Identifying Familiarity to Facilitate Intuitive Interaction for Older Adults

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Abstract

Almost every nation on the planet is experiencing increases in both the number and proportion of older adults. Research has shown that older adults use technology less intuitively than younger adults, and have more difficulty with using products effectively. With an ever-increasing population of older adults, it is necessary to understand why they often struggle to use technology, which is becoming more and more important in day to day living. Intuitive use of products is grounded in familiarity and prior experience. The aims of this research were twofold: (i) to examine the differences in familiarity between younger and older adults, to see if this could explain the difficulties faced by some older adults; (ii) to develop investigational methods to assist designers in identifying familiarity in prospective users.

Two empirical studies were conducted. The first experiment was conducted in the field with 32 participants, divided across four age groups (18 – 44, 45 – 59, 60 – 74, and 75+). This experiment was conducted in the participants’ homes, with a product they were familiar with. Familiarity was measured through the analysis of data collected through interviews, observation and retrospective protocol. The results of this study show that the youngest group demonstrated significantly higher levels of familiarity with products they own than the 60 – 74 and the 75+ age groups. There were no significant differences between the 18 – 44 age group and the 45 – 59 age group and there were also no significant differences between the three oldest age groups. The second experiment was conducted with 32 participants, across the same four age groups. Four everyday products were used in this experiment. The results of Experiment 2 show that, with previously unused products, younger adults demonstrate significantly higher levels of familiarity than the three older age groups. The three oldest age groups had no significant differences between them.

The results of these two studies show that younger adults are more familiar with contemporary products than older adults. They also demonstrate that in terms of familiarity, older adults do not differ significantly as they get older. The results also show that the 45 – 59 age group demonstrate higher levels of familiarity with products they have owned, in comparison with those they have not. The two older age groups did not demonstrate such differences. This suggests that interacting with products over time increases familiarity more for middle-aged adults than for older adults.

As a result of this research, a method that can be used by designers to identify potential users’ product familiarity has been identified. This method is easy to use, quick, low cost, highly mobile, flexible, and allows for easy data collection and analysis. A tool has been designed that assists designers and researchers to use the method. Designers can use the knowledge gained from this tool, and integrate it into the design process, resulting in more intuitive products. Such products may lead to improvements in the quality of life of older adults, as a result of improved societal integration, better health management, and more widespread use of communications technology.
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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

Date
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Chapter 1 – Introduction

1.1 Research Problem
The number and proportion of older adults is growing worldwide. Research shows that Australia has proportionally lower numbers of individuals under the age of 15 than in 1990, and further decreases are predicted (e.g. Pink, 2010). In the last 20 years, Australia has experienced a 3.3% increase in those over the age of 65, and remarkable increases in those over the age of 85 (170.6%), and those over the age of 100 (185%). All over the world both developed and developing countries are showing similar trends, and these demographic shifts are expected to continue in the near future (Lloyd-Sherlock, 2000; Pink, 2010). Africa is the only region where an ageing population trend is not seen (Lloyd-Sherlock, 2000). Such a demographic shift must result in changes in the products and services offered to society (Fisk, Rogers, Charness, Czaja, & Sharit, 2004).

Many older adults have difficulty with contemporary products. Older adults experience decreases in a wide range of capabilities that, in turn, affect how they interact with products (Gregor, Newell, & Zajicek, 2002; Keates & Clarkson, 2003b). Some of the effects of the ageing process on product interaction include difficulties with information organisation, system navigation, text and symbol comprehension, remembering instructions, fine motor control, glare, reduction in performance speed, higher interruption from errors, and increased likelihood of distraction (Fisk et al., 2004; Fisk, Rogers, Charness, Czaja, & Sharit, 2009). To ensure that older adults can lead a fully integrated and fulfilling life, issues surrounding the use of complex devices by older adults need to be addressed.

There is a considerable body of knowledge about the effects of ageing on the older adult. There are discussions in the literature about how to take these factors into consideration when designing for older adults (Fisk et al., 2009; Hawthorn, 2000). There have also been several design movements, such as Inclusive Design and Universal Design, which are integrating this research into practical guidelines for industry (e.g. Clarkson, Coleman, Keates, & Lebbon, 2003; Story, 1998). The integration of this knowledge into practice is critical, as the population ages. There are many opportunities moving forward, where technology offers potential to assist in making the lives of older adults richer and more rewarding (Fisk et al., 2009). Higher levels of engagement with technology are not only likely to lead to improvements in the quality of life of the older adult, but may also result in a socially richer society, with older adults empowered to engage longer with, and in, society.

It has been shown that older adults use products less intuitively than younger adults, and that familiarity is at the core of intuitive interaction (Blackler, 2008b). Kang and Yoon (2008) found that both age and prior experience affect interaction behaviour. O’Brien’s (2010) result also demonstrates that prior experience has a positive impact on performance. She also noted differences in the interaction styles of younger and older participants. Thus, a logical place to start investigating the differences in younger and older adults is with the concept of product familiarity.
1.1.1 Intuitive Interaction and Older Adults
Several researchers have shown that older adults use products less intuitively or less successfully than younger adults (e.g., Blackler, 2008b). The empirical studies conducted in this research also demonstrated less successful interactions with products and less intuitive interactions with products by older people when compared to younger people. Researchers generally attribute the differences between older and younger adults to either one or both of two factors: age or age-related declines in ability, and a lack of relevant prior knowledge (Blackler, Mahar, & Popovic, 2010; Kang & Yoon, 2008; Langdon, Lewis, & Clarkson, 2009; O’Brien, 2010; Reddy, Blackler, Mahar, & Popovic, 2010). O’Brien (2010) states that prior experience helps to predict success, but does not account for all performance differences between younger and older adults. Kang and Yoon (2008) discuss age and prior knowledge as factors that influence users’ interaction behaviour. Langdon et al. (2009) found that prior experience within the context of use was the primary determinant of interaction success, although there was some influence of age-related declines. Reddy et al. (2010) state that technology familiarity correlates with time on task, and that there is a strong relationship between attention (a central executive function) and the effective use of complex interfaces. Blackler et al. (2010) state that technology familiarity is a crucial element in effective interaction. They also state that central executive function is significantly related to variables that are important measures of interaction success (Blackler, Mahar et al., 2010). Blackler et al. (2010, p. 175) conclude by saying: “a complex mix of abilities and experience, rather than simple chronological age, affects how older people use new interfaces.”

