**Help CLUE:** Participants were provided a clue after 30 seconds from the time they made an error. This is indirect help where participants were asked to look at the features of the controls more closely and re-try. This was mostly to give participants a chance to step back and revisit the problem.

**Help EXPLICIT:** If the clue did not help the participants in recovering from the error they were provided with direct help after 2 minutes from the time they were provided with the clue. Explicit help provided participants with step-by-step information on how to complete the event.

The codes intuitive-*use* and correct non-intuitive use used the following four modifiers: learnt, prior knowledge, trial and error and with help. These modifiers allowed coding heuristics to take care of the knowledge acquired or learnt during the course of completing the tasks. For example, in many cases, participants in the first instance attempted an event non-intuitively. However, when they encountered the same event during a subsequent task, they intuitively completed the event. This was coded intuitive *use* with the modifier learnt attached to it.

The data collected from all the modifiers are not presented in the results section as they were mostly used to understand the decision making process of the participants. Moreover, the way the modifiers were implemented, they only provide numeric data of how many times they occurred but do not tell when during the task and for which event. This makes it impossible to statistically analyse the modifiers data. However, the modifier learnt did influence the development of the intuitively learnable interfaces model discussed in 8.3.2.
6.5 Results

The data collected for this experiment was analysed using two statistical analysis methods. First, ANOVA was used to measure effects of age and interface on different dependent variable (DVs). Second, the linear regression model was used to analyse the effects of cognitive measures data on the same DVs.

6.5.1 Technology prior experience, interface type and age

Participants’ score from the Technology Prior Experience Questionnaire were split into three equal groups, Low (11 to 40%), Mid (41 to 70%) and High (71 to 100 %). In this sample of participants, the lowest combined score of all three parts of the Technology Prior Experience Questionnaire was 11 % and the highest score was 99%.

As expected, the results suggest a negative correlation between technology prior experience (TP) and time to complete the task, $r(49) = -.59$, $p < .001$. Younger people also tended to score higher on TP and were more likely to use interfaces faster than older people. As can be seen in Figure 6.6 the variability in time to complete the task increases with age, with the younger group being more homogeneous than the older age group.
Figure 6.6: Box plots for time on task by three age groups

On the other hand, contrary to what was expected, participants with mid and low TP scores took more time to complete the tasks on the redundant interface (text and symbols) than did those on the words-only interface (Figure 6.7). An ANOVA with interface types (words-only, symbols-only, redundant) and TP scores (Low, Mid, High) was used to test differences between means for significance.

As the Levene’s test revealed a breach of homogeneity $F(4, 41) = 5.9, p < .001$, a strict alpha level of .025 was applied for this ANOVA (Keppel & Wickens, 2004). TP had a significant effect on time to complete the task: $F(2, 41) = 8.7, p = .001, \eta_p^2 = 0.30$. It is evident from Figure 6.7 that people with Mid and High TP scores performed significantly better than the people with a Low TP score. TukeyHSD post-hoc tests revealed that the Low TP group (11 to 40% score) took significantly more time to complete the tasks compared with Mid ($p = .013$) and High TP ($p = .002$) groups.
Interface type also had a significant impact on time to complete the task: $F(2, 41) = 5.9, p = .006, \eta^2 = .22$. TukeyHSD post-hoc tests reveal that the participants took most time to complete the tasks on the symbols-only interface compared with the words-only ($p = .045$) and the redundant ($p = .037$) interfaces. The difference in time to complete the tasks between the words and redundant was not significant.

Similar to time on task, participants with low and mid level TP found words only interface more intuitive to use. As the Levene’s test revealed a breach of homogeneity $F(8, 41) = 3.06, p = .009$, a strict alpha level of .025 was applied for this ANOVA (Keppel & Wickens, 2004). TP had a significant effect on intuitive uses: $F(2, 41) = 8.4, p = .001, \eta^2 = 0.29$. It is evident from Figure 6.8 that people with Mid and High TP scores used the interface more intuitively than the people with a Low TP score. TukeyHSD post-hoc tests revealed that the Low TP group (11 to 40% score) used interfaces

Figure 6.7: Technology prior experience and interfaces
significantly less intuitively compared with Mid ($p = .013$) and High TP ($p < .001$) groups.

![Figure 6.8: Technology prior experience and intuitive uses](image)

However, interface type did not have significant effect on intuitive uses: $F(2, 41) = 3.6$, $p = .034$, $\eta^2_p = 0.15$. On the other hand, the effect size is quite large.

On the other hand, Interface type had a significant impact on errors: $F(2, 41) = 8$, $p = .001$, $\eta^2_p = .28$ (Figure 6.9). TukeyHSD post-hoc tests revealed that the participants made most errors on the symbols-only interface compared with the words-only ($p = .003$) and there was no significant difference between words-only and redundant interfaces. TP also had a significant effect on errors: $F(2, 41) = 3.4$, $p = .042$, $\eta^2_p = 0.14$. However there were no significant differences between TP levels.
6.5.2 Effects of age and interface on DVs

All results presented in this section are two-way ANOVAs that reveal effects of interface design type (symbols-only, words-only, redundant) and age groups (18 to 39 years, 40 to 64 years, 65+ years) on the DVs time to complete the task, percentage of intuitive uses, errors and help to recover from errors.

Time to complete tasks

Breach of homogeneity was revealed by Levene’s test: $F(8, 41) = 3.2, p < .05$. For this reason a strict alpha level of .025 was applied for this ANOVA (Keppel & Wickens, 2004). An inspection of Figure 6.10 reveals that the effect of age was much larger for the redundant and the symbols-only interface than it was for the words-only interface. The difference was reflected in a significant age by type of interface interaction: $F(4, 41) = 11.24, p = < .001, \eta^2 = .52$. 

Figure 6.9: Technology prior experience and errors
Age had significant effect on time to complete the task: $F(2, 41) = 67.13, p < .001, \eta^2_p = 0.77$. It is evident from Figure 6.10 that the younger age group performed better than older age groups. TukeyHSD post-hoc revealed significant differences between all three age groups ($p < .001$). The 18 to 39 years group took least time ($M = 168$ seconds, $SD = 72$ seconds) followed by the 40 to 44 years group ($M = 314$, $SD = 136$), and the 65+ years group ($M = 525$, $SD = 198$). The SDs also reveal that variations within the groups increased with age.

The type of interface also had a significant impact on time to complete the task: $F(2, 41) = 17.41, p < .001, \eta^2_p = .46$. TukeyHSD post-hoc tests revealed a significant difference between the symbols-only interface compared with the words-only ($p < .001$) and the redundant ($p < .001$) interfaces. There was no significant difference between interface types words-only and redundant. All three age groups took more time on the symbols-only interface ($M = 441$, $SD = 270$) compared with words-only ($M = 287$, $SD = 119$) and redundant ($M = 287$, $SD = 173$) interfaces.

Figure 6.10: Time to complete task, age groups and interface level
Analysis of simple effects for the age by interface type interaction showed that there was significant age differences in interface type: symbols-only, [\(F(2,41) = 57.48, p < .001, \eta_p^2 = .74\)], redundant [\(F(2,41) = 24.60, p < .001, \eta_p^2 = .55\)], and words-only, \(F(2,41) = 6.70, p = .003, \eta_p^2 = .25\).

Table 6.6: Pairwise comparisons of differences of mean (time on task), with the Bonferroni correction.

<table>
<thead>
<tr>
<th></th>
<th>18 to 39 years</th>
<th>18 to 39 years</th>
<th>40 to 64 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 to 64 years</td>
<td>65+ years</td>
<td>65+ years</td>
</tr>
<tr>
<td>Words</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(P = .007^*)</td>
<td>(P = .015^*)</td>
<td>(P = 1)</td>
</tr>
<tr>
<td>Symbols</td>
<td>(P &lt; .001^*)</td>
<td>(P &lt; .001^*)</td>
<td>(P &lt; .001^*)</td>
</tr>
<tr>
<td>Redundant</td>
<td>(P = 1)</td>
<td>(P &lt; .001^*)</td>
<td>(P &lt; .001^*)</td>
</tr>
</tbody>
</table>

* Significant interaction

As can be seen from Table 6.6 and as illustrated in Figure 6.10, the effect of age was significant between all age groups for the symbols-only interface. The 18 to 39 years group taking least time (\(M = 163\ SD = 41\)), followed by the 40 to 65 (\(M = 394\ SD = 146\)) and 65+ age groups (\(M = 775\ SD = 82\)). The differences with the redundant interface were only significant between the 65+ age group and the two younger groups. The 65+ age group took significantly more time (\(M = 426\ SD = 99\)) on the redundant interface compared with the 18 to 39 (163 \(M = SD = 86\)) and 40 to 64 age groups (171 \(M = SD = 30\)). The differences for the words-only interface were significant between the 18 to 39 year group and the two older age groups. However, there was no significant time difference between the 40 to 65 year group (\(M = 360\ SD = 62\)) and the 65+ age groups (\(M = 343\ SD = 109\)). Interestingly, as can be seen from Table 6.7, older people took less time using the words-only interface (\(M = 343, SD = 109\)) compared to the redundant interface (\(M = 476, SD = 99.31\)).
Table 6.7: Descriptive statistics for time on task

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Interface</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 to 39 years</td>
<td>Symbols</td>
<td>163</td>
<td>41</td>
<td>5</td>
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<tr>
<td></td>
<td>Words</td>
<td>180</td>
<td>88</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Redundant</td>
<td>163</td>
<td>86</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>169</td>
<td>72</td>
<td>17</td>
</tr>
<tr>
<td>40 to 64 years</td>
<td>Symbols</td>
<td>394</td>
<td>146</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Words</td>
<td>360</td>
<td>62</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Redundant</td>
<td>171</td>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>314</td>
<td>136</td>
<td>16</td>
</tr>
<tr>
<td>65+ years</td>
<td>Symbols</td>
<td>775</td>
<td>82</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Words</td>
<td>343</td>
<td>109</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Redundant</td>
<td>476</td>
<td>99</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>525</td>
<td>198</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>Symbols</td>
<td>441</td>
<td>270</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Words</td>
<td>287</td>
<td>119</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Redundant</td>
<td>287</td>
<td>173</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>336</td>
<td>206</td>
<td>50</td>
</tr>
</tbody>
</table>

**Percentage of Intuitive uses**

An inter-rater reliability analysis using the Kappa statistic was performed to determine consistency of coding for intuitive use between the two raters. The inter-rater reliability for coding intuitive uses by the two raters was found to be Kappa = .77 (p < .001). Kappa values between 0.60 to 0.79 are considered to indicate substantial agreement between the raters (Landis & Koch, 1977).

Younger people used the interface more intuitively than older people (Figure 6.11). Older people used the interfaces less intuitively and also found the words-only interface more intuitive to use. An ANOVA revealed significant effects of age - F(2, 41) = 28.16, p < .001, ηp^2 = .58 - on intuitive use of interface. TukeyHSD post-hoc tests revealed that the 65+ age group differed significantly from the other two age groups, 18 to 39 (p < .001) and 40 to 64 years (p < .001). The 65+ year group used the interfaces
significantly less intuitively (\(M = 32, SD = 23\)) compared to the 18 to 39 (\(M = 68, SD = 13\)) and 40 to 64 year (\(M = 58, SD = 20\)) groups.

Type of Interface also had a significant effect on the percentage of Intuitive use; \(F(2, 41) = 7.56, p = .002, \eta_p^2 = 0.270\). Tukey HSD post-hoc tests revealed that the symbols-only interface significantly differed from The words-only (\(p = .002\)) and redundant interfaces (\(p = .019\)). All age groups used the symbols-only interface (\(M = 41, SD = 23\)) least intuitively compared with the words-only (\(M = 60, SD = 22\)) and redundant (\(M = 56, SD = 20\)) interfaces.

Figure 6.11: Intuitive use, age groups and interfaces

The interaction effect between interface type and age was not significant, \(F(4, 41) = 2.0, p = .118, \eta_p^2 = .16\). However, while the effect size of the interaction was large, the experiment lacked the power to detect it. Effect size was estimated based on the guidelines suggested by Cohen (1988).

Percentage of errors and error recovery

Older people also made more errors on the redundant interface when compared with the words-only interface (Figure 6.12). This was reflected in
a significant age by type of Interface interaction, $F(4, 41) = 4.3, p = .005, \eta^2_p = .29$.

Age had a significant effect on the percentage of errors made, $F(2, 41) = 11.3, p = < .001, \eta^2_p = 0.35$. TukeyHSD post-hoc tests revealed that the 65+ year group differed significantly from the other two age groups: 18 to 39 ($p < .001$) and 40 to 64 years ($p = .007$). The 65+ year group made significantly more errors ($M = 23, SD = 10$) compared to the 18 to 39 ($M = 12, SD = 7$) and 40 to 64 years ($M = 15, SD = 7$) groups.

Type of Interface also had a significant effect on the percentage of errors made: $F(2, 41) = 10.8, p < .001, \eta^2_p = .34$. TukeyHSD post-hoc tests revealed that the symbols-only interface significantly differed from the words-only ($p < .001$) and redundant interfaces ($p = .015$). All age groups made most errors on the symbols-only interface ($M = 22, SD = 10$) and least errors on the words-only ($M = 12, SD = 7$) followed by the redundant ($M = 16, SD = 9$) interfaces.

Figure 6.12: Errors, age groups and interfaces
Analysis of simple effects for the age by interface type interaction revealed that there was a significant age difference for interface type: symbols-only, $F(2,41) = 11.57, p < .001, \eta_p^2 = .36$; and redundant $F(2,41) = 7.15, p = .002$, $\eta_p^2 = .26$. Contrasts have revealed that, as shown in Table 6.8, the 65+ group differed significantly from the 18 to 39 ($p < .001$) and 40 to 64 years ($p = .005$) age groups on the symbols-only interface. Similarly, on the redundant interface the 65+ group differed significantly from the 18 to 39 ($p = .035$) and 40 to 64 years ($p = .003$) age groups. However, on the words-only interface there were no differences between age groups. Overall, the 65+ age group made more errors on the symbols-only interface ($M = 34, SE = 3$) followed by the redundant ($M = 23, SE = 2$) and words-only ($M = 11, SE = 3$) interface.

Table 6.8: Pairwise comparison for means (percentage of errors), with the Bonferroni correction.

<table>
<thead>
<tr>
<th></th>
<th>18 to 39 years</th>
<th>40 to 64 years</th>
<th>18 to 39 years</th>
<th>65+ years</th>
<th>40 to 64 years</th>
<th>65+ years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Words</td>
<td>$P = .336$</td>
<td>$P = 1$</td>
<td>$P = .931$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symbols</td>
<td>$P = .415$</td>
<td>$P &lt; .001^*$</td>
<td>$P &lt; .005^*$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redundant</td>
<td>$P = .903$</td>
<td>$P &lt; .035^*$</td>
<td>$P &lt; .003^*$</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significant interaction

Not only did older participants make more errors they also needed most help in recovering from the errors. There was a significant effect of age, $F(2, 27) = 14.36, p < .001, \eta_p^2 = 0.60$, on the help required to recover from the errors. TukeyHSD post-hoc tests revealed that the 65+ year group differed significantly from the other two age groups, 18 to 39 ($p < .001$) and 40 to 64 years ($p < .001$). The 65+ years group needed most help to recover from the errors ($M = 2.4, SD = 1.2$) compared to the 18 to 39 ($M = 0.5, SD = 0.5$) and 40 to 64 year ($M = 0.5, SD = 0.5$) groups.

An inspection of Figure 6.13 reveals that the effect of age was much larger for the symbols-only and the redundant interface than it was for the words-
only interface. The difference was reflected in a significant age by type of interface interaction, $F(4, 27) = 2.05, p = .040, \eta_p^2 = .30$.