Across the various research studies conducted in this area, some variables have been significantly related to both knowledge and age-related declines. Some researchers are attributing some aspects to age and/or cognitive capability and some researchers are attributing the same aspects to knowledge. Across eleven studies, the following aspects are significantly related to either age or knowledge: time on task, error rate, number of interaction steps, self-reported performance, self-reported time pressure, adoption of trial and error strategies, intuitive uses and amount of help required to recover from error (Blackler, 2008b; Blackler, Mahar et al., 2010; Langdon, Lewis, & Clarkson, 2007; Langdon et al., 2009; Lewis, Langdon, & Clarkson, 2006; Marsh & Setchi, 2008; O’Brien, 2010; Reddy et al., 2010). The major differences in these studies were the ways prior knowledge was measured. Almost all of the methods used were self-reported methods. Some studies measured cognitive ability, while others used chronological age. More precise research into the role of cognitive decline and prior knowledge is required to move beyond this confusion. This research is beginning to emerge (e.g., Blackler, Mahar et al., 2010; Hurtienne, Horn, & Langdon, 2010; Lawry, Popovic, & Blackler, 2010; Reddy et al., 2010).

As discussed, the deficits in performance that many older adults experience with products can be explained by two main components: cognitive decline, and relevant prior knowledge. There are several ways to address the issues surrounding these components.

1.1.2 Cognitive Decline
Existing research closely examines the declines in age-related abilities in relation to intuitive interaction. It shows that declines in central executive function have a more significant effect on intuitive interaction than age does (Blackler, Mahar et al., 2010).
The central executive is a component of working memory that is responsible for tasks such as reasoning, problem solving, and attention. Additional research identifies that at least one of the individual components of central executive function that is related to intuitive interaction is sustained attention (Reddy et al., 2010).

There are two ways to combat the effects of cognitive decline on intuitive interaction. The first way is to integrate knowledge about the impacts of cognitive decline into the design process. For example, Reddy et al. (2010) recommend using both visual and audio resources in interfaces, while avoiding deep, multi-layered interfaces. Minimising distractions on the interface is also constructive. It is clear that an understanding of the effects of declines in cognitive abilities will assist designers in developing more usable products for older adults (Charness & Boot, 2009). There are examples of guidelines that provide some of this knowledge (e.g., Bouma & Graafmans, 1992; Fisk et al., 2004).

The second way is to attempt to mitigate cognitive decline. Research shows that cognitive training can improve cognitive function (Mahncke et al., 2006), and reduce difficulties in everyday life (Willis et al., 2006). While this area of research shows promise, and could be beneficial to many older adults, it remains up to the individual to engage with cognitive training, and is thus out of the hands of the designer. Even if individuals do slow or reverse cognitive decline, they still need to have the relevant prior knowledge to engage successfully with contemporary products. Charness and Boot (2009) comment that it is likely that future generations of older adults will continue to lag behind younger adults in technology adoption, as a result of declines in abilities due to ageing. Cognitive training is beyond the scope of this research.

1.1.3 Relevant Prior Knowledge and Product Familiarity

There is a solid foundation of research that shows that prior knowledge is an important part of intuitive and successful interactions (e.g., Blackler, Mahar et al., 2010; Langdon et al., 2009; O’Brien, 2010). For an interaction to take place, the user needs to have the knowledge related to the use of the product to achieve the desired outcome. There are two approaches that can be used to ensure that users have the knowledge they require to use a product. The first approach, which is the most common approach, is to teach the user how to use the product. The most familiar format is the instruction manual. Unfortunately, many instruction manuals are inadequate, and users will often avoid reading them (Cushman & Rosenberg, 1991). The field of instructional design examines how to organise and present information more effectively through instructional materials, such as user manuals (e.g., Sweller, van Merrienboer, & Paas, 1998). Research in this area often utilises cognitive theory (Sweller, 1999, 2011; van Merriënboer & Sweller, 2005). The user is required to use any instructional material provided (such as a user manual) to learn how to use the interface. However, the designer cannot control if the user will engage with the training material provided, and it is shown that most users do not (Rettig, 1991). If no instructional material is provided, then a trial and error approach is likely to occur.

The other approach is to match the knowledge required to use a product to the knowledge that the users already have: a strategy which requires very little of the users. This researcher argues that this is most effective way for designers to increase the usability of products. Spool (2005) agrees with this position, and also states that
identifying the prior knowledge of a user is one of the biggest challenges to making a design intuitive.

1.2 Research Question
The focus of this research is to identify if there are any differences in product familiarity between younger and older adults and, if there are, to come to an understanding of these differences. There is an emphasis on the importance of making knowledge and methods available to the design professional, in order for the outcomes of this research to be applied to artefact design. The primary research question addressed in this thesis is:

How can familiarity be identified in order to facilitate intuitive interaction for older adults?

Two sub-research questions focused the broader research questions. These questions focused on two different aspects of the primary research question.

1. How familiar are older adults with contemporary products, and how does this differ from the familiarity of younger adults?

2. How can designers readily identify what interaction processes older adults are familiar with?

The aim of this research is two-fold. Firstly, it aims to provide researchers and designers with an understanding of the role of product familiarity in interaction, and how product familiarity varies with age. Secondly, it will provide a method for designers to discover what users are familiar with. This knowledge can then be integrated into the design process and result in more intuitive products.

1.3 Overview of Thesis
This section will provide an explanation of the content and structure of this thesis, and outline the contributions to knowledge made by this research.

1.3.1 Contents
Chapters 2, 3 and 4 review literature relevant to the research questions posed in Section 1.2. Chapter 2 outlines the existing research on intuitive interaction, provides a definition of intuitive interaction and explains how intuitive interaction links to familiarity. Chapter 3 reviews the literature on familiarity, prior experience, prior knowledge, and expertise. This chapter establishes definitions and provides reviews of terminology relevant to this research. Chapter 4 discusses older adults and reviews the literature surrounding definitions of older adults, and the effects of the ageing process. Chapter 4 then looks at some of the literature addressing both older adults and technology use and adoption.

Chapter 5 addresses the research methodology used. The methodological implications of conducting research with older adults are discussed and then a review of existing methods used in intuitive interaction research is presented. This knowledge has been integrated into a research plan, which will outline the two empirical studies conducted, and the experimental approach used. The tools and heuristics used to analyse the data obtained from the empirical studies are then introduced. Chapter 6
introduces and describes Field Experiment 1. This study investigated the differences in product familiarity between older and younger adults. The results of this experiment are discussed. Chapter 7 introduces and describes Experiment 2. This study built on Field Experiment 1 and investigated the differences in familiarity between younger and older adults with everyday products that participants did not own. The results are presented and discussed. Chapter 8 provides a discussion of the results from Field Experiment 1 and Experiment 2 within the context of the literature. The outcomes of this research are explained. Chapter 9 discusses the implications of this work, its limitations, and its contributions to knowledge. Finally, conclusions are drawn, and the future directions of this research are explained. Figure 1.1 illustrates an overview of the thesis.

1.3.2 Contributions to Knowledge

This research makes several contributions to knowledge. The first contribution is that younger adults are significantly more familiar with contemporary products than older adults, while older adults of varying ages do not display significant differences in familiarity with contemporary products. This demonstrates that chronological age alone does not explain all differences in familiarity with contemporary products.

The second contribution to knowledge is the finding that, while middled-aged adults demonstrate higher levels of familiarity with products they own than with novel products, the two oldest age groups do not experience this increase in familiarity. This suggests that middle-aged adults may be more readily able to access knowledge gained from prior experience with a product. This suggests that middle-aged adults are more likely to be able to learn new interaction methods, while older adults will likely benefit more from designs that utilise interaction methods they have already experienced.

The third contribution to knowledge is the development of a new research methodology that can be used to identify familiarity. This set of methods, unlike most existing methods, does not rely on self-reporting. Instead, participant knowledge is examined in context, allowing for more precise identification of participant familiarity and knowledge. A set of heuristics is also provided for identifying various levels of
familiarity through observation. Future researchers working in this area could use these heuristics.

A fourth contribution to knowledge involves the development of a method, the Primed Task Recall, and a tool built around the method, which can be used by designers to identify familiarity. This method is quick, low cost, flexible, and mobile—factors which may help increase industry uptake. The tool is designed to teach designers and researchers how to use the method, and also provides a platform on which to use the method. The knowledge acquired by the designer through the use of the tool can then be integrated into the design process to create products that are more intuitive to use.

1.4 Summary
Chapter 1 has introduced the research problem and also the primary and sub research questions that were formed in response to the research problem. The structure of this thesis has been explained, and the contents outlined. The contributions to knowledge made by this research have been presented. Chapters 2, 3 and 4 introduce the relevant literature on this topic.
Chapter 2: Intuitive Interaction

2.1 Intuition

Intuition is a powerful tool that has travelled through folklore with stories such as Newton and the apple, and Archimedes in the bath and his Eureka experience (Bastick, 2003). Philosophers who have provided definitions of intuition often rely on metaphysical, mystical or spiritual elements. While it may seem to be a concept that people think is universally understood, intuition is often considered to be an inexplicable phenomenon. There is no concrete definition, and some even define intuition as undefinable (Bastick, 1982, 2003).

Bastick (2003, p. 1) describes intuition as a “universal experience” that is poorly understood. Current research on intuition does not focus on the notion of ‘magical intuition’ or any type of psychic ability (Klein, 2003, p. xix). Blackler’s (2008b) review of various definitions of intuition demonstrates that, although there is no formal definition, most researchers agree on its basic properties. Her review identifies past experience as the main property attributed to intuition, while other common properties include faster speed, higher efficiency over other cognitive process, and intuition as a process which is not consciously recognised (Blackler, 2008b).

Based on an extensive literature review, Blackler, Popovic, and Mahar (2002, p. 120) conclude that “intuition is a cognitive process that utilises knowledge gained through prior experience”. [For a full review of intuition, see Blackler (2008b)]. Knowledge accessed without prior experience of the concept, or with no learning process, or no use of rationale, simply is not possible (Raskin, 1994). What is normally called ‘intuition’ is actually based in knowledge and experience (Klein, 2003). Klein (1998), in his analysis of the use of intuition by fire-fighters in real world scenarios, describes how one fire-fighter did not realise how he was using his experience to evaluate a situation, as he was not doing it deliberately or consciously. Interestingly, the fire-fighter attributed this to extrasensory perception. Raskin (1994, 2000) states that, in the context of interfaces, the intuitive is the familiar.

The use of intuition as a cognitive process sits on a continuum, with controlled, conscious actions on one end, and automatic actions requiring no thought on the other (Blackler et al., 2002). Reber (1989, p. 14) states that from all the various definitions, one of the most cited characteristics is “...that the individual has a sense of what is right or wrong, a sense of what is the appropriate or inappropriate response, given the circumstances, but is largely ignorant of the reasons for that mental state”. Reber (1989) argues that intuition is a cognitive state which emerges under specific conditions, after establishing a knowledge base that allows for such judgements to be made. Klein (1998, p. 31) agrees, stating that “intuition depends on the use of experience to recognise key patterns that indicate the dynamics of the situation”. As intuition is based on pattern recognition, it utilises generalised memories from a number of similar scenarios, rather than one specific event. As a result of this, Klein (1998, p. 33) argues that “intuition grows with experience”.

Experience helps people evaluate what is happening around them and helps them to decide how to react. Experience leads to pattern recognition which allows decisions to
be made quickly without conscious effort and deliberation (Klein, 1998). In other words, past experiences inform people of patterns relating to a given context, and these are compared with patterns in situations as they are encountered. Intuition is a direct result of high levels of experience (Klein, 2003). Intuition provides the relevant contextual information if the situation matches a recognised pattern, and also notifies if the situation does not quite fit. Klein (1998, p. 33) states that one of the basic features of intuition is “recognizing things without knowing how we do the recognizing”. Klein (2003, p. xvi) defines intuition as “the way we translate our experience into action”.

Bastick (2003) agrees with Klein on the role of experience in intuition. Given that experience is a key element of intuition, it is logical that the more experience people have, the more reliable intuition is (Bastick, 2003). Bastick (2003) argues that intuition is based in emotions, and is related to feelings. Experiences condition certain responses based on emotional states, which produce emotional sets. These emotional sets are utilised when an individual approaches certain situations, and help with recognition, acceptance, associations, analogies, and judgement, among other things (Bastick, 1982, 2003).

In summary, Klein’s (1998; 2003) approach to intuition is from a decision making point of view. Bastick (2003), on the other hand, comes from a creativity perspective. He agrees with Klein (1998; 2003) in areas such as the dismissal of the mystical view of intuition, the speed of intuition in relation to other types of cognitive processing, the role of context or environment, and the pervasiveness of intuition in everyday life. Both Bastick (2003) and Klein (1998; 2003) agree that intuition is based in experience, but the result of that experience differs. Klein (1998; 2003) states that increased experience leads directly to improved recognition of patterns, while Bastick (2003) states that more experience results in certain behavioural responses based on emotional states triggered by a situation. For the intents and purposes of this research, these two points of view are considered to be essentially the same, as both positions are grounded in a response to a given context based on experience.