![Figure 6.13: Error recovery with help, age groups and interfaces.](image)

Analysis of simple effects revealed that there were significant age differences for the interface type symbols-only, $F(2,27) = 9.48, p = .001, \eta_p^2 = .41$, and the redundant $F(2,27) = 11.95, p < .001, \eta_p^2 = .56$. However, there was no significant effect for the words-only: $F(2,27) = .75, p = .483, \eta_p^2 = .053$. Contrasts revealed that, as shown in Table 6.9, the 65+ group differed significantly from the 18 to 39 years ($p = .002$) and 40 to 64 year ($p = .004$) age groups on the symbols-only interface. Similarly, on the redundant interface the 65+ group differed significantly from the 18 to 39 year ($p = .002$) and 40 to 64 year ($p < .001$) age groups. However, as can be seen in Figure 6.13, on the words-only interface there were no differences between the age groups. Overall, the 65+ age group needed most help to recover from errors on the symbols-only interface ($M = 3.0, SE = 0.5$) followed by the redundant ($M = 2.8, SE = 0.3$) and words-only ($M = 1.2, SE = 0.4$) interface.
Table 6.9: Pairwise comparison of means (error recovery with help), with the Bonferroni correction

<table>
<thead>
<tr>
<th></th>
<th>18 to 39 years</th>
<th>18 to 39 years</th>
<th>40 to 64 years</th>
<th>40 to 64 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40 to 64 years</td>
<td>65+ years</td>
<td>65+ years</td>
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<tr>
<td>Words</td>
<td>$P = .1$</td>
<td>$P = 1$</td>
<td>$P = .772$</td>
<td></td>
</tr>
<tr>
<td>Symbols</td>
<td>$P = .791$</td>
<td>$P = .002^*$</td>
<td>$P &lt; .004^*$</td>
<td></td>
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<tr>
<td>Redundant</td>
<td>$P = .640$</td>
<td>$P = .002^*$</td>
<td>$P &lt; .001^*$</td>
<td></td>
</tr>
</tbody>
</table>

* Significant interaction

6.5.3 Regression analysis of cognitive measures data

The effects of cognitive measures on participants’ performance using the mediator product were explored using regression analysis. Scores for cognitive measures, visuospatial sketchpad capacity, phonological transformation response time and sustained attention were entered as IVs and, *time on task, percentage of intuitive uses* and *errors* were entered as DVs.

A bivariate correlation analysis has shown that visuospatial sketchpad capacity, phonological transformation response time and sustained attention scores correlate significantly with the DVs of this experiment (Appendix 6). However, as the analysis revealed that IVs also inter-correlate significantly with each other, multiple regression was used to assess the unique contributions of IVs on different DVs. Preliminary analyses were conducted to ensure that assumptions of normality, linearity and multicollinearity was not breached.

**Age**

As *age* is a mediator factor, it was not entered as an IV in the regressions model. However, this section presents regression analysis using age as a DV and cognitive measures scores as IVs to reveal the effect of age on the performance of participants on cognitive measures tests.
Visuospatial sketchpad capacity and response time for phonological transformation task was impacted most by age, (adjusted R square = .484) F(1,45) = 22.569, p < .001 (Stepwise) (Table 6.10). Visuospatial sketchpad capacity is one of the measures of Short-Term memory and transformation response time is one of the measures for central executive function. In the sample of this experiment, age significantly correlates with decline in visual sketchpad capacity and central executive function.

Table 6.10 Results of multiple regression for age

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>73.525</td>
<td>12.036</td>
<td>6.109</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Corsispan</td>
<td>-7.64</td>
<td>1.875</td>
<td>-4.093</td>
<td>.001</td>
<td>.126</td>
</tr>
<tr>
<td>PhonotransformRT</td>
<td>.001</td>
<td>.000</td>
<td>.3934</td>
<td>.000</td>
<td>.174</td>
</tr>
</tbody>
</table>

In the following sub-sections, scores from all cognitive measures tests were entered into a linear regression model, using stepwise method, with time to complete the task, percentage of intuitive uses, and errors as its DVs.

**Time on Task**

Multiple regression analysis of the data showed that the visuospatial sketchpad capacity and phonological transform response time significantly correlated with time to complete the task, percentage of intuitive uses, and errors as its DVs. Adjusted R square = .308  F(2,44) = 11.25, p < .001.

Table 6.11 Results of multiple regression for time to complete the task

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
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<td>142.881</td>
<td>3.717</td>
<td>.001</td>
<td></td>
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<tr>
<td>Corsispan</td>
<td>-64.568</td>
<td>22.260</td>
<td>-2.901</td>
<td>.006</td>
<td>.126</td>
</tr>
<tr>
<td>PhonotransformRT</td>
<td>.005</td>
<td>.002</td>
<td>.354</td>
<td>.008</td>
<td>.115</td>
</tr>
</tbody>
</table>
Both visuospatial sketchpad capacity and phonological transformation response times are both affected most by age. This result is similar to ANOVA that showed that age significantly correlates with time to complete the task.

**Intuitive uses**

Similarly, the score on Go/No go task, a measure of sustained attention, has most impact on the number of intuitive uses: adjusted R square = .150 F(1,45) = 9.15, p = .004 (Table 6.12).

Table 6.12 Results of multiple regression for percentage of intuitive uses

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
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<tr>
<td>(Constant)</td>
<td>26.172</td>
<td>9.586</td>
</tr>
<tr>
<td>Go/No go 2d</td>
<td>9.890</td>
<td>3.276</td>
</tr>
</tbody>
</table>

Sustained attention is one of the functions of central executive. Interestingly, chronological age, in this sample, had no significant effect on performance on sustained attention task.

**Errors**

Sustained attention had most impact on the *percentage of errors mad*:

adjusted R square = .160 F(1,45) = 8.55, p = .005 (Table 6.13).

Table 6.13 Results of multiple regression for percentage of Errors

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
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</thead>
<tbody>
<tr>
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<td>Std. Error</td>
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<tr>
<td>(Constant)</td>
<td>28.162</td>
<td>4.262</td>
</tr>
<tr>
<td>Go/No go 2d</td>
<td>-4.259</td>
<td>1.456</td>
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</tbody>
</table>
Similar to intuitive use results, sustained attention had significant effect on percentage of errors made. Figure 6.14 shows the scatter plot for age and three cognitive measures scores presented in these results.

Figure 6.14: Performance on cognitive tasks and chronological age
As can be seen, visuospatial sketchpad capacity (CorsiSpan) declines with age in a linear fashion. Phonological transform response time (PhonologicaltransformRT) increase with age, and its variability also increases as age progresses. On the other hand, sustained attention (pgng2d) decline is a little more varied. Both transformation response time and attention are functions of central executive. This shows that age-related cognitive decline is not linear, and it not only varies from person to person but also between different cognitive functions.

6.5.4 Age, technology prior experience, performance on task and cognitive ability

Cognitive ability plays a mediator role in the relationship between age, technology prior experience and performance on various tasks. For example, scatter plots (Figure 6.15) of time on task, TP, age and sustained attention from the Experiment 1 data clearly show that, although some cases scored high on the TP (for example, case 37 in the plots; red arrow), they took more time on the task. However, as can be seen in the second plot, their score for sustained attention is low. In some cases, it is the reverse (for example, case 2 in the plots; green arrow); they scored low on TP, high on sustained attention and took less time on task. This data suggests that cognitive ability is a mediating variable for the time on task and prior experience relationship.
Figure 6.15: Scatter plots showing how sustained attention mediates the relationship between technology prior experience, age and time to complete the task
6.6 Discussion

Contrary to what was hypothesised, older participants (65+) were significantly faster on the words-only interface when compared to the redundant and symbols-only interfaces. All age groups found the words-only interface more intuitive to use. Similarly, participants who had scored low on technology prior experience also took less time to complete the task on the words-only interface than the on redundant interface. On the other hand, all three technology prior experience scores groups and age groups took most time to complete the tasks using the symbols-only interface. The most probable reason could be that symbols are inherently ambiguous to interpret compared with words or text. Unlike verbal language, symbols do not have a set syntactic and semantic rules that helps in interpreting them with certainty (Yvonne, 1989). However, it was also observed that the delivery of concurrent verbal protocol could have had an impact on time to complete the task in older people. Mostly because, concurrent protocol puts additional burden on already limited cognitive resources of very old participants especially when the task gets difficult.

Older people also made significantly fewer number of errors on the words-only interface compared with the redundant interface. Interestingly, there were no significant age differences between all three age groups in terms of errors made on the words-only interface. This is consistent with an earlier study that suggests that words-based interface produce fewer errors compared to symbols-only interfaces (Camacho et al., 1990).

Older participants needed most help in recovering from errors and completing the task successfully. They received most help in recovering from errors on the symbols-only interface followed by the redundant interface. On the other hand, younger participants needed least help on the redundant interface followed by the words-only and symbols-only interfaces. Here again, there were no significant age differences on the words-only interface.
These findings support some aspects of the literature discussed in Section 4.2 that investigated differences between symbols-only and alphanumeric (text and numbers) interfaces mostly with younger people. Schröder and Ziefle (2008b) found that words-only interface was much faster and efficient to use compared to symbols-based interfaces (participants age < 32 years). Similarly Camacho et al. (1990) report that the text-based interface produced fewer errors compared to icon-based interface display. However, in a related study Steiner and Camacho (1989) found that when the quantity of the data presented was increased beyond eight bits of information, participants performed better on the icon-based display compared with text-based display of the information. However, both these studies used participants who were experts in the area and were below 67 years of age. A study that investigated learnability of interfaces found that text-based interfaces are more efficient to learn during early encounter compared to redundant and symbols-based interfaces (Wiedenbeck, 1999). This study again used participants with a mean age of 21.5 years of age.

In general, Experiment 1 showed that older participants and participants with low prior experience used words-only interface more intuitively, faster and with fewer number of errors compared with redundant and symbols-only interfaces. In addition, there were no differences between all three age groups in terms of errors on the words-only interface. Both these findings are quite unexpected because of the well-used recommendations for redundant interface design. However, there are few possible explanations for these surprising findings.

Both the redundant and symbols-based product interfaces used in trials were very visual in nature. Jenkins, Myerson, Joerding, and Hale (2000) suggest that ageing adversely affects visuospatial information processing and memory for spatial information more than verbal information processing. They also report that older adults are slower when processing visuospatial information compared with verbal information and also find it more difficult to cope with novel visuospatial information than with novel
verbal information. Older people, compared to younger people, have more difficulties in temporarily storing and actively manipulating visuospatial information (Borella, Carretti, & Beni, 2008; Jenkins et al., 2000). The regression analysis of cognitive measures data from Experiment 1 also showed that visuospatial sketchpad capacity is affected most by ageing and it is also one of the significant factors that influenced time to complete the task.

This provides an explanation for older people taking more time on redundant and symbols interfaces. In a redundant interface the amount of information to process is twice that of a words-only interface; this results in more stress on already limited visuospatial processing resources. On the other hand, age-related cognitive decline does not impact verbal processing and the age differences are minimal (Bäckman et al., 2001). This may be a reason why the performance of older people on the words-only interface was on a par with younger age groups in terms of errors.

Performance of older people on words-only interface also supports the Processing-speed Theory, proposed by Salthouse (1996) which suggests that, while ageing causes a slowing down of processing speed, the performance differences between young and old would be minimal if older people were allowed more time on the task. On the words-only interface, although older participants took more time to complete the task, there were no significant age differences in terms of errors made.

The findings of the Experiment 1 also suggest that a negative correlation exists between technology prior experience and time to complete the task. Younger people scored higher on Technology Prior Experience Questionnaire and used interfaces faster than older people. These findings are consistent with earlier studies. However, recent research (O’Brien et al., 2010) found that, even when the technology prior experience is controlled, there were still age differences. O’Brien attributes these differences to age-related deficits in information processing.
As shown in the Section 6.5.4, cognitive ability plays a moderator role in relationship between technology prior experience, age and performance on task. In Experiment 1 although some participants scored high on Technology Prior Experience, they took more time. This supports literature that notes that the working memory capacity is crucial for accessing and processing long-term memory. People who are deficient in central executive function find it difficult to consider alternative actions to find the most appropriate one for the situation (Wickens et al., 2004). On the other hand, there were some cases with a low technology prior experience score but with high cognitive abilities and less time on task. These participants, because of better cognitive abilities, could learn the interface on the task more efficiently.

Cognitive capability, especially central executive function, plays a crucial role not only in the retrieval and processing of information from long-term memory, but also in acquiring this information (Langdon et al., 2010; Lim, 2009). In short, both cognitive abilities and domain-specific prior knowledge are essential for successful use of product interfaces. Cognitive ability influences retrieval and application of relevant knowledge. It is also essential for efficiently learning unfamiliar features in the interface.

Other recent research also suggests a correlation between central executive function and time on task (Blackler, Mahar, et al., 2010; Lewis et al., 2008; Lewis, Langdon, & Clarkson, 2006). The results from this experiment not only support existing research about the relationship between central executive and performance on a task, but also identify correlations between subcomponents of central executive with the task performance: visual sketchpad capacity and phonological transformation response time had most impact on time to complete the task; sustained attention had most impact on Intuitive uses and number of errors made. Controlling and directing attention is one of the key functions of central executive (Morrison, 2005).
Finally, most of the studies available in this area (and discussed here and in Section 4.2) used younger participants, or age groups with a narrow range; this makes it difficult to analyse age differences. By contrast, Experiment 1 used a wider and continuous range of ages - from 18 to 83 years; this made analysis of age differences, in the context of the existing literature, much more robust. Overall, the finding support the literature that suggests that graphics-intensive interfaces can increase extraneous cognitive load and can hamper learning of their functionality (Feinberg & Murphy, 2000; Sweller, 1994). On the other hand, Experiment 1’s findings do not support the literature that recommends the use of redundancy (symbols and descriptive text to define the function of a button) to help in using an interface intuitively (Blackler, 2008; Gould & Schaefer, 2005). Also, an often recommended strategy in the usability literature to use redundancy in interface for its effectiveness in message comprehension, for example (Barfield & Furness, 1995; Cooper et al., 2007; Shneiderman & Plaisant, 2005), may not be very beneficial for older users.

In addition, some of the research suggests that, once the interface is learnt, symbols-only based interfaces are more efficient compared to text-based interfaces (Camacho et al., 1990; Wiedenbeck, 1999). The advantages of symbols are that they are much easier to learn and remember, because of their strong visual and spatial qualities. Although Experiment 1 had two tasks, it did not find any significant change in participants’ performance between the tasks in terms of learning. However, the tasks were performed back to back; probably, if the time gap had been longer, some effects of learning might have been detected.

Experiment 1 also highlights variability in older age groups in time to complete the task and errors made, when compared to the more homogenous younger group. Similarly, there is significant variability in technology prior experience scores and cognitive abilities in the older adults, both of which influenced time to complete the task and number of errors made. Overall, older participants (65+) used the words-only interface
faster, more intuitively, with fewer number of errors and with very little help in recovering from errors.

6.7 Summary

This experiment was designed to investigate if redundancy in product interface design facilitates intuitive use of complex products in older people. The experiment involved participation of people of aged between 18 and 83 years. The results of this experiment suggest a strong correlation between technology prior experience and time on complete the task. Contrary to what was hypothesised, older people (65+ years) completed the tasks on the words-only interface faster than on the redundant interface. On the other hand, younger participants (<65 years) completed the tasks significantly faster on the redundant interface. Moreover, all three age groups used the words-only interface more intuitively compared with the redundant and symbols-only interfaces. Interestingly, there were no age differences in terms of errors on words-only interface. This suggests that, although older people used words-based interface less intuitively than younger age groups, they were able to learn the features and functions of the product and use them successfully.

From a cognitive processing perspective, as anticipated, the central executive function (a component of working memory) has emerged as one of the most important cognitive functions in using complex interfaces. The strongest negative correlations were observed between sustained attention (one of the functions of the central executive), and participants’ intuitive uses and the number of errors made. Similarly, visuospatial sketchpad and phonological transformation response time had most impact on time to complete the tasks. It was also observed that, when compared with younger people, the older people took more time to recover from mistakes and also tended to get more anxious when the task became difficult.

Chapter 7 discusses Experiment 2, which investigated the effect of complexity in an interface structure on use of contemporary technological product interfaces by younger and older people under both stressful and non-stressful conditions.
Chapter 7
Experiment 2: Complexity of Interface structure,
Anxiety and Intuitive Use
7.1 Introduction

Chapter 6 presented Experiment 1. Contrary to what was hypothesised, results from Experiment 1 suggest that redundancy does not help older people in using interfaces intuitively. Older people found the words-based interface much easier to use when compared with the redundant and symbols-based interfaces. Furthermore, Experiment 1 showed that the central executive function (a component of working memory) is one of the most important cognitive functions for using complex interfaces with ease.

This chapter presents and discusses results from Experiment 2. Experiment 2 was designed to investigate the effect of complexity in an interface structure (nested/multi-level versus flat/broad) on use of contemporary technological product interfaces by younger and older people under both stressful and non-stressful conditions.

7.2 Method

7.2.1 Experiment design

The objective of this experiment was to investigate the relationship between age, anxiety, and intuitive use of complex interface structure (nested versus flat). Based on the literature reviewed, the following hypotheses were framed to investigate this relationship.

1. That nested interface structure will have an adverse effect on time to complete the task, percentage of intuitive uses and percentage of errors on older participants and participants with low technology prior experience when compared with younger participants.

2. That participants who score low on the Technology Prior Experience Questionnaire will also report low on the Self-efficacy Questionnaire and report high anxiety on the State-Trait Anxiety Inventory (STAI) questionnaire.
3. That anxiety, induced by stressful conditions, will have an adverse impact on the time to complete the task, and the percentage of intuitive uses and errors in both younger and older participants.