2.2 Intuitive Interaction

Intuitiveness is one of the most desirable attributes a product can have (Turner, 2008a; Turner, 2008b). Principle Three of the seven principals of universal design is “Simple and Intuitive Use – Use of the design is easy to understand, regardless of the user’s experience, knowledge, language skills, or current concentration level” (Story, 1998, p. 8). As Blackler (2008b) notes, it appears that making something intuitive will address many usability problems. Intuition, it would seem therefore, is an important concept to integrate into the design of products. Thus, it is important to gain an understanding of what intuition is in the context of product use.

Recently there has been a trend in marketing and advertising to use intuitive interaction as a unique selling point, with particular products claimed to be ‘intuitive to use’, or to have an ‘intuitive interface’ (Hurtienne & Blessing, 2007). The term ‘intuitive use’ has become somewhat of a buzzword, but until recently, had not been defined (Blackler & Hurtienne, 2007).

Blackler (2008b, p. 107) provides the following 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 their decisions during intuitive interaction.

Hurtienne and Israel (2007) introduce the definition of intuitive use developed by the Intuitive Use of User Interfaces (IUUI) research group from the Technische Universität Berlin. The IUUI claims that: “A technical system is intuitively usable if the user’s subconscious application of prior knowledge leads to effective interaction” (Hurtienne & Israel, 2007, p. 2). Raskin (1994) uses an example of a software review to point out the role of experience in intuition. The author of the review states that aspects of the software became increasingly intuitive over time. Raskin translates this to mean that, once one has learned about the software, it becomes intuitive (Raskin, 1994). He also states that ‘familiar’ equates to ‘intuitive’.

Blackler and her colleagues conducted the first empirical investigations into intuitive interaction (Blackler, 2008b). Their research is published in a book titled ‘Intuitive Interaction with Complex Artefacts’ (Blackler, 2008b), and a series of papers (Blackler & Hurtienne, 2007; Blackler, Mahar et al., 2010; Blackler, Popovic, & Mahar, 2003b, 2005b, 2006). They initially conducted three experiments, with which they have established a knowledge base that has expanded the understanding of intuitive interaction. Blackler (2008b) developed a coding scheme which allowed intuitive uses to be coded from audiovisual data. The first experiment tested the hypothesis that “intuitive interaction involves utilising knowledge gained through other products or experience(s)” (Blackler, 2008b, p. 149). The aim of this experiment was to establish whether past experience with a product feature affects the amount of time required to complete a task, and the intuitive use of product features (Blackler et al., 2003b). The 20 participants used a digital camera, and were videoed while executing a range of tasks, during which they delivered verbal concurrent protocol (Blackler et al., 2003b).

The particular camera chosen (Fuji 4700) borrowed features from other digital products, so experience with digital cameras alone was not enough to use this camera intuitively (Blackler, 2008b). After using the camera, the participants were interviewed about how familiar they were with each feature they used, and completed a questionnaire examining how familiar they were with technology similar to the camera used in the experiment. From this questionnaire, a Technology Familiarity score was calculated (Blackler, Popovic, & Mahar, 2005a). This experiment suggested that relevant past experience with other products (as established by the Technology Familiarity questionnaire) helped participants to complete the tasks more quickly and intuitively (Blackler, 2008b).

Experiment 2 was designed to further test the results of Experiment 1. A touch screen universal remote control was used with a sample larger than the sample used in Experiment 1. Due to the results of Experiment 1, the 30 participants were grouped according to technology familiarity, rather than experience with a single product type (Blackler et al., 2003b). The results of this experiment supported the results from Experiment 1. Those participants who had higher technology familiarity scores had higher levels of intuitive interaction, and completed the tasks in less time (Blackler,
It was also discovered that interface features that are less familiar are used less intuitively, and with more mistakes (Blackler, 2008b). The results of this experiment suggest that older adults have significantly fewer intuitive first uses than younger users, and that older users take significantly longer to complete the tasks than younger users (Blackler, 2008b).

From these two experiments, three principles for intuitive use were established (Blackler, Popovic, & Mahar, 2003a):

1. Use familiar symbols and/or words for well-known functions.
2. Make it obvious what less well-known functions do by using familiar things to demonstrate their function.
3. Increase consistency across the interface.

These principles were applied to the interface of the universal remote control used in Experiment 2 by eighteen postgraduate Industrial Design students, who redesigned the interface within the constraints of the product, based on a brief provided by the researcher (Blackler, Popovic, & Mahar, 2007). A redesigned interface was selected for testing. From this, four different interfaces were created for testing: Default (as used in Experiment 2), modified Appearance, modified Location, and modified Appearance and Location. The selected student design utilised a combination of redesigned button appearance and button location. The modified location configuration kept the default appearance of features, but used the new layout from the student redesign. The modified appearance configuration kept the new button designs, but used the default layout (Blackler et al., 2007).

Blackler’s third experiment was conducted with 60 participants across three age groups: 18 – 29, 30 – 39 and 40+, and four interface groups: Default, Location, Appearance and Location-Appearance. A cross section of individuals was selected, based on gender, education and technology familiarity. No participants had used the remote before (Blackler et al., 2005b). Experiment 3 confirmed the results of the previous two experiments, with the findings also suggesting that performance is affected by experience and familiarity with similar products and technologies (Blackler, 2008b; Blackler et al., 2005a). Furthermore, this experiment showed that the appearance of an interface feature contributes more to intuitive interaction than it’s location (Blackler, 2008b; Blackler et al., 2005a). This experiment also revealed differences between age groups in relation to intuitive uses and other relevant measures. The 40+ age group had significantly lower scores for intuitive use than the 30 – 39 age group. Also, time to complete tasks for the 40+ age group was significantly higher than any other age group (Blackler, 2008b). There was a significant increase in intuitive use, and decrease in time on task across all age groups with the versions of the interface that used more familiar feature appearances (Blackler, 2008b).

From this work, Blackler (2008b) produced the set of principles for intuitive use (expanded from the principles above), a continuum of intuitive interaction (Figure 2.1), and a tool to help designers create intuitive products. When designing for intuitive interaction, all sections of the continuum can lead to intuitive interaction (Blackler, 2008b). The simplest form of intuitive interactions is on the left, and the most complex form of intuitive interaction is on the right. For a full explanation of the
continuum, see Blackler (2008b). Blackler’s (2008b) tool uses an iterative process to ensure that intuitiveness is met across function, appearance, and location for each product feature. Each feature is addressed by the simplest form of intuitive interaction as shown by the continuum, and then moves on to the next form, until a suitable design solution for each element of the function is reached. This process is repeated across all functions of the product.