This experiment used a mixed-factorial design. The Dependent Variables (DVs) for this experiment were time on task, percentage of errors and percentage of intuitive uses. Independent Variables (IVs) were, interface type, age and anxiety with their levels listed in Table 7.1. Interface type - flat or nested - was repeated factors and low or high stress conditions were the between subjects factors. Levels in the IV age were increased to five (Experiment 1 used 3 groups only) to address the issue of larger variability in older people.

Table 7.1: Experiment design and Independent Variables

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Levels of Independent Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interface type</td>
<td>Repeated measures</td>
</tr>
<tr>
<td></td>
<td>Low complexity – flat/single layer interface</td>
</tr>
<tr>
<td>Age</td>
<td>Young (17 to 34 years)</td>
</tr>
<tr>
<td></td>
<td>Older young (35 to 49 years)</td>
</tr>
<tr>
<td></td>
<td>Younger old (50 to 64 years)</td>
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<tr>
<td></td>
<td>Old (65 to 72 years)</td>
</tr>
<tr>
<td></td>
<td>Older old (73+ years)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>Low stress condition – Positive reinforcement</td>
</tr>
<tr>
<td></td>
<td>High stress condition – Negative reinforcement</td>
</tr>
</tbody>
</table>

In addition, like in Experiment 1, linear regression model was used to
explain the relationship between age related cognitive decline and different DVs.

Participants

Overall 54 participants (29 male, 25 female) between the ages 18 to 84 years ($M = 54$, $SD = 18$) participated in this experiment. Table 7.2 shows the distribution of participants against IVs. They were recruited from different sources to maintain a good sample of the general population. Individuals from organisations (for example, sports clubs, educational institutes, recreational facilities and retirement resorts) were asked if they could volunteer to take part in the study. All the participants were screened for visual acuity (corrected or uncorrected) using a Snellen chart. All participants were given a small gift as a token of appreciation gift (a $3AU worth scratch lottery ticket or coffee voucher) and were entered into a $200AU shopping voucher draw.
Table 7.2: Description of participants demographics and independent variables

<table>
<thead>
<tr>
<th>Interface type</th>
<th>Age groups</th>
<th>Stress</th>
<th>Gender</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat interface</td>
<td>17 to 34 years</td>
<td>High</td>
<td>Female</td>
<td>3</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>Female</td>
<td>4</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>2</td>
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<tr>
<td></td>
<td>35 to 49 years</td>
<td>High</td>
<td>Female</td>
<td>2</td>
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<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>3</td>
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<tr>
<td></td>
<td>Low</td>
<td>Female</td>
<td>1</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>50 to 64 years</td>
<td>High</td>
<td>Female</td>
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<td></td>
<td></td>
<td></td>
<td>Male</td>
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<td></td>
<td>Low</td>
<td>Female</td>
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<td></td>
<td></td>
<td>Male</td>
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<tr>
<td></td>
<td>65 to 72 years</td>
<td>High</td>
<td>Female</td>
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<td></td>
<td>Male</td>
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<td></td>
<td>Low</td>
<td>Female</td>
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<td></td>
<td>Male</td>
<td>2</td>
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<tr>
<td></td>
<td>73+ years</td>
<td>High</td>
<td>Female</td>
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<td></td>
<td>Male</td>
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<tr>
<td></td>
<td>Low</td>
<td>Female</td>
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<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>3</td>
</tr>
<tr>
<td>Nested interface</td>
<td>17 to 34 years</td>
<td>High</td>
<td>Female</td>
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<td></td>
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<td>Male</td>
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<td></td>
<td>35 to 49 years</td>
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<td>65 to 72 years</td>
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<td>Male</td>
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<tr>
<td></td>
<td>73+ years</td>
<td>High</td>
<td>Female</td>
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<td>Male</td>
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<td></td>
<td></td>
<td></td>
<td>Male</td>
<td>3</td>
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</tbody>
</table>
7.2.2 Apparatus and measures

Technology Prior Experience Questionnaire
This was a two-part questionnaire to capture participants’ exposure to, and knowledge of, technologies related to the mediator product used for this experiment (Appendix 6).

Self-efficacy Questionnaire
This questionnaire was based on a well-tested instrument to measure perceived general self-efficacy (GSE) that was suggested by Schwarzer, and Jerusalem (1995). For the specific self-efficacy (SSE), a short questionnaire, as suggested by Cassidy and Eachus (2002) was used (Appendix 8). SSE was specifically designed to measure perceived self-efficacy on using domain-specific technology.

STAI Questionnaire
The State-Trait Anxiety Inventory (STAI) is a self-evaluation questionnaire administered to measure level of state and trait anxiety (Spielberger, 1979). A short form six-question questionnaire was used to measure current state of anxiety (Marteau & Bekker, 1992) (Appendix 9). State anxiety measure was used, instead of technology anxiety, for the experiments because situation-specific anxiety (computer or technology anxiety) exhibits physiological signs that are similar to state anxiety, such as perspiration, sweaty palms, dry mouth, muscle contraction and tension, and increase in heart rate. The STAI questionnaire was used to measure current state of anxiety in participants, as it is a symptom for both trait and state or situation specific anxiety.

Cognitive measures instrument
The cognitive measures instrument (CogLab) used in this experiment was same as that used for Experiment 1. As in Experiment 1, five tasks were used
to measure different components of working memory; the Corsi-span test for visuospatial sketchpad capacity, digit-span for phonological loop capacity, visual and phonological transform tasks for central executive function and a vigilance task was used to measure sustained attention.

A vigilance task was used to measure sustained attention instead of Go/No-Go task used in Experiment 1, as it was found then that the latter was very demanding for the very old (73+) participants. The vigilance task is a test used to measure sustained attention. In this task participants viewed a pair of shapes on the touch-sensitive LCD screen for 1 second. They were then required to respond by tapping the ‘target present’ button on the LCD touch screen whenever the pair consisted of identical shapes. This task was also used to capture the reaction time of the participants.

**Mediator product**

A touch-based device (iPad) was used as the mediator platform for the experiment. This decision was based on observing the increasing use of touch-based interfaces for consumer products.

The mediator interface for this experiment was designed based on the outcome of Experiment 1. Data from Experiment 1 suggested that there was a significant negative correlation between visuospatial sketchpad capacity and time to complete the task and the number of errors. The number of controls in the mediator product for this experiment was kept at 5, to keep it within the visuospatial sketchpad capacity of an average older participant (Charness, 1981; Cowan, 2001). Interface structure was kept at an optimal two levels (Miller, 1981). At the same time, the product interface was designed so that, to avoid floor or ceiling effects, it was not too easy for the younger and not too difficult for the older participants.

The design of the interface and the task difficulty was established based on the outcome of the two pilot studies. The difficulty level was kept slightly below the threshold of failure for the average older participant so as to
investigate effects of anxiety on a relatively easy-to-use product interface. This product also had an elaborate backend administration interface that allowed the researcher to change the application's behavior to suit the levels of IVs.

The tasks for this experiment were designed to emulate a real-life, meaningful situation, as earlier research suggests that involving the participants in the task is very important to gain meaningful data for the experiment (Hawthorn, 2007). The task scenarios were based on the real life situation of pet sitting. Moreover, they provided enough interest for both younger and older participants during the pilot study. The tasks that participants were asked to perform were scripted to make sure all participants went through the same number of steps to complete them successfully.

Figure 7.1 illustrates the layout of the screen with different elements. Interface for the device was displayed only in black, white and grey scales. This was done to control any colour perception issues that the participants might have. However, other elements of the screen were displayed in high contrast colours.

![Image of the screen layout](image)

Figure 7.1: Layout of the screen with different elements: a) performance feedback bar b) message window and c) interface
Figure 7.2 illustrates the two repeated measures, flat and nested conditions. Each condition has 5 menu options. In the flat condition, all the five menu items were presented in a row at the bottom; in the nested condition, they were nested under two pop-up menus, one located on the right and the other one on the left bottom corners.

Figure 7.2: Flat and nested interfaces

Figure 7.3 illustrates two between subject factors, low and high stress conditions. The low stress condition was induced through positive feedback provided through a bar located on the top centre of the screen. Similarly, high stress condition was induced through negative feedback provide through the feedback bar.

Figure 7.3: Positive feedback and negative feedback display bar on the top of the task window
Feedback was not tied to the actual performance of the participant. Depending on the condition (low or high stress) the performance bar changed its status (towards excellent or poor) at certain pre-determined milestones of the task.

In the low stress condition, the feedback given was always positive, no matter what the actual performance of the participant was. Similarly, on the high stress condition, the feedback was negative no matter what the actual performance was.

**Task sheet**

Two task sheets were prepared that described the task scenarios, Play and Walk, for the participants (Appendix 9). They were asked to read the task scenario before they were asked to start on the device.

**7.2.3 Procedure**

As in Experiment 1, Experiment 2 was also conducted in a controlled laboratory setting. The whole experiment was scripted (Appendix 11) to make sure all the participants followed similar patterns of events, timing, sequence of tasks and instructions from the experimenter.

Participants within each age group were randomly assigned to one of the stress conditions, and completed two task scenarios (Play and Walk), one each on a flat and nested interfaces. To avoid sequencing effects, the tasks were counter-balanced by alternating the sequence of interfaces (flat and nested) and two tasks scenarios (Play and Walk) on the device.

Two cameras were used to record the experiment for later analysis using the Observer software (Figure 7.4). One camera was positioned to record participants’ facial expressions and body language; the second camera was positioned to record tasks performed by the participant on the screen.
Figure 7.4: Video recording setup for observational data collection

Once a participant was allocated to a group, they were introduced to the lab environment and, experimental setup, and were screened for visual acuity using the Snellen chart. They were provided with the information package and consent form (Appendix 12). Participants were also informed that they could stop the experiment at any time and could request the deletion of all the record of their participation.

Participants were then provided with the Technology Prior Experience Questionnaire (Appendix 6) followed by the combined General and Specific Self-efficacy Questionnaire. As not all participants were familiar with the mediator platform (iPad), they were asked to use a simple calculator application on the platform to get a feel for the device. This was also done to ensure that the seating and the position of the device was comfortable for the participants, as it was observed during the pilot study that some of the older participants were bothered by the glare that could occur when the device was placed at certain angles and positions.
Once the participants were comfortable with the setup, they were provided with the STAI Questionnaire and were asked to complete it based on their current state. Soon after this they were given the Task 1 scenario sheet, and after making sure they understood what was expected of them, they were asked to start on the task.

Soon after completing Task 1, they were provided with the STAI Questionnaire for the second time to record their current state of anxiety. Once they completed the STAI, they were provided with the Task 2 scenario sheet. After making sure they understood what was expected of them they were allowed to start on the Task 2. Soon after completing the Task 2 they were asked to complete the STAI Questionnaire for the third and final time.

After the participants completed the third STAI Questionnaire, they were debriefed. This was especially needed for the participants in the high stress condition, as some tended to get a bit upset with their performance. It was explained to them that the performance bar was rigged and was not a reflection of their actual abilities or performance. This was done to make them comfortable and prepare them for the cognitive measures tasks.

Final step of the procedure was completion of five cognitive tasks on the CogLab application. This was run on a computer with a touch-sensitive LCD monitor. The sequence of the cognitive tasks was changed for every participant to avoid sequencing effects.

### 7.3 Data analysis

Similar to Experiment 1, the observational data was coded using the Observer software. Coding heuristics for the intuitive use, correct non-intuitive use, error, help and help explicit were the same as those for Experiment 1. For this experiment, one more code explore was added. The explore code was used when a participant explored the interface even when no action was expected of them. For example, when a participant was on a nested interface they often clicked on the menu button to learn what options
were nested under it. The explore code was mostly used to better understand differences between the nested and flat interfaces.

The data from the Observer application, the questionnaires and the CogLab application were later exported into statistical analysis software (SPSS) for analysis.

7.4 Results

This section describes the results of Experiment 2. It is organised into four subsections: Sub-section 7.4.1 will look at the effects of different measures used in this experiment; Sub-section 7.4.2 presents the relationship between technology prior experience and DVs time to complete the task and percentage of intuitive uses; Sub-section 7.4.3 presents the relationship between the type of interface, anxiety and DVs; Sub-section 7.4.4 presents the results from cognitive measures instrument data and their relationship with DVs.

7.4.1 Effects of different conditions and measures used in the experiment

Technology prior experience

Similar to Experiment 1, older people were much more diverse in their capabilities and exposure to the technology. Figure 7.5 shows that younger people tended to score much higher on technology prior experience score and were also much more homogenous in their capabilities.
Before proceeding to analyse the rest of the data it was important to check if the method used for inducing stress had the planned effect on the participants. A two-way ANOVA with 5 age groups and two stress conditions as it factors revealed that there was a significant effect of age \([F(4,44) = 3.73, p = .011, \eta_p^2 = .25]\) and stress condition \([F(1,44) = 6.45, p = .015, \eta_p^2 = .13]\) on the anxiety reported on STAI Questionnaire (Figure 7.6). There was no significant interaction between the age and stress conditions \([F(4,44) = 0.75, p = .561, \eta_p^2 = .064]\).
A TukeyHSD post-hoc test revealed a significant difference between age groups 35 to 49 and 73+ years ($p = .016$). As can be seen in Table 7.3, except for the 35 to 49 years age group, all other groups reported more anxiety on high stress condition compared with low stress condition.
### Table 7.3: Comparison of STAI score means and stress conditions

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Stress</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>17 to 34 years</td>
<td>High</td>
<td>49.00</td>
<td>14.31</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>34.00</td>
<td>9.50</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>41.50</td>
<td>13.98</td>
<td>12</td>
</tr>
<tr>
<td>35 to 49 years</td>
<td>High</td>
<td>34.80</td>
<td>11.62</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>35.80</td>
<td>5.31</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>35.30</td>
<td>8.53</td>
<td>10</td>
</tr>
<tr>
<td>50 to 64 years</td>
<td>High</td>
<td>43.50</td>
<td>13.92</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>36.16</td>
<td>14.87</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>39.83</td>
<td>14.26</td>
<td>12</td>
</tr>
<tr>
<td>65 to 72 years</td>
<td>High</td>
<td>54.00</td>
<td>19.27</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>46.60</td>
<td>11.67</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>50.30</td>
<td>15.52</td>
<td>10</td>
</tr>
<tr>
<td>73+ years</td>
<td>High</td>
<td>62.60</td>
<td>15.32</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>46.20</td>
<td>7.98</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>54.40</td>
<td>14.40</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>2</td>
<td>48.59</td>
<td>16.63</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>39.40</td>
<td>11.20</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>44.00</td>
<td>14.79</td>
<td>54</td>
</tr>
</tbody>
</table>

Overall, the method used for inducing stress appears to have worked to a large extent. However, although not significant, one of the younger age groups (35 to 49 years) reported less anxiety on the high stress condition when compared to the low stress condition (Low $M = 35.80$, $SD = 5.31$, High $M = 34.80$, $SD = 11.62$). The main reason for reporting this non-significant result is to highlight an anomaly that is again reflected in some of the analysis discussed in the following sections.
Perceived self-efficacy, technology prior experience and anxiety

As anticipated, participants with low technology prior experience (TP) had reported low perceived specific self-efficacy (SSE) and high anxiety on the STAI. Although there was a significant correlation between perceived general self-efficacy (GSE) and technology prior experience (TP), \[ r (52) = .453, p = .001 \] between GSE and SSE \[ r (52) = .526, p < .001 \] and between SSE and TP \[ r (52) = .650, p < .001 \] there was no significant correlation between the perceived GSE and anxiety \[ r (52) = -.172, p = .212 \] or between TP and anxiety \[ r (52) = -.198, p = .151 \]. On the other hand, SSE had a significant correlation with reported anxiety \[ r (52) = -.269, p = .049 \].

Overall, TP has a significant positive correlation with both the SSE and GSE and, SSE has a significant negative correlation with the reported anxiety. In other words, participants with more TP reported higher SSE and participants with higher SSE reported lower anxiety on the STAI.

Interface structure

It is also important to stress that the nested interface requires a higher number of responses \( M = 22, SD = 7.3, N = 54 \) from participants, when compared to the flat interface \( M = 16, SD = 4.5, N = 54 \). The nature of the nested interface is such that the controls are accessed through two pop-up menus and the additional action of using this two menu controls increases the number of responses needed to complete a task.