Figure 2.1: Blackler’s Continuum of Intuitive Interaction (Blackler & Hurtienne, 2007)

A later empirical study by Blackler, Mahar, and Popovic (2010) showed that technological familiarity and cognitive decline due to ageing affect time on task, and intuitive uses and correct uses of two different microwave interfaces. The study used digital prototypes of an existing commercial microwave, and a microwave redesigned to be more intuitive. Participants interacted with the microwaves via a touch screen. A total of 32 participants across three age groups (18 – 39, 40 – 56 and 57+) took part in the study. Cognitive ability was measured using a range of tests, focusing on different aspects of working memory (Blackler, Mahar et al., 2010). Technology familiarity was measured using a self-reporting technology familiarity questionnaire, as in the three original experiments. Participants were required to perform a series of tasks with the designated microwave interface (the existing interface, or the redesign). The results of this experiment show that technology familiarity and central executive function had an effect on time on task. The central executive is a component of working memory that is responsible for tasks such as reasoning, problem solving, and attention. Declines in working memory also had an impact on intuitive interaction. Age was less important than the measures of cognitive ability for the regression analysis, and declines in central executive function varied among older adults (Blackler, Mahar et al., 2010). This may imply that central executive function has more of an impact than chronological age.

Building on earlier work (Blackler, 2008b; Blackler, Mahar et al., 2010), Reddy, Blackler, Mahar, and Popovic (2010) further examined the role of cognitive decline in the use of technology. Their study utilised an observation with concurrent protocol, a technology familiarity questionnaire, and a battery of cognitive tests. A total of 44 participants between the ages of 18 and 83 participated in the study. Each participant was required to perform two tasks with a virtual touch-screen prototype of a commercially available body fat analyser. The results of this study support Blackler’s (2008b) results regarding prior experience. Reddy et al. (2010) found that prior experience resulted in less time on task, and that younger adults generally scored higher on the technology familiarity questionnaire, and performed faster than older adults. The results show strong negative correlations between sustained attention (a central executive function) and time on task and errors. Age also correlated negatively with sustained attention (Reddy et al., 2010). This further confirms that prior experience is relevant to interaction; however, a cognitive aspect also plays a role in
performance. Reddy et al. (2010) have also identified a specific component of central executive function—sustained attention—which contributes to successful interaction.

The results reported in Blackler et al. (2010) are supported by earlier work by Blackler and her colleagues (Blackler, 2008b; Blackler et al., 2005b), and by the work of Lewis and his colleagues on usability with respect to cars (Lewis et al., 2006). Lewis et al., and other researchers at Cambridge University have been conducting research into the role of prior experience on product usage, with a focus on inclusive design (e.g. Hurtienne et al., 2010; Langdon et al., 2007; Langdon et al., 2009; Lewis et al., 2006; Lewis, Langdon, & Clarkson, 2008). The methods used by the research group are similar to the methods used by Blackler (2008b). A more recent study reported by Lewis, Langdon and Clarkson (2008) and Langdon, Lewis and Clarkson (2009) using microwaves shows some discrepancies with Blackler’s (2010) findings. Lewis et al. (2008), for example, found that age was more important than prior experience in using the microwaves, while Blackler et al. (2010) found technology familiarity most important for time on task, and elements of central executive function most important for correct uses, and intuitive correct uses.

The first relevant study by Lewis et al. (2006) focused on the role of prior experience with cars and examined the use of secondary controls such as windscreen wipers and headlights. Participants were required to execute a series of tasks, and were observed doing so. The measure of experience used was drivers versus non-drivers. The findings show that non-drivers had more difficulties performing the tasks than drivers did. Also, drivers who owned a European car had more difficulties than those who owned an American car, as the car used was an American car (Lewis et al., 2006). These results support Blackler’s findings that prior experience leads to improved interactions. This study only used 15 participants, and the only measure of experience was drivers versus non-drivers. No data is provided to show the ratio of drivers to non-drivers in the study. Also, no comparisons between older and younger drivers are made, even though the age range of the participants was from 20 to 60 years.

Langdon et al (2007) reported on another study conducted by the research group. A total of 16 participants ranging in age from 23 to 84 were given two sets of tasks to execute with a camera, and a car, respectively. Each participant completed an intelligence test, and also an experience questionnaire. The experience questionnaire asked participants what products and brands they had experience with, and how frequently these were used. Questions were then “scored and weighted with a value based upon how relevant that experience was judged to be in completing the trial successfully” (Langdon et al., 2007, p. 184). Participants were recorded executing the set tasks. Once the tasks were completed, the video was played back to the participants and they delivered retrospective protocol. Time on task and errors were measured. The study found that the results from the intelligence test decreased with age, as did the experience score. There was a negative relationship between the intelligence score, time on task, and errors. Higher levels of experience were also shown to result in fewer errors, and less time on task. Langdon et al. (2007) state that although there is clearly an age-related component in the declines in performance, prior knowledge plays a larger role in determining performance.
Langdon et al. (2009) report two studies, one using microwaves, and the other using digital radios. The first study involved 19 participants ranging in age from 21 to 85. Three participants were used in a control group, and the remaining participants were split into two groups of eight. Each group used one microwave first, and then switched to the alternative interface. All participants completed an intelligence test and an experience questionnaire, as in the Langdon et al. (2007) study. An additional symbol recognition and button position test was carried out to further test participant knowledge. Participants were required to complete the same set of tasks, whether they were using the button interface or the dial interface (Langdon et al., 2009). The button interface had a higher error rate than the dial interface. Experience measures had much weaker relationships with time and errors than in the previous experiment. There was greater variance in performance between the two interface styles as the score from the intelligence test declined. The control group, which used a simplified version of the button microwave, achieved results that sat between the dial and button interface results.

The study focusing on digital radios attempted to control prior experience by training all participants with one product, and then testing the participants with two similar products. A total of 42 participants were split across two age groups (40 – 60 and 60 – 80), and then into a further three groups based on the score from the same intelligence test used in Langdon et al.’s (2007) earlier experiment. All participants also conducted an experience questionnaire, which asked questions relating to previous experience with radios. Participants were given a set of tasks that was held constant across all three radios. Participants were trained to a point of zero error with the first radio. At this point, the participants performed the tasks with the second radio (similar to the first radio), and then the third radio (different to other radios). This study found a significant effect of age and intelligence test score on time on task. The training also had a significant effect on time on task. Users were able to transfer knowledge from one product to the next.