7.4.2 Technology prior experience and DVs

All the results reported in this section used two-way repeated measures (ANOVA), with type of Interface (flat, nested) as the repeated factor and technology prior experience score (Low, Mid, High) as the between subjects factor. The maximum possible score on the TP Questionnaire was 64, and in this sample the lowest score was 9 and the highest was 59. The scores from the questionnaire were split into three equal parts to form groups under Low (9 to 25), Mid (26 to 42) and High (43 to 59).
**Time to complete the task**

Levene’s test showed that the homogeneity was breached for the *time to complete the task* on the flat interface \([F(2,51) = 7.15, p < .05]\) and nested interface \([F(2,51) = 5.27, p < .05]\). Hence, a strict alpha of .025 was used for this analysis (Keppel & Wickens, 2004)

An ANOVA showed that there was a significant effect of *type of interface* structure on the *time to complete the task*: \(F(1,51) = 37.30, p < .001, \eta_p^2 = .42\). Participants took significantly more time to complete the task on the nested interface \((M = 134, SD = 71)\) compared with the flat interface \((M = 101, SD = 40)\).

There was also a significant effect of TP on *time to complete the task*: \(F(2,51) = 15.75, p < .001, \eta_p^2 = .38\). TukeyHSD post-hoc test revealed that the Low TP participants took significantly more time to complete the tasks compared to Mid \((p < .001)\) and High \((p < .001)\) TP participants. It also revealed a significant interaction between the *type of Interface* and TP: \(F(2,51) = 8.76, p = .001, \eta_p^2 = .26\). This indicated that time to complete the task in different TP levels differed for flat and nested interfaces.

To break down this interaction, contrasts were performed to compare each level of TP across type of interface. This revealed that in flat interface, Low TP participants took significantly more time to complete the task compared to Mid TP \((p = .009)\) and High TP participants \((p = .009)\). Similarly, in nested interface, Low TP participants took significantly more time to complete the task compared to Mid TP \((p < .001)\) and High TP participants \((p < .001)\). As can be seen in Table 7.4, Low TP participants took significantly more time to complete the task, compared with Mid TP and High TP participants, on both types of interface.
Table 7.4: Comparison of time on task means (in seconds) for interface type and TP

<table>
<thead>
<tr>
<th>TP Scores</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>154</td>
<td>78</td>
<td>5</td>
</tr>
<tr>
<td>Mid</td>
<td>97</td>
<td>29</td>
<td>28</td>
</tr>
<tr>
<td>High</td>
<td>95</td>
<td>34</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>102</td>
<td>40</td>
<td>54</td>
</tr>
<tr>
<td>Nested</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>270</td>
<td>114</td>
<td>5</td>
</tr>
<tr>
<td>Mid</td>
<td>129</td>
<td>39</td>
<td>28</td>
</tr>
<tr>
<td>High</td>
<td>108</td>
<td>56</td>
<td>21</td>
</tr>
<tr>
<td>Total</td>
<td>134</td>
<td>71</td>
<td>54</td>
</tr>
</tbody>
</table>

On the other hand, the time difference between Mid and High TP was not significant. This can clearly be seen in Figure 7.7, where both the Mid and High TP score lines are very close to each other with insignificant time differences between flat and nested interfaces. By contrast, the Low TP score line is distinctly away from the other groups, and there is a significant time difference between nested and flat interface types.

![Figure 7.7: Technology prior experience scores and time on task](image)
Percentage of intuitive uses

TP levels had a similar effect on intuitive uses as well. There was a significant effect of type of interface \([F(1,51) = 4.64, p = .036, \eta_p^2 = .08]\), and non significant effect (with large effect size) of TP \([F(2,51) = 3.02, p = .058, \eta_p^2 = .11]\), on intuitive use. TukeyHSD post-hoc test revealed that Low TP participants used both the flat and nested interfaces significantly less intuitively when compared with High TP participants \((p = .050)\). The percentage of Intuitive uses on the flat interfaces was, Low TP \((M = 11, SD = 2)\), High TP \((M = 17, SD = 7)\). On nested interface, the percentage of intuitive uses was, Low TP \((M = 7, SD = 4)\), High TP \((M = 17, SD = 9)\). These can be clearly seen in Figure 7.8.

Figure 7.8: Technology prior experience and intuitive uses
Percentage of Errors

There were no significant effects of TP \( F(2,50) = 1.34, p = .271, \eta_p^2 = .05 \), and type of interface \( F(1,50) = 2.17, p = .147, \eta_p^2 = .04 \) on percentage of errors. There was also no significant interaction between type of interface and TP: \( F(2,50) = 1.38, p = .261, \eta_p^2 = .05 \).

7.4.3 Age, Type of Interface, Anxiety and DVs

All ANOVA analyses reported in this section are three-way, interface type (flat, nested) x age (18 to 34 years, 35 to 49 years, 50 to 64 years, 65 to 72 years and 75+ years) x stress condition (Low, High), mixed factorial design, with interface type (flat and nested) as the repeated measure factor.

Time to complete the task

Due to the violation of homogeneity revealed by Levene’s test, for flat interface \( F(4,49) = 12.72, p < .001 \), and nested interface \( F(4,49) = 12.09, p < .001 \), a strict alpha of .025 was used for this analysis (Keppel & Wickens, 2004). A three-way mixed ANOVA showed that there was a significant effect of interface type on time to complete the task \( F(1,44) = 24.53, p < .001, \eta_p^2 = .36 \). Participants took significantly more time to complete the task on the nested interface \( (M = 134 \text{ seconds } SD = 71) \) when compared with the flat interface \( (M = 102 \text{ seconds } SD = 40) \).

Age also had a significant effect on time to complete the tasks: \( F(4,44) = 26.69, p < .001, \eta_p^2 = .71 \). TukeyHSD post-hoc test revealed that the 73+ years age group took significantly more time to complete the task when compared with the four younger age groups \( (p < .001) \). The age group 65 to 72 years also took significantly more time than the youngest (17 to 34 years) age group \( (p = .003) \). There were no significant differences between the three younger age groups.

However, stress condition had no significant effect on time to complete the tasks: \( F(1,44) = 3.61, p = .064, \eta_p^2 = .07 \).
There was a significant *interface type by age* interaction: \( F(4,44) = 3.63, p = .012, \eta^2_p = .25 \). This shows that the *time to complete the task* in age groups differed between the flat and nested interfaces. To break down these interactions, contrasts were performed comparing different age groups between nested and flat interfaces. *Type of interface* had a significant effect on the 73+ \((P < .001)\) and 65 to 72 year age group \((p .013)\). Both of these age groups took more time to complete the task on the nested interface when compared to the flat: 65 to 72 years \((flat M = 106 \text{ seconds}, SE = 10, \text{nested } M = 149 \text{ seconds}, SE = 15)\) and 73+ years \((flat M = 154 \text{ seconds}, SE = 10, \text{nested } M = 234 \text{ seconds}, SE = 15)\).

There was also a significant *interface type by stress condition* interaction: \( F(1,44) = 5.68, p = .021, \eta^2_p = .12 \). This indicates that the time to complete the task on both interfaces differed between stress conditions. Contrasts revealed that the time to complete the task on the nested interface differed significantly between High and Low stress conditions \(p = .012\). On the flat interface there was no significant time difference between the Low \((M = 101 \text{ seconds}, SD = 47)\) and High stress \((M = 103 \text{ seconds}, SD = 33)\) conditions. Interestingly, on nested interface, participants took significantly less time in High stress condition \((M = 120 \text{ seconds}, SD = 48)\) when compared with Low stress condition \((M = 149 \text{ seconds}, SE = 86)\).

There was also a non-significant (due to violation of homogeneity) interaction between *age and stress condition*: \( F(1,41) = 2.78, p = .032, \eta^2_p = .21 \). Although the interaction was not significant, it is mentioned here as the effect size is very large. This interaction indicates that the effect of stress differed between the age groups. Figure 7.9 shows these differences clearly. On both stress conditions (Low Figure 7.9A, High Figure 7.9B) all age groups took most time to complete the task on the nested interface. As can be seen, the oldest age groups took a lot more time to complete the tasks on both interface types; also, the time differences increased between the nested and flat interfaces. Differences between the other three age groups were not significant.
Figure 7.9: Time to complete the task on flat and nested interfaces under A) Low stress and B) High stress condition.
Interestingly, in high stress condition, the younger age group (17 to 34 years) took less time on the nested interface compared to the flat interface under High stress condition. Moreover, as can be seen in Table 7.5, older age groups took a lot less time to complete the task on both interfaces under High stress condition compared with Low stress condition.

Table 7.5: Mean time on task on Low and High stress condition

<table>
<thead>
<tr>
<th>Age groups</th>
<th>Low stress</th>
<th></th>
<th></th>
<th>High Stress</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Flat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 to 34 years</td>
<td>70</td>
<td>5</td>
<td></td>
<td>84</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>35 to 49 years</td>
<td>72</td>
<td>5</td>
<td></td>
<td>94</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>50 to 64 years</td>
<td>95</td>
<td>14</td>
<td></td>
<td>86</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>65 to 72 years</td>
<td>110</td>
<td>25</td>
<td></td>
<td>97</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>73+ years</td>
<td>165</td>
<td>75</td>
<td></td>
<td>143</td>
<td>53</td>
<td></td>
</tr>
<tr>
<td>Nested</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 to 34 years</td>
<td>89</td>
<td>16</td>
<td></td>
<td>77</td>
<td>10</td>
<td></td>
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<tr>
<td>35 to 49 years</td>
<td>93</td>
<td>21</td>
<td></td>
<td>98</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>50 to 64 years</td>
<td>133</td>
<td>37</td>
<td></td>
<td>107</td>
<td>26</td>
<td></td>
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<tr>
<td>65 to 72 years</td>
<td>158</td>
<td>42</td>
<td></td>
<td>141</td>
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<td></td>
</tr>
<tr>
<td>73+ years</td>
<td>289</td>
<td>98</td>
<td></td>
<td>179</td>
<td>65</td>
<td></td>
</tr>
</tbody>
</table>

**Percentage of intuitive uses**

A three-way mixed ANOVA with percentage of intuitive uses as one of its factors revealed a significant effect of type of interface \(F(1,44) = 4.45, p = .041, \eta^2 = .09\) on percentage of intuitive uses. This indicated that the participants used flat interface \((M = 17, SD = 7)\) more intuitively when compared with nested interface \((M = 15, SD = 8)\).

*Age* had a significant effect on percentage of intuitive uses: \(F(4,44) = 5.33, p = .001, \eta^2 = .33\). TukeyHSD revealed that the age effect was significant between the age groups 17 to 34 and 65 to 72 years \((p = .008)\), 35 to 49 and 65 to 72 years \((p = .004)\), 35 to 49 and 73+ years \((p = .048)\). There was no significant difference among the older three age groups. There was no
significant effect of stress condition on percentage of intuitive uses: \( F(1,44) = 0.004, p = .95, \eta_p^2 = .00.\)

There was also a significant three-way interaction between interface type by age by stress condition: \( F(4,44) = 2.97, p = .029, \eta_p^2 = .21.\) This indicates that the interface type by age interaction was different for Low and High stress conditions. Contrasts were performed to reveal the age by interface type interaction under Low and High stress conditions. These revealed that in Low stress condition (Figure 7.10A) age had a significant effect on both flat, \( F(4,22) = 3.38, p = .027, \eta_p^2 = .38,\) and nested, \( F(4,22) = 6.36, p = .001, \eta_p^2 = .54,\) interfaces.

A pairwise comparison using Bonferroni correction revealed a significant difference between the age group 35 to 49 and 65 to 72 years on flat interface, \( p = .031.\) There was a significant difference between the 35 to 49 and 50 to 64 (\( p = .013\)) age groups, and between the 65 to 72 (\( p = .003,\)) and 73+ (\( p = .003\)) age groups on nested interface. Basically, the 35 to 49 age group’s behaviour was a mirror image of the rest of the age groups (Figure 7.10A).

In High stress condition (Figure 7.10B) the effect of age was significant for nested interface \([F(4,22) = 3.85, p = .016, \eta_p^2 = .41].\) A pairwise comparison using Bonferroni correction revealed no difference between age groups on the flat interface (Figure 7.10A). However, there were significant differences between the 17 to 34 and 65 to 72 years (\( p = .025\)) age groups, and between the 17 to 34 and 73+ (\( p = .049\)) years age groups on Nested interface.
Figure 7.10: Percentage of intuitive uses, interface type and age under A) Low stress B) High stress conditions.
Interestingly, similar to the results for time on task, older age groups did better under stressful conditions. As can be seen in Table 7.6, the 50+ age groups used both types of interfaces more intuitively under the High stress condition.

Table 7.6: Differences of percentage of intuitive uses under Low and High stress conditions

<table>
<thead>
<tr>
<th>Interface</th>
<th>Age groups</th>
<th>Low stress</th>
<th></th>
<th>High stress</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Flat</td>
<td>17 to 34 years</td>
<td>20</td>
<td>7</td>
<td>19</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>35 to 49 years</td>
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<td>17</td>
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<td>50 to 64 years</td>
<td>17</td>
<td>8</td>
<td>18</td>
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</tr>
<tr>
<td></td>
<td>65 to 72 years</td>
<td>9</td>
<td>3</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>73+ years</td>
<td>14</td>
<td>8</td>
<td>17</td>
<td>7</td>
</tr>
<tr>
<td>Nested</td>
<td>17 to 34 years</td>
<td>17</td>
<td>6</td>
<td>23</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>35 to 49 years</td>
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<td>4</td>
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<tr>
<td></td>
<td>50 to 64 years</td>
<td>13</td>
<td>5</td>
<td>16</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>65 to 72 years</td>
<td>10</td>
<td>5</td>
<td>11</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>73+ years</td>
<td>10</td>
<td>7</td>
<td>12</td>
<td>6</td>
</tr>
</tbody>
</table>

**Percentage of errors**

*Age* had a significant effect on the percentage of errors: $F(4,43) = 3.11, p = .025, \eta^2_p = .22$. Overall, older age groups made more errors on both types of interfaces when compared with the younger age groups. However, the *type of interface* had no effect on errors made (Figure 7.11). Similarly, *stress condition* had no significant effect on percentage of errors: $F(1,43) = 1.05, p = .31, \eta^2_p = .02$. 
Figure 7.11: Percentage of errors, interface type and age under A) Low stress and B) High stress conditions
There was a significant interaction between age and stress condition: $F(4,43) = 2.64, p = .047, \eta^2_p = .20$. This indicates that the percentage of errors made between age groups differed between the Low and High stress conditions. Contrasts revealed that in Low stress condition (Figure 7.11A), age had a significant effect on use of the flat interface: $F(4,43) = 4.94, p = .002, \eta^2_p = .31$. A pairwise comparison using Bonferroni correction revealed that significant differences were only observed between the 35 to 49 and 65 to 72 years age groups with the flat interface ($p = .001$). As shown in Table 7.7, under Low stress condition on the flat interface, the 65 to 72 years ($M = 17$, $SD = 7$) age group made substantially more errors compared to the 35 to 49 year ($M = 3$, $SD = 2$) age group. Table 7.7 also shows that, similar to other DVs, older age groups appear to have done better under High stress condition when compared with Low stress condition.

Table 7.7: Differences in percentage of errors under Low and High stress conditions

<table>
<thead>
<tr>
<th>Interface</th>
<th>Age groups</th>
<th>Low stress</th>
<th></th>
<th>High stress</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td></td>
</tr>
<tr>
<td>Flat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 to 34 years</td>
<td>9</td>
<td>6</td>
<td>11</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>35 to 49 years</td>
<td>3</td>
<td>2</td>
<td>11</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>50 to 64 years</td>
<td>10</td>
<td>6</td>
<td>10</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>65 to 72 years</td>
<td>17</td>
<td>7</td>
<td>11</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>73+ years</td>
<td>11</td>
<td>9</td>
<td>11</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Nested</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17 to 34 years</td>
<td>10</td>
<td>8</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>35 to 49 years</td>
<td>7</td>
<td>10</td>
<td>10</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>50 to 64 years</td>
<td>14</td>
<td>11</td>
<td>7</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>65 to 72 years</td>
<td>22</td>
<td>12</td>
<td>9</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>73+ years</td>
<td>16</td>
<td>9</td>
<td>16</td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>
7.4.4 Regression analysis of cognitive measures data

Multiple regression analysis using stepwise method was conducted to investigate relationships between cognitive data and the DVs time to complete the task, percentage of intuitive uses and percentage of errors and interface types. Variables entered in the regression model were, scores on: TP, visuospatial sketchpad and phonological loop capacity, visual and phonological transformations, visual and phonological transformations response time, sustained attention and attention reaction time. Preliminary analyses were conducted to ensure that assumptions of normality, linearity and multicollinearity were not breached.

Time on Task

Results of the multiple regression showed that visuospatial sketchpad capacity and phonological transform response time significantly correlated with time to complete the task on the flat interface: Adjusted R square = .289 F(1,48) = 9.75, p < .001 (Table 7.8A). Phonological transform response time and attention also had significant influence on time to complete the task on nested interface: Adjusted R square = .538 F(2,48) = 30.14, p < .001 (Table 7.8B).