This author is concerned with the methods used to examine participant familiarity in both studies reported by Langdon et al. (2007; 2009), due to the potential for bias, and reliance on the researcher’s judgement. Familiarity was measured using a self-reporting questionnaire, but was also supplemented with a symbol recognition and button position test in Langdon et al. (2009). In both studies, the researchers weighted the scores from the questionnaire subjectively. The method used by Langdon et al. differs slightly to Blackler’s Technology Familiarity (TF) questionnaire (Blackler, 2008b). The TF questionnaire asked questions about specific product categories and created a score from the answers. Concerns are also raised about the use of the online intelligence test. The validity and rigour of the test is unclear. Robust tests, such as those used by Blackler et al. (2010), would likely provide more meaningful results. Nevertheless, the results from these studies do concur with Blackler’s (2008b) findings.

Hurtienne (2009) conducted research with the IUUI group at the Technical University of Berlin. The IUUI’s definition of ‘intuitive use’ has been reported earlier in this section. One of the aims of the IUUI group is to provide a set of tools and guidelines to assist in designing intuitive interactive products (Blackler & Hurtienne, 2007). The IUUI has created a continuum of knowledge relevant in intuitive interaction (Figure 2.2). The levels of knowledge within the continuum are: Innate, Sensorimotor,
Culture, and Expertise. Across the three latter levels, specialist knowledge related to the use of tools and technology is found. The frequency of encoding and retrieval of knowledge increases as one moves from the higher levels of knowledge to the lower levels (Blackler & Hurtienne, 2007). There are similarities between the work of the IUUI group and the work of Blackler and her colleagues. One of the primary similarities is that both groups agree that intuition is grounded in the subconscious use of prior knowledge. For a full review of the similarities and differences between the two groups, see Blackler and Hurtienne (2007).

Figure 2.2: The IUUI Continuum of Knowledge in Intuitive Interaction (Blackler & Hurtienne, 2007)

Image schemas fall into the sensorimotor level, and can be used to facilitate intuitive interaction as long as the knowledge within the image schema is applied subconsciously (Hurtienne & Blessing, 2007). Hurtienne (2009) conducted a range of studies examining the role of image schemas in intuitive use. Image schemas are “assumed to be a subconscious form of human knowledge representation that is derived from basic sensorimotor experiences” (Hurtienne, 2009, p. 5). They are based on the individual’s experience with recurring patterns of interaction with the physical world. One of the most prominent image schemas is the up-down schema, with up often being associated with more, and down with less. The metaphorical use of image schemas allows abstract meaning to be embedded in an interface. For an example of some of the possible metaphorical extensions of the up-down schema, and a list of image schemas, see Hurtienne & Blessing (2007). For a more thorough review of image schemas, see Chapters Three and Four of Hurtienne (2009).

Hurtienne’s (2009) first four studies used software to test whether metaphorical extension of image schemas could be used to improve interaction. Studies Five and Six examined the reliability of the process of identifying image schemes across a range of individuals. Study Seven examined the application of image schemas to the design process through a case study. Hurtienne’s (2009) first and second studies examined the effect of using metaphor congruent interfaces and metaphor incongruent interfaces using the image schemas up-down and left-right. Forty participants took part in each study. These studies found that the metaphorical extensions of the up-down and left-right image schemas can be used in interface design to improve usability.

Studies Three and Four conducted by Hurtienne, examined the metaphorical extensions of the image schema near-far. The results obtained from Study Three were
ambiguous, and thus Study Four was designed with an improved methodology. The results of this study support the relevance of the metaphorical extensions of the near-far schema in interaction. Studies Five and Six examine the use of force image schemas, which result from interaction with dynamic objects. Study Five involved the identification and testing of interaction examples for ten force image schemas. These schemas had an identification rating from ‘fair’ to ‘almost perfect’ across four participants. Study Six compared two coders coding image schemas in a real-world design scenario (the redesign of accounting software). This study demonstrates that image schemas can be applied to realistic usage scenarios, with a high level of agreement between two separate coders (Hurtienne, 2009).

The final study examined the application of image schemas to a user centred design process. The study ran through a four step design process with an accounting software package (Hurtienne, 2009), following the International Standards Organisation standard 13407 (ISO 13407) (ISO 13407, in Hurtienne, 2009). The process resulted in two possible design solutions: one utilising a graphical user interface, and the other a hybrid graphical/tangible user interface. Five users of the existing system rated the proposed redesigns. The users rated the interfaces based on whether they thought they would work faster with them, or whether they would better support them. Although the number of participants was low (n=5), the results show that both the redesigned graphical user interface and a hybrid graphical/tangible interface were rated more highly than the existing system.

Through his extensive research, Hurtienne (2009) has demonstrated that the metaphorical extensions of image schemas can be used in interface design and do result in better performance. The effective use of image schemas and their metaphorical extensions are likely to facilitate intuitive use, as the knowledge the image schemas are based in comes from individuals’ sensorimotor experience of their environment. Due to this fact, performance using interfaces based upon image schemas should remain consistent across heterogeneous user groups.

O’Brien (2010) is another researcher who has conducted investigations into intuitive interaction. She conducted two studies, specifically investigating prior knowledge, interaction and older adults. The first study was a diary-based study, where participants recorded their interactions with technologies they used over a ten day period. Any new technology used, or problems encountered, were recorded and analysed. The participants included 10 adults between the ages of 18 – 28, and 20 adults between the ages of 65 – 75. The adults in the older age group were split into two further groups based on their level of experience with technology. The high and low technology levels were determined by a technology survey, based on Blackler’s (2008b) Technology Familiarity questionnaire. O’Brien’s (2010, p. 40) technology survey addressed the breadth of technology experience and also the depth of experience with ‘representative’ everyday technologies. Participants were also required to complete a battery of cognitive tests, and demographic and health questionnaires. The results of this study show that all age groups used a wide variety of products, with younger adults and ‘high tech’ older adults showing similar usage levels. ‘Low tech’ older adults had lower levels of technology usage. Younger and ‘high tech’ older adults reported similar levels of encounters with new and infrequently used technology, while younger adults experienced less. All participants reported a higher success rate than failure rate. The data suggests that prior knowledge
commonly results in the successful use of technology (O’Brien, 2010). O’Brien (2010) suggests that relying only on prior knowledge may not always result in successful interaction. Participants often mentioned ‘knowledge in the world’ as contributing to their successful interactions (Norman, 2002).

O’Brien’s (2010) second study examined everyday technology interactions with younger and older adults, using three separate products. The participants were 12 younger adults aged from 18 – 28 years, and 24 older adults, aged from 65 – 75 years. The older participants were divided into ‘high tech’ and ‘low tech’ groups as in the first study. The cognitive tests were identical to Study One and demographic and health questionnaires were also used. Participants also completed a technology experience questionnaire, as in Study One. Participants used three products, a Flip video camera, a Kindle eBook reader, and a Sony Dream Machine alarm clock. For each product, participants completed three tasks that reflected basic functionality of each product. The observation methodology was based upon Blackler’s (2008b) procedure. After the observation, the participant was required to make an explanatory video for a friend, showing them how to use the product. A technology specific questionnaire was also filled out after the observation. The results of this study show that prior knowledge with similar technologies helps predict success with the products, but it does not explain all differences in performance. Understanding the information on the device (e.g. icons) was assisted by prior experience. Holding technology experience constant across age groups did not eliminate age differences in performance. Overall, O’Brien (2010) found prior experience contributes to successful interaction with products, but it does not account for all differences between younger and older adults.