Table 7.8: Results of multiple regression for time to complete the task on A) Flat and B) Nested interface

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
</tr>
<tr>
<td>(Constant)</td>
<td>122.898</td>
<td>20.544</td>
</tr>
<tr>
<td>Visualtranform</td>
<td>-5.680</td>
<td>1.762</td>
</tr>
<tr>
<td>PhonotransformRT</td>
<td>.001</td>
<td>.001</td>
</tr>
</tbody>
</table>
Table 7.8: continued from previous page

B. Time on task: nested interface

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>134.437</td>
<td>34.042</td>
<td>3.717</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>PhonotransformRT</td>
<td>.004</td>
<td>.001</td>
<td>-2.901</td>
<td>.006</td>
<td>.175</td>
</tr>
<tr>
<td>Attention</td>
<td>-29.569</td>
<td>8.501</td>
<td>2.766</td>
<td>.008</td>
<td>.111</td>
</tr>
</tbody>
</table>

Intuitive uses

Attention had a significant effect on intuitive uses on the flat interface
[Adjusted R square = .150  F(1,49) = 9.82, p = .003 (Table 7.9A)], and
attention, reaction time and visual transform task response time had a
significant effect on intuitive uses on nested interface: Adjusted R square = .440  F(3,47) = 14.07, p < .001 (Table 7.9B).

Table 7.9: Results of multiple regression for intuitive use on A) Flat and B) Nested interface

A. Intuitive uses: flat interface

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>9.591</td>
<td>2.636</td>
<td>3.639</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>-3.068</td>
<td>.979</td>
<td>3.134</td>
<td>.003</td>
<td>.167</td>
</tr>
</tbody>
</table>

B. Intuitive uses: nested interface

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>42.236</td>
<td>11.116</td>
<td>3.799</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>3.287</td>
<td>.997</td>
<td>3.298</td>
<td>.002</td>
<td>.121</td>
</tr>
<tr>
<td>RTattention</td>
<td>-.027</td>
<td>.008</td>
<td>-3.235</td>
<td>.002</td>
<td>.116</td>
</tr>
<tr>
<td>VisualtransformRT</td>
<td>.000</td>
<td>.000</td>
<td>-2.566</td>
<td>.014</td>
<td>.073</td>
</tr>
</tbody>
</table>
Errors

The visual transformation performance had a significant effect on percentage of errors on the flat interface \[ \text{adjusted R square } = .069 \quad \text{F}(1,48) = 4.61, \ p = .037 \] (Table 7.10A], and attention had a significant effect on the percentage of errors on nested interface \[ \text{adjusted R square } = .285 \quad \text{F}(1,49) = 20.95, \ p < .001 \] (Table 7.10B].

Table 7.10: Results of multiple regression for percentage of errors on A) flat and B) nested interface

A. Errors: Flat interface

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>16.634</td>
<td>3.072</td>
<td>5.414</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Visual transform</td>
<td>-.736</td>
<td>.343</td>
<td>-.296</td>
<td>-2.148</td>
<td>.037</td>
</tr>
</tbody>
</table>

Table 7.10 continued:

B. Errors: nested interface

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
<th>sr²</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>27.962</td>
<td>3.681</td>
<td>7.597</td>
<td>.000</td>
<td></td>
</tr>
<tr>
<td>Attention</td>
<td>-6.257</td>
<td>1.367</td>
<td>-.547</td>
<td>-4.577</td>
<td>.000</td>
</tr>
</tbody>
</table>

In summary, the central executive functions - attention, visual and phonological transformation response times and attention reaction times- had significant effects on the use of interfaces. Similar to the findings in Experiment 1, attention scores significantly correlated with intuitive uses on both types of interface. Moreover, attention also had a significant effect on all DVs on the nested interface.
7.5 Discussion

This experiment was designed to investigate the relationships between age, anxiety, and intuitive use of complex interface structure (nested versus flat). The structure of the following discussion roughly reflects the structure of the results Section 7.4.

Age, technology prior experience perceived self-efficacy and anxiety

Consistent with Experiment 1, most of the people who scored low on technology prior experience (TP) in Experiment 2 were from the older age group. TP scores of the older people were also more diverse compared with younger participants. Participants who scored low on TP also took significantly more time to complete the task on the nested interface and used it less intuitively. However, the time to complete the task differences between the nested and flat interfaces were not significant between Mid and High TP scores.

As hypothesised, people who scored low on TP and Specific Self-efficacy (SSE) reported higher anxiety. This supports the research that suggests a relationship between age, cognitive decline, technology adoptions, self-efficacy and technology anxiety (Bandura et al., 1999; Czaja et al., 2006).

Age, interface and stress

As hypothesised, all age groups took significantly more time to complete the tasks on the nested interface when compared with the flat interface, probably because the nested interface needed more actions to complete the task. However, these differences between nested and flat interface use increased with age. Age also had a significant effect on time to complete the tasks on both types of interface. All age groups used the flat interface more intuitively compared with the nested interface. This finding supports existing data that suggests that older people find nested interfaces more difficult to use (Detweiler et al., 1996; Docampo Rama, 2001).
Contrary to what was hypothesised, although older age groups made more errors, there were no significant differences in error rates between use of the nested and flat interface types. Similarly, anxiety had different effects on the age groups. Both the younger age groups reacted differently compared to the older age groups. Older people (65+) reported more anxiety than the younger age groups. This supports Eisma et al.’s (2003) research which suggests that older people may experience more anxiety when they interact with new technologies. However, surprisingly, the performance of the two older age groups was better in the high stress conditions. These groups completed the tasks faster and used the interfaces more intuitively under the high stress condition.

This supports Attentional control theory (Eysenck et al., 2007), which suggests that anxiety affects processing efficiency more than performance effectiveness. In other words, highly anxious individuals, under stressful conditions, trade time for accuracy in achieving their goal. They also use increased effort and more working memory resources. However, if the task does not overwhelm available resources, increased effort on the working memory resources actually enhances the performance. Since the experiment tasks were designed to be only moderately difficult, it did not induce high enough levels of anxiety to have a catastrophic effect on the older age groups’ performance. This could be explained by the inverted U-hypothesis of anxiety-performance. According to this hypothesis, for any given task optimal performance is achieved at some intermediate level (the peak of the inverted U) of arousal. Performance starts deteriorating as the level of arousal increases or decreases from its optimal level. This could be the most probable reason behind the performance increase in the older age groups under high stress condition.

The behaviour of the 35 to 49 years age group under stressful condition was different to that of the other age groups. Unlike other age groups, they reported low anxiety on high stress condition and high anxiety on low stress condition. However, while they performed better in a high anxiety state as
older age groups did, their performance was opposite to that of the older age groups since they experience high anxiety under low stress condition.

This behaviour did pose a few challenges in interpreting the results. For example, ANOVA showed that age had a significant effect on number of errors. However, contrasts showed that the difference was significant only between the 35 to 49 and 65 to 72 year age groups. The probable cause of this difference was that the 35 to 49 years age group made a lot fewer errors on low stress condition, whereas the other age groups did not differ that much. One of the possible reasons for the peculiar behaviour could be, as noted by Kosnik et al. (1988) study of the perception of vision related problems through adulthood, middle-aged people are more concerned about age-related changes that start becoming noticeable at this age. This behaviour of the middle age group needs further investigation.

The findings from this experiment also support Processing-speed Theory (Salthouse, 2010), which suggests that older people tend to trade speed for accuracy. Although older people took more time to complete the tasks compared to younger people, overall they did not make significantly more errors than younger groups on both types of interfaces. However, as discussed earlier, middle-age groups differed significantly from the 65 to 72 year age group.

Finally, data from cognitive measures suggests that central executive functions - attention, visual and phonological transformation response times and attention reaction times - had a significant effect on time to complete the task, intuitive use and errors. Interestingly, attention has emerged as a significant factor for completing the tasks on nested interfaces. For nested interfaces, it is essential that the participant holds the available options under the menu in the memory and retrieves them as and when required, while also responding to the task instructions and activities on the screen. This calls for the cognitive functions, selective and divided attention, both of which are adversely affected by the process of ageing (Kramer & Madden,
2008; McDowd & Shaw, 2000). This could be one of the reasons the oldest age group (73+) did not do as well on the nested interface.

Overall, older people scored lower on technology prior experience, took more time to complete the tasks and used the interfaces less intuitively. However, the number of errors is one of the most crucial indicators for successful use of a product interface. This data suggests that when the interface is designed with consideration of the cognitive limitations of older people, the differences in its use among age groups can be minimal. Apart from the oldest age group (73+) the differences in terms of intuitive use of the interface were not significant. This supports the research which suggests that working memory deficiencies in ageing are mediated by coping mechanisms adopted by older individuals, especially when the task is simple (Brébion et al., 1997).

Surprisingly, although most of the older participants had never used an iPad (mediator product for Experiment 2) they were at ease in using it. This supports recent research on touch-based products that has made similar observation (Häikiö et al., 2007; Isomursu et al., 2008) (see details in Section 6.3). This observation has a great potential for design of adaptable interfaces for designing inclusive interfaces (Shneiderman, 2003). The adaptable interface paradigm involves customisation of interfaces to match a user's capabilities. This process of customisation is much simpler with products that use touch-based interfaces.

7.6 Summary

This experiment was designed to investigate if complexity of interface, in terms of its structure, has any impact on older users under stressful and non-stressful conditions. The tasks used in this experiment, based on pilot studies, were designed to consider older people's cognitive limitations. The outcome showed that, as expected, older people took more time on the nested interface compared to the flat interface. However, the type of
interface structure had no significant effect on errors made. In addition, the age differences in terms of errors made were also minimal.

Contrary to what was hypothesised, older age groups did better under stressful conditions. Overall, the data suggest that when the tasks are designed to consider the limitations of older people, the age differences are minimal for the four age groups (between 18 to 72 years). However, the oldest age group (73+) was significantly slower and used the interfaces less intuitively. Although this age group took more time to complete the tasks, they did not necessarily make more errors. As in Experiment 1, cognitive data shows that central executive functions, attention, visual and phonological tasks and response times significantly correlate with effective use of interfaces. Interestingly, attention task scores correlate significantly with all DVs on the nested interface.

Chapter 8 will briefly summarise the findings of this study and discusses how they contributes to the overall aim of this thesis. It concludes by listing its major contributions, limitation and future directions.
Chapter 8

Discussion and Conclusion
8.1 Introduction

This study started with the aim to develop an approach that will help designers create interfaces that are more intuitive for older adults to use. Two objectives were set for this study: 1) to identify and investigate one of the possible strategies for developing intuitive interfaces for older people; and 2) to identify and investigate factors that could interfere with intuitive use.

This chapter briefly present the outcome of the two experiments and discusses how they address the objectives of this study. It then provides an explanation of how this outcome has lead to the development of an adaptable interface design model that will help designers develop interfaces that are intuitive to learn and, over time, intuitive to use. Important contributions of this study are listed, along with its limitations and directions for future research. The chapter closes with conclusion that synthesises the findings and show how they address the primary aim of the thesis.

8.2 General discussion

Prior exposure and competence with related technologies are essential for intuitive use of interfaces (Blackler, 2008; Blackler, Popovic, et al., 2010; Hurtienne et al., 2008; Lewis et al., 2008; Naumann et al., 2008). One of the important reasons for older people finding contemporary interfaces difficult to use is their low domain-specific prior knowledge (Hurtienne et al., 2010; O’Brien, 2010). Moreover, prior knowledge of technology is a lot more variable in older people when compared with younger people. There are many reasons behind older people being deficient in prior knowledge and more varied in their capabilities. For example, age-related cognitive degradation (Langdon et al., 2007; Lim, 2009), low perceived self-efficacy (Bandura et al., 1999; Czaja & Lee, 2007) and cohort effects (Docampo Rama et al., 2001; Lim, 2009).
As people age, they tend to specialise in an area of their choice. Their other interests also tend to become more focused. Each individual has different needs, professions and interests, and this brings about the variability in older people (Salthouse, 2010). Older people are also slow in adopting new technologies, as they do not see a need to keep up with technology for the sake of doing so. However, where they see a need, they do embrace the technology without reservations (Czaja & Lee, 2007). Finally, age-related cognitive decline slows down acquisition of new knowledge (Bäckman et al., 2001). The awareness of this limitation probably also compels older people to be more selective in determining what they should learn.

These and other related factors results in two issues regarding domain-specific prior knowledge in older people: 1) the variability in their knowledge and 2) not in pace with contemporary technology. The other side of the story is that lack of prior knowledge could lead to low perceived technology self-efficacy, which in turn has the potential for causing technology anxiety. Both low domain-specific prior knowledge and technology anxiety can impede intuitive and successful use of complex contemporary technological products. Difficulties in using technological products in turn feed and amplify their already low perceived technology self-efficacy. Low technology self-efficacy discourages adoption or use of new technological products, resulting in low domain-specific prior knowledge. Thus, this is a vicious, self-perpetuating loop. However, on a positive note, older people are aware of these limitations and are not averse to embracing new technology when they see a need for it (Czaja & Lee, 2007).

This study has addressed these issues by, firstly, investigating redundancy as one of the strategies that could bridge the variability in older people’s capabilities, and help them use complex technological devices intuitively and, secondly, investigating the relationships between technology prior experience, self-efficacy, technology anxiety, complexity of interface (nested versus flat) and intuitive use in older people.
8.2.1 Research approach

There is a considerable amount of research literature that is focused on the importance of inclusive design, as discussed in Chapter 1. There is a steady increase in research that is also focused on understanding how to design for older people. However, most of the research available focuses on ageing as a variable in understanding patterns of technology usage, preferences and difficulties. What is more necessary is research that explains why the age differences occur. For this reason, it is essential to investigate mediating factors such as cognitive abilities and experience (Rogers & Fisk, 2010). Addressing this need, this study was specifically designed to investigate age differences from the perspectives of both chronological age and cognitive abilities. The outcomes of this study are summarised in Sections 8.2.2 and 8.2.3 below.

8.2.2 Summary of findings

The outcomes of two experiments conducted for this study have highlighted that older age groups, when compared with younger age groups, are very diverse in their capabilities in terms of technology prior experience and cognitive functioning. In brief, the outcome has resulted in three important findings.

First, a text/words-based interface, compared with symbols-based or redundant (symbols and words) interface, is much more intuitive, faster and less prone to errors for older users and users with low domain-specific prior experience. Most importantly, there were no differences between young and older age groups in terms of errors on a text-based interface. One of the reasons emerged was that this could be due to age related degradation in visual information processing, as both symbols-based and redundant interfaces are visually more complex to process compared to text-based interface.
Second, from a cognitive processing perspective, sustained attention, visuospatial sketchpad capacity and phonological transformation response time had the most impact on time to complete the task, intuitive uses and errors. Attention and phonological transformation response time are functions of central executive function. Central executive function is one of the memory systems that are affected by the process of ageing. Central executive is also involved in learning and the retrieving of knowledge from long-term memory. Both the experiments showed that some older people, although reported high domain-specific prior knowledge, did not do well on the task because they scored low on cognitive measures. In summary, both these experiments have shown that the use of contemporary technological products is mediated by both domain-specific prior knowledge and cognitive abilities.

Third, as expected, older people took less time to complete the task on the interface that used a flat structure when compared to the interface that used a complex nested structure. All age groups also used the flat interface more intuitively compared with the nested interface. Interestingly, older participants did not make significantly more errors compared with younger age groups on either interface structures. Overall, the findings suggest that when the tasks are designed with consideration of the cognitive limitations of older people, the age differences are minimal for most age groups, except for the oldest age group (73+), who were significantly slower and used the interfaces less intuitively; however, they did not make more errors.

8.2.3 Facilitating intuitive use for older users

In Section 2.3, two studies, one by Blackler (2008) and the other by Hurtienne (2009) were discussed in detail. Both these in-depth studies have shown that the intuitive use of an interface involves non-conscious use of prior knowledge. In other words, when an interface is designed to match domain-specific prior knowledge and competence of a user that interface will appear more intuitive to use. However, when it comes to implementing
these approaches to designing intuitive interfaces for older people, designers face two major problems.

First, because of the complexity of their functions, designing of contemporary technological products require use of prior knowledge from higher sources on continuum of knowledge sources (Blackler & Hurtienne, 2007; Hurtienne, 2009). Knowledge from higher sources on the continuum is not commonly shared in the population (Hurtienne, 2009). In addition, older people are a very heterogeneous group in terms of both prior knowledge and cognitive capabilities. Therefore, for designers to find common knowledge of this target group before developing intuitive product interfaces could be a very complex and extremely resource-intensive exercise in terms of both time and money.

Second, there are some models that postulated a structure of prior knowledge and a process of decision making that suggest how prior knowledge could be applied in reaching a goal (Blackler, 2008; Hurtienne et al., 2010; Klein, 2005; Rasmussen, Klein, Orasanu, Calderwood, & Zsambok, 1993). However, little has been determined about how to elicit prior knowledge from the target users. Although there are some suggested tools to investigate users’ exposure and competence with technology, they only inform us of what and how much users know. As this study and other related studies (Lawry, 2012; O’Brien, 2010) have shown, these measures may not be enough. There were occasions where older participants reported high prior knowledge but scored low on cognitive tasks, and did not do well on the task times. On the other hand, there were occasions when participants scored low on technology prior experience and high on cognitive tasks, and did well on task times.

This finding suggests that it is also important to know, apart from their technology exposure and competence, how the target users make use of prior knowledge under different circumstances and situations. A person might have the required knowledge about a device but, for various reasons,
may not be able to retrieve it when required (Section 3.7). In summary, the data from this study and relevant literature suggests that, in practice, it might be difficult to develop product interfaces that are entirely intuitive to use for a group of people with diverse capabilities.

On the other hand, it was also observed in this study that many older participants used controls on the interface non-intuitively/correctly on the first encounter but started using the same controls intuitively during subsequent encounters. Some of these correct uses were based on the trial and error process and others were through logical reasoning. In general, younger participants who scored high on technology prior experience tend to learn the controls faster or learn intuitively based on the related experiences or reasoning. Figure 8.1 illustrates the probable way in which participants learnt to use some controls intuitively as the task progressed.

![Figure 8.1: Learning on the task](image)

Moreover, as Experiment 2 has shown, when the interface was designed to accommodate limitations of the older users there were very few age differences observed in the number of errors made. Similarly, in Experiment 1 there were no significant differences between age groups, in terms of
errors, on the text-based interface. In other words, older people could learn
the interface on task when it was designed according to their limitations.
This finding is also supported by other related research that shows that a
text-based interface aids learning of an interface without external help
(Camacho et al., 1990; Wiedenbeck, 1999). Keeping these findings in
perspective, it might be prudent to aim for developing interfaces that are
intuitive to learn rather than intuitive to use. An intuitive-to-learn interface
has potential to counter the variability in prior knowledge and cognitive
abilities over time and, eventually, to make the interface intuitive to use. An
intuitively learnable interface in this context can be defined as ‘an interface
that allows a person to intuitively apply various strategies to learn and to
successfully use a unique interface during first and early encounter’.

In summary, existing methods for developing intuitive interfaces are not
effective when target users have varied cognitive and technological abilities.
The data from this study and related literature suggests that effective use of
a product is based on prior knowledge and learning on the task, mediated by
cognitive abilities. These findings suggest, therefore, that it would be more
practical if product interfaces were built for intuitive learning rather than
intuitive use.

## 8.3 Strategies for design for older people

As discussed in Section 2.6, most of the prescriptive design methods are not
able to meet their intended objectives. One of the main reasons is that
designers seldom follow a systematic decision-making strategy during
practice (Klein & Brezovic, 1986; Visser, 2009). The process of designing is
more opportunistic, and Visser (1990) suggests that, when an activity is
opportunistically organised, any system/method that imposes a hierarchical
or structured design process will severely constrain the designer. In view of
this observation it was decided to present a possible approach that would
allow interested designers to contextualise the findings of this study with
their own requirements, methods and cognitive process.
8.3.1 Intuitively learnable interfaces as an approach to designing for older people

The findings from this research suggest that, for a first time encounter with a product interface cognitive ability and domain-specific prior knowledge are important factors that will decide the effectiveness of its intuitive use. This research and related literature also show that, for novice users and users with low prior experience and age-related cognitive decline, use of a simple text-based interface with flat interface structures would be beneficial. Text-based interfaces are easier to learn without external help for older people, and for people with low prior knowledge and cognitive abilities.

However, text-based interfaces offer minimal spatial cues for visual search (Cooper et al., 2007). This could be a problem for older people, as age-related decline in visual information processing reduces their ability to search in a cluttered visual environment (Fozard & Gordon-Salant, 2001; Hawthorn, 2000, 2006). In contrast, symbols offer strong visual and spatial cues and it is much easier to learn them and to remember their location in the interface structure. Most of the research supports the view that a symbols-only interface is more efficient once users have learnt the system (Camacho et al., 1990; Cooper et al., 2007; Mertens et al., 2011; Schröder & Ziefle, 2008a, 2008b; Yvonne, 1989). On the other hand, Experiment 1 showed that older people found the symbols-based interface most difficult to use. Camacho et al. (1990) attribute this to inherent ambiguity in the interpretations of symbols.

Widenbeck (1999) noticed that, on a redundant interface, people learnt the meaning of symbols through their textual labels. Redundancy in the context of information communications is also often suggested for minimising the ambiguity of symbols and for aiding their comprehension and learning (Wickens & Hollands, 2000; Wickens et al., 2004). Keeping this in mind, it might be better that once the functions of the interface are learnt on the
text-based interface, it could progressively be switched to redundant interface to help with learning the meaning of the associated symbols; finally, the interface could move to a symbols-only based interface for the most effective use of the interface.

Similarly, although a flat interface structure is good for making information more accessible, too many options tend to clutter the screen, resulting in more strain on the limited spatial ability of older people. Here again, it might be better to structure the options into a simple nested interface once the user learns all the functions of the system thereby reducing the visual clutter (Miller, 1981).

In practice, these findings strongly support universal/inclusive design paradigms, such as the multi-layered interface design proposed by Shneiderman (2003), and ordinary and extra-ordinary interaction developed by Newell (1995). The multi-layered interface paradigm proposes that interfaces should have different layers of complexity based on the capabilities of target users. The basic idea behind a multi-layered interface is that a person can select the interface level based on their current ability and move up the levels as they acquire more experience with the system. One of the advantages of a multi-layered interface is its flexibility to adapt to multiple user categories with varied prior knowledge and cognitive abilities. Most importantly, it allows users to develop their own learning curve based on their current abilities (Linn Gustavsson, 2008).

This process also supports Newell’s design paradigm, which suggests that products be designed for older people first and then extended to use for other age groups. The basic idea is that, if a product is designed to accommodate (for example) people with low vision, it not only helps people with low vision but also people with normal vision in a low visibility condition. A very good example is given in Newell’s (2008) publication: an automobile that was designed specifically for older people with low mobility later went on to become best selling car in the United Kingdom.
Until recently, implementation of the multi-layered design paradigm was difficult as most consumer products had physical controls, and these are very difficult to customise to the abilities of the user. However, recent trends show that more and more products are using touch-screen interfaces with minimal or no physical controls. Therefore, it would now be an appropriate time to embrace a multi-layered interface design paradigm. Moreover, Experiment 2 also showed that older people are comfortable with touch-based devices and a simple multi-layered interface structure. Recent research also suggests that, regardless of their cognitive or physical deficiencies, older people find touch-based products easier to learn and use (Häikiö et al., 2007; Isomursu et al., 2008; Taveira & Choi, 2009).

8.3.2 Adaptable interface model for intuitively learnable interfaces

There is some research that compares different implementations of multi-layered interfaces: static, adaptive, adaptable and mixed-initiative. A static interface is one that does not change; adaptive interface change is controlled by the system; adaptable interface change is controlled by the user; and a mixed-initiative interface is a mix of adaptive and adaptable (Findlater & McGrenere, 2004).

Findlater and McGrenere (2004) found significant support for adaptable interfaces from a general population sample. They also reported that, although static interface was most effective, when participants were guided by example, there was no significant difference between static and adaptable interfaces. In a related and much more recent study, a multi-layered interface paradigm was tested on small screen device with older participants (Leung, Findlater, McGrenere, Graf, & Yang, 2010). The outcome of this study (Leung et al., 2010) suggests that older people benefited most from an adaptable interface. On the negative side, it was also observed that their performance was affected when the interface was changed from reduced-functionality to full-functionality. However, this change did not
affect the learning of the full-functionality interface. Overall, Leung et al. (2010) report that a multi-layered interface had benefitted older participants more than the younger participants in terms of learning and time to complete the task.

Based on the literature and the outcome of this research, a multi-layered interface model is proposed for designing and developing intuitively learnable interfaces (Figure 8.2). Although the proposed model illustrated in Figure 8.2 shows only three layers, in practice, the number of layers can be varied depending on the complexity of the interface being designed.

![Figure 8.2: Adaptable interface model for intuitively learnable interface](image)

The core idea of the model is to illustrate how levels of domain-specific prior experience are related to the levels of complexity of the interface structure, functions and features. A person with low specific technology exposure and competence will find a flat interface structure with essential functionality and text-based representation most beneficial for intuitive learning. On the other hand, a person with high specific technology exposure and
competence may find a multi-layered structure with full functionality and symbols-only representation more efficient to intuitively learn and use.

In terms of implementation, a platform that allows direct manipulation or touch-based interaction is essential for allowing smooth transitions between the interface levels. The interface should be designed with flexibility to vary the complexity of structure from flat to nested, of functions from essential to full access, and of features from textual representation to symbols-based representation.

Designers could face some limitations when implementing this model. As Leung et al. (2010) note, a sudden change from partial to fully functional systems might require substantial learning. To avoid such problems, transition between the interface levels should be planned so that it requires minimal learning. However, this issue needs further research to investigate different methods for changing interface levels in small increments. Whether the actual multi-layered interface implementation is adaptive, adaptable or mixed-initiative also needs further investigation to see how older people will cope with each.

### 8.4 Future directions

This research has suggested three possibilities and considerations for its future directions. First, Experiment 1 only looked at redundancy in terms of repetition of visual form (text and symbols). Due to the visual nature of both words and images, they demand more visual processing cognitive resources. However, if two different modalities are used, for example image and audio, the demands on working memory are reduced (Sweller, 2002). It would be interesting to see how using two modalities would affect intuitive use in older people.

Second, in Experiment 2, there was a significant effect of anxiety on participants’ behaviour. However, the middle-aged group reported anxiety quite differently; thus, it was not certain if this anxious behaviour was false
reporting or an accurate record. It would be interesting to see the experiment repeated with a more reliable method for creating the stressful condition, and with an instrument to measure anxiety more objectively. The experimental scope could also be expanded by including more complex interface structures and tasks.

Third, further research could investigate the proposed model for multi-layered interface design for intuitively learnable product interfaces. At this point, it is not understood how older users will cope with the changes in complexity of the interface over time.

### 8.5 Limitations

The first limitation of this research was methodological. As older age groups were more diverse in their capabilities compared with the more homogenous younger age groups, the homogeneity tests for ANOVA analysis were often breached. This necessitated employing a strict alpha of .025, which resulted in masking of possible significant results. The variability in older age groups also resulted in non-significant results with big effect sizes. This was addressed to a certain extent by increasing the number of age groups in Experiment 2. However, more participants are also required to keep sample sizes large enough to produce significant results, and finding older participants is very time consuming.

For future research, it might be much more effective if other methods of statistical analysis are employed, for example, multiple regression. There were two reasons why multiple regression was not used in this study, 1) The extreme variability in older population was not anticipated, hence experiments were designed as between-groups experiment (using ANOVA) as a very effective method to investigate differences between variables and, 2) Running regression analyses with age as a moderator is a very complex method.
The second limitation of the study was the representativeness of users participating in this study. All participants were volunteers who had to travel to the PAS lab situated on the University’s city campus. Most of the post-retirement older participants had to travel quite a distance to reach the venue, and this required a considerable amount of motivation and enthusiasm on their part. This had two implications, 1) Most of the participants knew that they had to interact with high technology products and still volunteered, so there is a good possibility that they had a higher perceived technological self-efficacy compared with a representative population and, 2) The majority of participants were more active in pursuing social, cognitive and physical activities (as revealed by TP questionnaire, Appendix 1) when compared with a more representative older population.

Finally, Experiment 2 used the STAI Questionnaire for reporting anxiety experienced by the participants. Middle-aged and, to certain extent younger participants reported less anxiety on the high stress condition. As this is an unexpected outcome, it could not be ascertained if this had something to do with false reporting or was a real phenomenon in this sample population. Using a more objective measure of anxiety would have offered a lot more confidence in interpreting this data.

8.6 Contributions to knowledge and implications

This study makes a significant contribution to the study of interaction design and knowledge about the methods of researching with older people in three significant ways.

Older people and interaction design

First, the findings of Experiment 1 show that many existing hypotheses that suggest redundancy in interface to counter diversity in older people’s capabilities may not be beneficial.
This research has established that a simple text-based interface is most effective to use and learn for older people and people with low prior experience and cognitive capabilities. This supports other research on learnability of interfaces that shows that text-based interfaces are most beneficial for novice users. Most importantly, the finding that a text-based interface is most beneficial for older and novice users has contributed to developing an adaptable interface model for intuitive learning.

Second, the findings of Experiments 1 and 2 established a possible baseline design for complex interfaces that significantly minimises the effects of age differences.

A considerable amount of research has been done in the past two decades on differences between nested and flat interface structures. In general, most of the research agrees that older people take more time to complete the task on a nested interface and also find them hard to use. However, when the task is designed while taking into consideration the cognitive limitations of older people, the differences in accurate completion of the tasks between young and old were not significant.

Third, the findings of Experiment 2 of this study supports Attentional Control Theory (Eysenck & Derakshan, 2011) which suggests that anxiety is associated with increased allocation of cognitive resources, and this results in better performance.

Experiment 2 has showed that, contrary to what is suggested by the literature, an anxious or stressful condition does not have an adverse effect on intuitive use of complex technological product interfaces. Interestingly, older people under the stressful condition used interfaces much more intuitively.

Overall, in terms of theoretical implication, the outcome of this study has resulted in developing an adaptable interface design model for intuitively learnable interfaces (Figure 8.2). This model was developed after reviewing
the reasons behind the ineffectiveness of existing design methods. When this model is implemented as envisaged, it has the potential to help designers develop intuitively learnable products that will effectively address diversity in the capability of the older population. This is an important contribution to the field of inclusive or universal design.

**Research methodologies for older participants**

The combination of measures and apparatus used in this study, from both sociology and cognitive psychology, allowed it to focus more on the source of age-related differences, rather than on age as a variable. This research contributes to research methods that involve older participants.

*The study used a comprehensive mix of data collection methods: Technology prior experience, self-efficacy, cognitive measures and STAI questionnaires and video observations.*

This approach was based on the literature reviewed that suggests that the use of technology in older people is mediated by prior experience, self-efficacy, anxiety and cognitive abilities. For any meaningful research to occur, these factors should be considered so as to understand the true effects of age on different aspects of technology use. The methods used in this study are valuable for application in further studies in interdisciplinary areas such as, interaction design, cognitive science, psychology and social sciences.

**8.7 Conclusion**

This study was started with an aim to propose strategies to develop interfaces that appear more intuitive for older people to use. Two experiments were conducted: one to investigate a strategy that could facilitate intuitive use in older people, and the other to investigate factors that could impede intuitive use in older people.
Experiment 1 investigated redundancy in interfaces as a strategy for intuitive use by older people. The outcome was surprisingly different from what was initially hypothesised. Findings suggested that a simple text-based interface was much more helpful for older people than a redundant interface. Not only did older people use the text-based interface more intuitively they also made fewer errors compared with their use of the redundant interface. This implies that they are able to learn the functions of the interface on the task. This was a highly significant finding as it challenges most of the reviewed literature which suggested that redundancy in interface would be beneficial for older people and people with low domain-specific prior knowledge.

Experiment 2 investigated the relationship between age, technology prior experience, self-efficacy, anxiety, complexity in interface structure and the impact of this relationship on intuitive use of contemporary technological products. The findings from this experiment show that older people with low perceived technological self-efficacy reported more anxiety. However, the level of anxiety reported did not have any adverse effect on intuitive use. In contrast, older people used interfaces faster and more intuitively under the high stress condition. Most importantly, this experiment showed that, if the task is designed with consideration for the cognitive limitations of older people, the differences between young and old in terms of errors are not significant.

In general, the findings of this study show that older age groups are more heterogeneous in their capabilities than younger people and that their intuitive use of contemporary technological devices is mediated more by domain-specific technology prior knowledge and cognitive abilities than chronological age. This highlights the fact that the development of entirely intuitive-to-use product interfaces is extremely difficult mostly due to diversity of older people’s prior knowledge and cognitive abilities. Indeed, this finding is of enormous importance to the interface design field as it
implies that most of the existing design methods for developing intuitive interfaces may be ineffective for older users.

The findings of the study do show, however, that when interfaces are developed with consideration for the cognitive limitations and prior experience of older people, using simple text-based interface helps older people to learn and, over time, to use complex technological products more intuitively. This finding, combined with other related research, leads to the proposal of an adaptable interface design model for intuitive learning as the most optimal strategy for developing complex technological product interfaces for older people.