The author of this thesis has some concerns with O’Brien’s (2010) study. The first is that ‘high tech’ older adults are assumed to have the same level of technology experience as younger adults. Given that the results of this work suggest that older adults do not have the same level of technology experience as younger adults (Sections 6.5.1, 7.5.1, and 8.2), and research has shown that different birth cohorts use and learn about technology differently (Czaja & Sharit, 1998; Docampo Rama, 2001; Lim, 2010), this author considers O’Brien’s (2010) claim that ‘high tech’ older adults have the same level of technology experience as younger adults to be an assumption.

In support of this author’s concerns with O’Brien’s (2010) study, Prensky (2001, 2005) argues that those born into the digital age (digital natives) have notable differences to those who were born before the digital age (digital immigrants). While digital immigrants can learn the skills required to exist in the digital world, Prensky argues that immigrants still lag behind the natives (Prensky, 2001, 2005). This is supported by Docampo Rama’s (2001) ‘technology generations’ (Section 4.6). The products that an individual is exposed to during the first 25 years of life (the formative years) have a large influence on how the individual will interact with products later in life (Docampo Rama, 2001; Docampo Rama, de Ridder, & Bouma, 2001). The youngest age group in O’Brien’s study was 18 – 28, while the ‘high tech’ and ‘low tech’ older adults were between the ages of 65 and 75. The products that the older adults were exposed to during their formative years are very different to the products the youngest age group have been exposed to during their formative years.
A second area of concern is the performance levels described in O’Brien’s (2010) second study. The optimal level of performance is assessed based on a lack of errors, rather than on any sort of exceptional performance or other measure of highly successful or skilled interaction. While O’Brien’s scale is sufficient, it does not consider participant behaviour when examining performance or interaction success.

Despite the variation in methodological details, O’Brien’s (2010) findings support and strengthen Blackler and her colleagues’ findings (Blackler, 2008b; Blackler, Popovic, & Mahar, 2010). O’Brien found that experience with similar technology helped predict successful interactions, but did not explain all differences in performance. Age affected performance levels, regardless of the prior knowledge of the participants. O’Brien (2010) also reports that younger adults are more successful across all technologies. Overall, her results suggest that successful interaction is affected partly by prior knowledge of similar technologies, and partly by age.

The research discussed in this section supports Blackler’s (2008b) findings that prior experience is the basis of intuitive interaction. Additionally, some of the studies discussed also confirm Blackler, Mahar, et al.’s (2010) findings that age-related cognitive decline plays a role in intuitive successful interaction, and present differences in performance that are not solely based on prior experience (Langdon et al., 2009; O’Brien, 2010). From the research conducted, Blackler and her colleagues developed principles of intuitive interaction (Blackler, 2008b; Blackler et al., 2003a), and empirically confirmed the effectiveness of these (Blackler, 2008b). They have discovered that experience and familiarity are critical elements of intuitive interaction. These findings will be further explored and discussed in Chapter 3.

2.3 Summary

Intuition is a cognitive process that occurs as a result of knowledge gained through prior experience. (Blackler, 2008). This knowledge leads to pattern recognition, and allows people to have a sense of right or wrong, or to know what to do, without being aware of how they know (Klein, 1998; Reber, 1989). Intuition affects the speed and efficiency of tasks performed (Blackler, 2008b).

Intuitive interaction is the utilisation of prior knowledge by the user of some sort of user interface, whether that is a product, or a system. It is fast and effective, and a highly desirable attribute for an interface to have. Blackler’s (2008b) initial studies revealed that appearance and location contribute to intuitive use, as well age. She recommended the use of familiar features to help facilitate intuitive interaction. Additional research confirms that prior experience is a crucial element in successful interaction (Hurtienne, 2009; Langdon et al., 2007; Lewis et al., 2006; O’Brien, 2010; Reddy et al., 2010). Hurtienne (2009) has demonstrated that prior knowledge can indeed be used to improve interfaces. More recent studies have found that cognitive function and age play a role in intuitive interaction, alongside familiarity and prior knowledge (Blackler, Mahar et al., 2010; Langdon et al., 2009; O’Brien, 2010; Reddy et al., 2010).

Experience is a crucial part of intuitive interaction Blackler (2008), and it is also a crucial element of familiarity (Gefen, 2000). Raskin (2000) suggests that the words ‘intuitive’ and ‘familiar’ can basically be used interchangeably. Experience is, therefore, an important aspect of this research, as it is relevant to both familiarity and
intuitive interaction. None of the studies have thoroughly investigated prior experience or familiarity, so it is necessary to examine these concepts in order to better understand intuitive interaction. The next chapter discusses the concepts of prior knowledge, experience, familiarity, and expertise.
Chapter 3 – Familiarity, Prior Experience and Expertise

3.0 Introduction
This chapter introduces the literature on familiarity, provides a review of this literature, and then specifies a definition of ‘familiar’ that is used in this current research. A framework of familiarity was constructed based on the literature, and is presented here. Experience is then discussed, and the terms ‘prior knowledge’ and ‘prior experience’ are further examined. The use of these terms in this research is clarified. Finally, ‘expertise’ is introduced, and some of the characteristics of experts relevant to this research are discussed.

3.1 Familiarity
Research into familiarity has occurred within several different fields. The first field is consumer research (e.g. Gefen, 2000; Johnson & Russo, 1984; Wood & Lynch, 2002; Zaichkowsky, 1985). The original interest in familiarity in consumer research is in relation to the role of familiarity in product knowledge, primarily in the context of consumer choice (Bettman & Park, 1980; Johnson & Russo, 1984; Zaichkowsky, 1985). Some of the more recent research examines the role of familiarity in people’s trust of e-commerce websites (Gefen, 2000; Gefen, Karahanna, & Straub, 2003; Gulati & Sytch, 2008). The second field that discusses familiarity is the field of recognition memory. Familiarity is one of two distinct recognition processes, the other being recollection (Yonelinas, 2002). Yonelinas (2002) describes familiarity in this context as seeing someone known to be familiar, but not being able to recollect who they are, or when or from where they are known. The third field is Human Computer Interaction (HCI). Familiarity has been mentioned in this field for since at least 1987. Familiarity was one of the principles used by the design team of the Xerox 8010 (Star) computer (Bewley, Roberts, Schroit, & Verplank, 1987). Recently, Turner (Turner, 2008a; Turner & van de Walle, 2006) and his colleagues have begun a new discussion of the term ‘familiarity’ in Human Computer Interaction.