An adaptable interface allows older users and users with low domain-specific prior knowledge to use a simple text-based, flat-structured interface to help them learn and successfully use the new product interface during early encounter, and over time, the interface can progressively be changed to a symbols-based, nested interface for more efficient use. In other words, this model will help in designing products that are intuitive to learn and which, over time, are intuitive to use for older people with varied abilities.

An enormous advantage of an adaptable interface model is that it removes the necessity for developing products specifically for older people. In effect, this provides an economy of scale to the development of new products. Indeed, most of the current generation touch-based products can be reprogrammed to suit the needs of a wide range of ages and user capabilities. Above all, what is most significant and encouraging for the field, and people in general, is that this model has the tremendous potential to finally bridge the digital divide between older and younger generations.
References


Isomursu, M., #228, iki, #246, , J., Wallin, A., & Ailisto, H. (2008). Experiences from a Touch-Based Interaction and Digitally Enhanced Meal-


psychology: A user’s portfolio, Causal and control beliefs (pp. 35-37). Windsor, England: NFER-NELSON.


Appendix 1

TP Questionnaire for Experiment 1

(This page is intentionally left blank.)

Note: The font size in the following questionnaires is reduced to fit within this document’s margins. Original questionnaires had larger fonts and more leading for easy reading.
## TP Questionnaire Part 1 (pre-task)

### SECTION ONE

<table>
<thead>
<tr>
<th>Name:</th>
<th>:-------------------------------------------------------------------------------------------------</th>
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</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Contact (Email and/or phone number)</th>
<th>:-------------------------------------------------------------------------------------------------</th>
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<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Highest academic qualification and year of graduation</th>
<th>:-------------------------------------------------------------------------------------------------</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Age at last birthday</th>
<th>:-------------------------------------------------------------------------------------------------</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other details</th>
<th>: Height ________ cm   Weight _________ kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(You may lie about your height and weight. However, they should look realistic)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Gender</th>
<th>☐ Male    ☐ Female</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Occupation</th>
<th>:-------------------------------------------------------------------------------------------------</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(If retired please indicated your pre-retirement occupation)</td>
</tr>
<tr>
<td>Retired</td>
<td>☐Retired (Year ........................................)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Annual Household income (Optional)</th>
<th>:-------------------------------------------------------------------------------------------------</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**SECTION TWO** *(Please tick the appropriate boxes)*

How often do you use following products?

<table>
<thead>
<tr>
<th>Product</th>
<th>Never used</th>
<th>Used once or twice</th>
<th>Use it once a month</th>
<th>Use it few times a week</th>
<th>Use it every day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fax machine</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Photocopy machine</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Multifunction printer (Scan, fax and print)</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Mobile phone</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Health monitor devices</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td>BP monitor</td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Body fat analyser</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>MP3 player</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Digital camera</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Video recorder/ camcorder</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Television/video player remote control</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Software application (e.g. Microsoft word)</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Internet browser (Internet explorer, firefox etc.)</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>Video game console (PS3, Nintendo etc.)</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>ATM machine</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
<tr>
<td>GPS device/ Sat Navigation</td>
<td></td>
<td>In the past</td>
<td>Now</td>
<td>Now</td>
<td>Now</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
<td>In the past</td>
</tr>
</tbody>
</table>
SECTION THREE *(Please tick the appropriate boxes)*

If relevant, please answer the following questions

• If you own a mobile phone/smart phone how often do you upgrade/buy new one?
  □ Every 6 months or less
  □ Every year
  □ When my old phone stops functioning

• Please indicate the interests and activities related to technology in which you enjoy participating on a regular basis.
  □ Electronics
  □ Home Workshop/Do-it-yourself
  □ Photography
  □ Science Fiction
  □ Science/New Technology
  □ Home Video Games
  □ Other ................................................
  □ None of the above

• If retired please indicated your activity since retirement
  □ Pursuing hobbies
  □ Working part-time
  □ Working full-time
  □ Taking it easy and enjoying life
  □ Learning new skills
  □ Travel
  □ Other ................................................
TP Questionnaire Part II (post-task)

SECTION ONE

Please tick the appropriate boxes, and fill in the blanks if appropriate.

When using following products please state how familiar you are with their features and functions?

1. Below is an example image of control panel for a multifunction printer.

Please tick appropriate box below that describes your familiarity with different control buttons on the above panel image.

☐ I can identify and describe the function of **ALL THE CONTROL BUTTONS** on the panel

☐ I can identify and describe the function of **MOST OF THE CONTROL BUTTONS** on the panel

☐ I can identify and describe the function of **SOME OF THE CONTROL BUTTONS** on the panel

☐ I can identity some of the buttons but **NOT SURE OF THEIR FUNCTION**

☐ I **CANNOT IDENTIFY ANY** of the control buttons on the panel

If you are not familiar with some of the controls on the panel please circle them on the image.
3. Below is an image of few buttons from a windows based computer application.

![Image of buttons](image)

Please tick appropriate box below that describes your familiarity with different control buttons on the above image.

- [ ] I can identify and describe the function of **ALL THE CONTROL BUTTONS** on the panel
- [ ] I can identify and describe the function of **MOST OF THE CONTROL BUTTONS** on the panel
- [ ] I can identify and describe the function of **SOME OF THE CONTROL BUTTONS** on the panel
- [ ] I can identify some of the buttons but **NOT SURE OF THEIR FUNCTION**
- [ ] I **CANNOT IDENTIFY ANY** of the control buttons on the panel

If you are not familiar with some of the controls on the panel please circle them on the image.
4. Below is an image of few buttons from a web site. They are usually referred to as **tabbed navigation**.

![Tabbed Navigation](image)

Please tick appropriate box below that describes your familiarity with different control buttons on the above image.

- ☐ I have used this kind of control buttons and am **COMFORTABLE** with devices and software applications that use them

- ☐ I have seen devices using this mode of controls but am **NOT VERY COMFORTABLE** with them

- ☐ I have seen devices that used this mode of controls but **NEVER USED THEM**

- ☐ I never seen it before but **I GUESS I KNOW HOW IT FUNCTIONS**

- ☐ I have **NEVER SEEN IT NOR DO I KNOW HOW THEY FUNCTION**
5. Below is an example image of digital camera control buttons.

Please tick appropriate box below that describes your familiarity with different control buttons on the above image.

☐ I can identify and describe the function of **ALL THE CONTROL BUTTONS** on the panel

☐ I can identify and describe the function of **MOST OF THE CONTROL BUTTONS** on the panel

☐ I can identify and describe the function of **SOME OF THE CONTROL BUTTONS** on the panel

☐ I can identify some of the buttons but **NOT SURE OF THEIR FUNCTION**

☐ **I CANNOT IDENTIFY ANY** of the control buttons on the panel

If you are not familiar with some of the controls on the panel please circle them on the image.
4. Below is an example image of a mobile phone control buttons.

Please tick appropriate box below that describes your familiarity with different control buttons on the above image.

☐ I can identify and describe the function of **ALL THE CONTROL BUTTONS** on the panel

☐ I can identify and describe the function of **MOST OF THE CONTROL BUTTONS** on the panel

☐ I can identify and describe the function of **SOME OF THE CONTROL BUTTONS** on the panel

☐ I can identity some of the buttons but **NOT SURE OF THEIR FUNCTION**

☐ I **CANNOT IDENTIFY ANY** of the control buttons on the panel

If you are not familiar with some of the controls on the panel please circle them on the image.
## SECTION TWO

<table>
<thead>
<tr>
<th>Power button</th>
<th>Familiar</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not familiar</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Four way navigation and selection</th>
<th>Familiar</th>
</tr>
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<tbody>
<tr>
<td>Not familiar</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
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</table>

<table>
<thead>
<tr>
<th>Direction symbols</th>
<th>Familiar</th>
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</thead>
<tbody>
<tr>
<td>Not familiar</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ok/selection symbol</th>
<th>Familiar</th>
</tr>
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Appendix 2

STAI Questionnaire for Experiment 1

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Pre-experiment STAI

Self-evaluation questionnaire

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate how you feel right now, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Moderately</th>
<th>Very much</th>
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<tbody>
<tr>
<td>I feel calm</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am tense</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I feel upset</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am relaxed</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I feel content</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am worried</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
</tbody>
</table>
Post-experiment STAI

Self-evaluation questionnaire

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate how you feel right now, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Moderately</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel calm</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am tense</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I feel upset</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am relaxed</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I feel content</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am worried</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
</tbody>
</table>

Were you upset, felt tense or worried at anytime during Task 1 or 2? If YES please give the answer that seems to describe your feelings at that moment.

During Task 1: (Details:.............................................................................................)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Moderately</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>I was tense</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I felt upset</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I was worried</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
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During Task 2: (Details:.............................................................................................)

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<tbody>
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<td>I was tense</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I felt upset</td>
<td>☐ 1</td>
<td>☐ 2</td>
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<tr>
<td>I was worried</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
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</table>

(Marteau, Bekker 1992)
Appendix 3

Task list for Experiment 1

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Touch screen familiarisation task

Task 1

Can you please use it to calculate 1656 divided by 23?

Task 2

Can you find out square root for 4624?

Or

Can you multiply 267 with 56?

If you wish you may play with it for some more time.
Task 1

Objective: To enter and save personal data and measure your body fat composition

Scenario: You have just purchased this device and it is the first time you are using it. To properly use this device first time users are required to provide personal details and save them before they proceed to measure body fat composition.

Please note: All the measures displayed on this device are in metric system

Once you are comfortably settled down, please proceed to use the device. This task roughly has four steps.

1. Switching the fat monitor on
2. Entering your data as a new user and saving it for present and future use.
3. Measuring your body fat composition and
4. Switching the device off

Help will be provided on request if you are unable to complete a task after repeated attempts.
Task 2

**Objective:** To recall your saved data, update saved data, and measure your body fat composition

**Scenario:** You are using this device after few weeks of making changes in your life style. Now you have lost 2 kilograms of body weight. Since you have already entered and saved your personal details earlier all you have to do now is to recall/load your saved details and measure your body fat composition.

Once you are comfortably settled down, please proceed to use the device. This task roughly has five steps.

1. Switching the fat monitor on
2. Loading your saved data
3. Update your data
4. Measuring your body fat composition and
5. Switching the device off

Help will be provided on request if you are unable to complete a task after repeated attempts.
Appendix 4

Script for Experiment 1

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Observers’ script

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<tr>
<td>Date:</td>
<td>Start time:</td>
</tr>
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<td>Task 1 time:</td>
<td>Task 2 time:</td>
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</table>

Welcome

Hi! I’m Reddy
Thank you for volunteering to assist with my experiment. This session will roughly take one hour of your time.
Before we start could you please read through the information package? If you have any questions regarding this experiment or any information provided in this document, please don’t hesitate to ask.

Consent form

[Consent form + pen]
Could you please go thorough carefully and sign this consent form?

Introduction to lab

Explain clearly that experiment is recorded on AV recorder. Show them where the cameras and mikes are located.

[Make sure they understand that anxiety and cognitive measures tests are not recorded]
Introduction to experiment

The purpose of this research is to investigate appropriate design approaches that will enable designers to design technological products that are perceived as intuitive to use by older adults. The gradual shift from hardware-based to microprocessor controlled software-based products has brought a higher level of abstraction into interaction with products; resulting in older generation finding it more difficult to use contemporary products. This research tries to bridge this gap by proposing a designing tool to help designers facilitate intuitive interactions with complex technological products for older adults.

Basic idea behind this experiment is... we will ask you to use certain product and observe how easy or difficult it is to use.

Vision test

[Ask the participant to read last two lines from vision chart]

Technology Prior Experience Questionnaire

Could you please fill up this questionnaire?

[Pre-experiment TP Questionnaire]

Touch screen practice

This experiment uses this touch sensitive screen exclusively. It is very easy to use. However, I have a small application that will help you get familiar with it. I'll give you couple of tasks to get you started. While you are performing the given tasks, please speak aloud about your thought process and your actions related to the task. This will help us in recording your thoughts about how you use the product.

This is not a test to measure your abilities; if you fail to perform a given task it is because the device is not designed properly.

What you see here is a calculator.

Task 1: Can you please use it to calculate 1656 divided by 23?

Task 2: Can you find out square root for 4624?

If you wish you may play with it for some more time.
**Pre-experiment anxiety test**

This is an interactive questionnaire that’ll provide me with information regarding how you are feeling before you have used the product. We’ll do this again at the end of the experiment for data on your feeling/mood after using this product.

**Set up virtual device**

Enter age, weight and height details of the participant.

**Product introduction**

The product used for this experiment is called a body fat analyser. What I have in my hand is an example of this product. However, for this particular experiment we are using a virtual product, meaning, the product will be shown on the touch sensitive computer screen here. It functions and behaves just like the real product (*show how the actual product looks like*). The reason we can't use the real product is that they do not allow us to modify or improve it for experimental purposes.

What is this product used for?

This product is designed to measure a person's body fat composition in terms of percentage and mass. Like weighing machines, to get a accurate picture of body composition, users are supposed to use this machine over a period of time taking readings at regular interval (weekly or fortnightly) at a specific day and time (example, every Tuesday morning at 7 am before breakfast).

This particular device is modified in such a fashion that it will not actually measure your body fat. In other words, the readings, which you will see on the device, are NOT a true indicator of your body fat composition.

Any questions?

If you are ready we can start without experiment

**Experiment - Concurrent protocol**

To help us record your actions in a systematic fashion we need to do things in a particular sequence.

When asked please do only the tasks I mention during the experiment and stop when finished. Please do not use features not related to the given task,
if you want to explore other features of the products you may do so only after experiment is concluded.

While you are performing the given tasks, please speak aloud about your thought process and your actions related to the task. This will help us in recording your thoughts about how you use the product.

This is not a test to measure your abilities; if you fail to perform a given task it is because the device is not designed properly. Your participation will help us improve design of similar devices.

During this experiment you’ll be asked to perform two tasks. Once again this not a test of your abilities, you may take your own time to complete the given task and if you are stuck you are free to ask me.

[Start recording audio and video]

We are now recording; please state your name for identification purposes.

Please let me know when you are ready.
Task 1

Objective: To enter and save personal data and measure your body fat composition

Scenario: You have just purchased this device and it is the first time you are using it. To properly use this device first time users are required to provide personal details and save them before they proceed to measure body fat composition.

Duration: ___________ Seconds

Briefing for task 2: Approximately 2 minutes

Task 2

Objective: To recall your saved data, update saved data, and measure your body fat composition

Scenario: You are using this device after few weeks of making changes in your life style. Now you have lost 2 kilograms of body weight. Since you have already entered and saved your personal details all you have to do is to recall/load your saved details, update saved data and measure your body fat composition.

Duration: ___________ Seconds
Post-experiment anxiety test

Please complete this interactive anxiety questionnaire. Your answers to the questions may differ from that you have provided earlier. Please respond to the question in the context of how you feel right now.

Debriefing

• Please share your thoughts on using this device (ice breaker question no concrete answer is expected)

• Did you have difficulty with using any particular feature or function? If yes do you have any recommendations for improvement?

____________________________________________________________________________
____________________________________________________________________________
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Rating questionnaire for the device

(Walk through different display icons on the experiment device)

• What are the features you were familiar with before you commenced the experiment? Please mark them on the image below

• Are there any features you learnt today while performing any of the tasks?

[Stop recording audio and video]
Cognitive Measures Tasks

These interactive tasks are intended to provide me with necessary information about you that would help me sort experiment data objectively.

- Digit span
- Visual span
- Visual transform
- Phonological transform
- PGNG

Notes:
Appendix 5

Ethics and Consent Form for Experiment 1

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“Approaches to designing for intuitive interaction with complex devices for older adults”

Research Team Contacts

<table>
<thead>
<tr>
<th>Gudur Raghavendra Reddy – PhD candidate</th>
<th>Dr. Alethea Blackler – Senior Lecturer</th>
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<tr>
<td>07 3138 9183</td>
<td>7 3138 7030</td>
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<td><a href="mailto:r.gudur@qut.edu.au">r.gudur@qut.edu.au</a></td>
<td><a href="mailto:a.blackler@qut.edu.au">a.blackler@qut.edu.au</a></td>
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Description

This project is being undertaken as part of a PhD by Gudur Raghavendra Reddy. An Australian Research Council Discovery Grant (DP087764) funds the project. The funding body will not have access to the data obtained during the project.

The purpose of this research is to investigate appropriate design approaches that will enable designers to design technological products that are perceived as intuitive to use by older adults. Past decades have seen a substantial increase in the use of technology in all aspects of our lives. The gradual shift from hardware-based to microprocessor controlled software-based products has brought a higher level of abstraction into interaction with products; resulting in older generation finding it more difficult to use contemporary products. This research tries to bridge this gap by proposing a designing tool to help designers facilitate intuitive interactions with complex technological products for older adults. The research team requests your assistance because your participation will help us in developing this tool.

Participation

Your participation in this project is voluntary. If you do agree to participate, you can withdraw from participation at any time during the project without comment or penalty. Your decision to participate will in no way impact upon your current or future relationship with QUT.

Your participation will involve a think aloud protocol session where you will be asked to narrate your thought process while interacting with a product. This session will be conducted at the Human-Centred Research and Usability Laboratory at Gardens Point campus of the Queensland University of Technology. The session is expected to last up to an hour. The aim of the session is to understand the impact of ageing on intuitive use of complex technological devices. During this session you may also help us evaluate different strategies in designing interfaces that older
users perceive as intuitive to use. The session will be recorded with video and audio recording equipment present in the laboratory.

**Expected benefits**

It is expected that this project will not directly benefit you. However, it may benefit you in the future when the tools developed from this research project are adopted by the designers, resulting in products that are perceived as intuitive to use by older adults.

**Risks**

There are no risks beyond normal day-to-day living associated with your participation in this project.

**Confidentiality**

Only the research team involved with this project will have access to any information you provide, and resulting data from the experiment you were involved in. Your anonymity and confidentiality will be safeguarded in any and all publications resulting from this research.

Participation in the project is not possible without recording video and audio of the participating session. Although these recording may be listened to or watched by others on occasions, your personal information will never be displayed. Only members of the research team involved in this project will have access to personal information like name and affiliation.

All audio and video data will be stored in a secured location, the data is also backed up in a secured location and both can only be used by members of this research project, for this project, and for no other purpose.

**Consent to Participate**

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate. You can withdraw at any time without comment or penalty.

**Questions / further information about the project**

Please contact the researcher team members named above to have any questions answered or if you require further information about the project.

**Concerns / complaints regarding the conduct of the project**

QUT is committed to researcher integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Officer on 3138 2340 or ethicscontact@qut.edu.au. The Research Ethics Officer is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.
CONSENT FORM for QUT RESEARCH PROJECT

“Approaches to designing for intuitive interaction with complex devices for older adults”

Statement of consent

By signing below, you are indicating that you:

• have read and understood the information document regarding this project
• have had any questions answered to your satisfaction
• understand that if you have any additional questions you can contact the research team
• understand that you are free to withdraw at any time, without comment or penalty
• understand that you can contact the Research Ethics Officer on 3138 2340 or ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project
• understand that the project will include audio and/or video recording
• understand that images/video from this research that include me may be published as part of research communication

☐ Please cross the box if you don’t want your images to appear in any publications.

• agree to participate in the project

Name

Signature

Date

Please type or print clearly.
Appendix 6

Experiment 1: cognitive measures correlation.

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Figure 1: Bivariate correlation chart of cognitive measures data from Experiment 1.

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<td>-.358*</td>
<td>.446**</td>
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<tr>
<td>Sig. (2-tailed)</td>
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<tr>
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<td>.232</td>
<td>.513**</td>
<td>.164</td>
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<td>-.333*</td>
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</tr>
<tr>
<td>VisualtransfRT</td>
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<td>-.030</td>
<td>-.037</td>
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<td>-.202</td>
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<tr>
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<td>.383**</td>
<td>-.389**</td>
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<td>.337*</td>
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</tr>
</tbody>
</table>

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

*. Correlation is significant at the 0.05 level (2-tailed).
Appendix 7

TP Questionnaire for Experiment 2

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Ethics No: 0800000799

Technology Prior Experience Questionnaire

SECTION ONE

Name: 

Contact 
(Email and/or phone number): 

Highest academic qualification and year of graduation: 

Age at last birthday: 

Gender: □ Male □ Female

Occupation: 
(If retired please indicated your pre-retirement occupation)

□ Retired (Year ..............................)
### SECTION TWO *(Please tick the appropriate boxes)*

How often do you use following products?

<table>
<thead>
<tr>
<th>Product</th>
<th>Never used</th>
<th>Used once or twice</th>
<th>Use it once a month</th>
<th>Use it few times a week</th>
<th>Use it every day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch screen based products (eg. GPS, iPad, iPod, iPhone, Galaxy tab, etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Mobile phone</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Microwave oven</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Digital camera</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Internet browser (Internet explorer, firefox etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Video game console (PS3, Nintendo etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Software applications (e.g. Word, Excel, Pages etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Self-checkout machines at shopping malls</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
</tbody>
</table>
**SECTION THREE (Please tick the appropriate boxes)**

When using following products, how many of the features on the product do you use??

<table>
<thead>
<tr>
<th>Product</th>
<th>You do not know how to use this product</th>
<th>Your limited knowledge of the features limits your use of the product</th>
<th>Just enough features to get by with</th>
<th>As many features as you can figure out without manual</th>
<th>All the features (learnt it all systematically from the manual)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Touch screen based products (e.g. GPS, iPad, Galaxy tab, etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Mobile phone</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Microwave oven</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Digital camera</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Internet browser (Internet explorer, firefox etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Video game console (PS3, Nintendo etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Software applications (e.g. Word, Excel, Pages etc.)</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>Self-checkout machines at shopping malls</td>
<td>☐</td>
<td>☐</td>
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</tr>
</tbody>
</table>
Appendix 8

Self-efficacy Questionnaire

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Technology Self-efficacy Questionnaire

Rate your degree of confidence by recording a number from 0 to 5 using the scale given below:

1. I can always manage to solve difficult problems if I try hard enough.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree

2. When interacting with a new technological devices, I am confident I can learn to use it without much difficulty.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree

3. If someone opposes me, I can find the means and ways to get what I want.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree

4. I am confident that I could deal efficiently with unexpected events.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree

5. I find it easy to learn how to use a new software package or online application on computer.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree

6. I can solve most problems if I invest the necessary effort.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree

7. I am very unsure of my abilities to use new technological devices.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree

8. When I am confronted with a problem, I can usually find several solutions.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree

9. I can usually handle whatever comes my way.
   
   0 1 2 3 4 5
   
   Strongly disagree   Strongly agree
10. New technological devices frightens me

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

11. I am very confident in my abilities to use new technological devices

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

12. Thanks to my resourcefulness, I know how to handle unforeseen situations.

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

13. I find it difficult to get new technological devices to do what I want it to

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<tr>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

14. If I am in trouble, I can usually think of a solution.

<table>
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<tr>
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<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
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</tbody>
</table>

15. It is easy for me to stick to my aims and accomplish my goals.

<table>
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<tr>
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<th>1</th>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

16. I always seem to have problems when trying to use new technological devices

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<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

17. When confronted with a problem using new technological device, I am confident I can solve it on my own with out help.

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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

18. I can remain calm when facing difficulties because I can rely on my coping abilities.

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<thead>
<tr>
<th>0</th>
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<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly disagree</td>
<td>Strongly agree</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 9

STAI Questionnaire for Experiment 2

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Pre-experiment STAI

Self-evaluation questionnaire

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate how you feel right now, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

<table>
<thead>
<tr>
<th></th>
<th>Not at all</th>
<th>Somewhat</th>
<th>Moderately</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel calm</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am tense</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I feel upset</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am relaxed</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I feel content</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am worried</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
</tbody>
</table>
Post-task STAI

Self-evaluation questionnaire

Were you upset, felt tense or worried at anytime during task. If YES please give the answer that seems to describe your feelings at that moment.

<table>
<thead>
<tr>
<th></th>
<th>Was upset</th>
<th>Was Worried</th>
<th>Was Tense</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking pet for walk</td>
<td>☐ Some what</td>
<td>☐ Some what</td>
<td>☐ Some what</td>
</tr>
<tr>
<td></td>
<td>☐ moderately</td>
<td>☐ moderately</td>
<td>☐ moderately</td>
</tr>
<tr>
<td></td>
<td>☐ very much</td>
<td>☐ very much</td>
<td>☐ very much</td>
</tr>
<tr>
<td>Calling the pet back</td>
<td>☐ Some what</td>
<td>☐ Some what</td>
<td>☐ Some what</td>
</tr>
<tr>
<td></td>
<td>☐ moderately</td>
<td>☐ moderately</td>
<td>☐ moderately</td>
</tr>
<tr>
<td></td>
<td>☐ very much</td>
<td>☐ very much</td>
<td>☐ very much</td>
</tr>
<tr>
<td>Giving snack to pet</td>
<td>☐ Some what</td>
<td>☐ Some what</td>
<td>☐ Some what</td>
</tr>
<tr>
<td></td>
<td>☐ moderately</td>
<td>☐ moderately</td>
<td>☐ moderately</td>
</tr>
<tr>
<td></td>
<td>☐ very much</td>
<td>☐ very much</td>
<td>☐ very much</td>
</tr>
<tr>
<td>Calling the Vet</td>
<td>☐ Some what</td>
<td>☐ Some what</td>
<td>☐ Some what</td>
</tr>
<tr>
<td></td>
<td>☐ moderately</td>
<td>☐ moderately</td>
<td>☐ moderately</td>
</tr>
<tr>
<td></td>
<td>☐ very much</td>
<td>☐ very much</td>
<td>☐ very much</td>
</tr>
</tbody>
</table>

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the most appropriate number to the right of the statement to indicate how you feel right now, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

<table>
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<th>Somewhat</th>
<th>Moderately</th>
<th>Very much</th>
</tr>
</thead>
<tbody>
<tr>
<td>I feel calm</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am tense</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I feel upset</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am relaxed</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I feel content</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
<tr>
<td>I am worried</td>
<td>☐ 1</td>
<td>☐ 2</td>
<td>☐ 3</td>
<td>☐ 4</td>
</tr>
</tbody>
</table>
Appendix 10

Task list for Experiment 2

(This page is intentionally left blank.)
Task 1

You are pet sitting for your friend. This particular pet is a new breed and is psychologically and physiologically extremely sensitive. It needs to be closely monitored and kept happy at all the times. When enough attention is not paid the pet will become unhappy and, if no remedial action is taken, will make the pet very sick. Your responsibility as a pet sitter is to take care of it till your friend returns. In summary, you have to keep the pet happy and make sure that it won’t get sick.

Press the start button when you are ready.
Task 2

You are asked to pet sit again by your friend. As you have already experienced, this pet is a new breed with special needs. You are asked to take care of it till your friend returns. This time you’ll take charge of the pet at a different time under different circumstances. Remember you have to keep the pet happy at all times or else it’ll get very sick.

Press the start button when you are ready.
Appendix 11

Script for Experiment 2

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Experiment 2 script

Pre-experiment activity

- Consent form signing
- Visual acuity test
- Introduction to the lab
- Technology familiarity questionnaire
- Self-efficacy questionnaire

Short break

Short break to let users get accustomed to lab environment and feel at ease.

Introduction to the experimental product:

Show and briefly explain the touch-based device (iPad), followed by familiarisation task on iPad.

Short form STAI Questionnaire

Administration of Short from STAI instrument

Introduction to task

When asked please do only the tasks I mention during the experiment and stop when finished. Please do not use features not related to the given task, if you want to explore other features of the products you may do so only after experiment is concluded.

This is not a test to measure your abilities; if you fail to perform a given task it is because the device is not designed properly. Your participation will help us improve design of similar devices.

[Start recording audio and video]
Explain the mediator product and the performance bar on the top

This is your performance feedback. It'll start in the middle and either goes up to excellent or goes down to poor based on your performance on the task. The feedback is relative and it is based on the performance of previous participants. If your performance is better than the average of previous participants, it'll go up and vice versa. So far, N number of participants attempted this task.

Task 1

Hand them Task 1 sheet and make sure they understand what is expected of them.

Post-task 1 short form STAI Questionnaire

Administration of Short from STAI instrument

Note: Please complete this interactive anxiety questionnaire. Your answers to the questions may differ from that you have provided earlier. Please respond to the question in the context of your interaction with the experiment product.

Task 2:

Hand them Task 2 sheet and make sure they understand what is expected of them.

[Stop recording audio and video]

Post-task 2 short form STAI Questionnaire

Administration of Short from STAI instrument

Note: Please complete this interactive anxiety questionnaire. Your answers to the questions may differ from that you have provided earlier. Please respond to the question in the context of your interaction with the experiment product.
Debriefing

Explain to the participant what the experiment was about. If they were on Hi-stress conditions explain to them that the feedback was rigged to show negative performance and it does not reflect their actual abilities. Make them feel at ease.

- Please share your thoughts on using this device. Did you have difficulty with using any particular feature or function? If yes do you have any recommendations for improvement?

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Cognitive measures instrument

- Digit span
- Corsi span
- Visual transform
- Phonological transform
- Sustained attention task

Notes:
Appendix 12

Experiment 2: Ethics and Consent Form

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PARTICIPANT INFORMATION for QUT RESEARCH PROJECT
Ethics approval number: 0800000799

“Approaches to designing for intuitive interaction with complex devices for older adults”

Research Team Contacts

<table>
<thead>
<tr>
<th>Gudur Raghavendra Reddy – PhD candidate</th>
<th>Dr. Alethea Blackler – Senior Lecturer</th>
</tr>
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<tbody>
<tr>
<td>07 3138 9183</td>
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<td><a href="mailto:r.gudur@qut.edu.au">r.gudur@qut.edu.au</a></td>
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</tbody>
</table>

Description

This project is being undertaken as part of a PhD by Gudur Raghavendra Reddy. An Australian Research Council Discovery Grant (DP087764) funds the project. The funding body will not have access to the data obtained during the project.

The purpose of this research is to investigate appropriate design approaches that will enable designers to design technological products that are perceived as intuitive to use by older adults. Past decades have seen a substantial increase in the use of technology in all aspects of our lives. The gradual shift from hardware-based to microprocessor controlled software-based products has brought a higher level of abstraction into interaction with products; resulting in older generation finding it more difficult to use contemporary products. This research tries to bridge this gap by proposing a designing tool to help designers facilitate intuitive interactions with complex technological products for older adults. The research team requests your assistance because your participation will help us in developing this tool.

Participation

Your participation in this project is voluntary. If you do agree to participate, you can withdraw from participation at any time during the project without comment or penalty. Your decision to participate will in no way impact upon your current or future relationship with QUT. This session will be conducted at the People And Systems lab at Gardens Point campus of the Queensland University of Technology. The session is expected to last up to an hour. The aim of the session is to understand the impact of ageing on intuitive use of complex technological devices. During this session you may also help us evaluate different strategies in designing interfaces that older users perceive as intuitive to use. The session will be recorded with video and audio recording equipment present in the laboratory.
Expected benefits

It is expected that this project will not directly benefit you. However, it may benefit you in the future when the tools developed from this research project are adopted by the designers, resulting in products that are perceived as intuitive to use by older adults.

Risks

There are no risks beyond normal day-to-day living associated with your participation in this project.

Confidentiality

Only the research team involved with this project will have access to any information you provide, and resulting data from the experiment you were involved in. Your anonymity and confidentiality will be safeguarded in any and all publications resulting from this research.

Participation in the project is not possible without recording video and audio of the participating session. Although these recording may be listened to or watched by others on occasions, your personal information will never be displayed. Only members of the research team involved in this project will have access to personal information like name and affiliation.

All audio and video data will be stored in a secured location, the data is also backed up in a secured location and both can only be used by members of this research project, for this project, and for no other purpose.

Consent to Participate

We would like to ask you to sign a written consent form (enclosed) to confirm your agreement to participate. You can withdraw at any time without comment or penalty.

Questions / further information about the project

Please contact the researcher team members named above to have any questions answered or if you require further information about the project.

Concerns / complaints regarding the conduct of the project

QUT is committed to researcher integrity and the ethical conduct of research projects. However, if you do have any concerns or complaints about the ethical conduct of the project you may contact the QUT Research Ethics Officer on 3138 2340 or ethicscontact@qut.edu.au. The Research Ethics Officer is not connected with the research project and can facilitate a resolution to your concern in an impartial manner.
CONSENT FORM for QUT RESEARCH PROJECT

“Approaches to designing for intuitive interaction with complex devices for older adults”

Statement of consent

By signing below, you are indicating that you:

• have read and understood the information document regarding this project
• have had any questions answered to your satisfaction
• understand that if you have any additional questions you can contact the research team
• understand that you are free to withdraw at any time, without comment or penalty
• understand that you can contact the Research Ethics Officer on 3138 2340 or ethicscontact@qut.edu.au if you have concerns about the ethical conduct of the project
• understand that the project will include audio and/or video recording
• understand that images/video from this research that include me may be published as part of research communication

☐ Please cross the box if you don’t want you images to appear in any publications.
• agree to participate in the project

Name

Signature

Date / /