3.1.1 Familiarity and Consumer Behaviour
Familiarity and consumer decision making
Johnson and Russo (1984) conducted one of the first experiments in relation to product familiarity and learning. Specifically, their research is about domain knowledge and how individuals learn about product classes and make decisions relating to product selection and purchasing. The empirical work in this area examines product selection from a range of products within a product category, with different attributes of the product presented to the participants. Production selection was studied using microwaves (Bettman & Park, 1980; Park & Lessig, 1981) and cars (Johnson & Russo, 1984). Johnson and Russo (1984) equate familiarity to prior knowledge of a domain. This knowledge does not necessarily come from product usage, but from other sources such as advertisements as well. They also state that familiar consumers have superior knowledge over unfamiliar consumers, and that familiar consumers have advantages over new consumers, including improved memory of new knowledge and an enhanced ability to encode knowledge (Johnson & Russo, 1984).
Park and Lessig (1981) conducted a similar study, and state that product familiarity can be measured in two ways. The first is in terms of ‘how much a person knows about the product’, and the second is a subjective measure of ‘how much a person thinks s/he knows about a product’ (Park & Lessig, 1981, p. 223). Park and Lessig (1981) utilised a subjective, self-reporting measure. They acknowledge that this makes comparisons difficult, as different individuals may utilise different criteria when assessing their familiarity. They do not provide a definition of familiarity, and group participants into three categories based on the participants’ perceived knowledge of dimensions relevant to the evaluation of the product. The levels of familiarity used relied on an interview related to the product category, experience with product, and ownership of product (Park & Lessig, 1981).

Bettman and Park (1980) fail to provide a definition of familiarity, yet used a self-reported, five-tiered measure of familiarity in their study. The levels of familiarity used are the same as the measures used by Park and Lessig (1981) and were used to examine prior knowledge and experience. Interestingly, Bettman and Park (1980) treat prior knowledge and experience as the same thing, and again, do not provide a definition for these terms.

Johnson and Russo (1984) discuss some characteristics of familiarity that are relevant to this research. One of these is a decrease in search time when considering possible options as a result of high familiarity. This could result in faster time on task due to quick decision making. Similarly, Klein (1998) discusses how high levels of experience lead to rapid decisions in his Recognition-Primed Decision model. Johnson and Russo (1984) also state that familiarity may lead to a more in-depth understanding of meaningful relationships between different elements of a product. They suggest that this knowledge also leads to more efficient encoding of information about new products, and to increases in learning. Research from the field of expertise supports this. Ericsson and Lehmann (1996), for example, state that material can be rapidly encoded by linking the material to existing knowledge and patterns. Johnson and Russo (1984) also state that familiarity results in relevant information selection, and the ability to disregard information not relevant to the task at hand. This is also supported by research in expertise which holds that experts perceive and then utilise knowledge that non-experts also perceive, but do not interpret as useful (Durso & Dattel, 2006; Huys, Smeeton, Hodges, Beek, & Williams, 2008).

The field of consumer behaviour provides little in the way of a concrete definition of familiarity, yet it helps to develop an understanding of the areas that need to be addressed. Zaichkowsky (1985) comments that the word ‘familiarity’ used in the studies mentioned above (and in additional studies) is problematic, as there is minimal commonality in meanings of the word. Across several studies, the term ‘familiarity’ has been implied to mean—or been used interchangeably with—experience, prior knowledge, product ownership, product usage, domain knowledge, and usable product knowledge (Johnson & Russo, 1984; Zaichkowsky, 1985). This demonstrates the difficult nature of the word, and its inconsistent use even within a single research domain. There appear to be assumptions made as to what the word means, as Blackler (2008b) found when researching definitions of the term ‘intuition’.
Familiarity and consumer trust

Familiarity is considered to be a prerequisite of trust (Luhmann, 1979, in Gefen, 2000) as it creates an understanding of the environment and the other party, which allows expectations to be expressed. Gefen (2000, p. 727) defines familiarity as “an understanding, often based on previous interactions, experiences and learning…”. He describes how familiarity is an understanding of the behaviour, function, or action of an individual or an object. He also describes familiarity as an understanding of context. Familiarity in relation to an interface is an awareness based on experience and reduces complexity through an understanding of the process and procedures involved in an interaction; this should result in increased use (Gefen, 2000).

Gefen, Karahanna, and Straub (2003) continue this line of argument, saying that familiarity reduces complexity by facilitating an understanding of what is happening in the present moment. Gulati and Sytch (2008) similarly state that direct inter-organisation experience is necessary for trust to exist, and that “prior interaction creates ‘familiarity’” (Gulati & Sytch, 2008, p. 167). Gefen (2000, p. 728) agrees, stating that “prior experience is the basis of trust”. A study conducted by Komiak and Benbasat (2006) shows a statistically significant relationship between familiarity and trust in the ability of an online recommendation agent. Those who used the agent more displayed higher levels of familiarity and, hence, trust. Two levels of familiarity were used in the study, ‘high’ and ‘low’ familiarity, and rankings were based upon the number of uses of the recommendation agent (Komiak & Benbasat, 2006).

3.1.2 Familiarity and Recognition Memory

The second field that discusses familiarity is recognition memory. Familiarity is one of two distinct recognition processes, the other being recollection. The literature shows that the two processes are different and that familiarity and recollection utilise different areas of the brain (Yonelinas, 2002). This has been confirmed by Curran (2000), who measured event-related brain potentials—which measure patterns of electromagnetic activity in the brain as a result of cognitive processing (Bressler & Ding, 2006)—and found that different distributions of electromagnetic activity over the scalp accompany the use of familiarity and the use of recollection to access information (Curran, 2000).

A common assumption of memory models is that a cue can trigger information in two ways, either as a scale-based value of familiarity, or as structured recall of an event (Hintzman, Caulton, & Levitin, 1998). There are a number of different models of recollection memory. Yonelinas (2002) conducted an in-depth review and comparison of six models and outlines a number of similarities and dissimilarities. There is general agreement that familiarity is faster than recall (Hanks, 1990; Hintzman & Caulton, 1997; Hintzman et al., 1998). Four of the six models assume that familiarity and recollection are independent processes at the time of retrieval (Yonelinas, 2002). Yonelinas’ (2002, p. 492) review of the literature concludes that: familiarity is fast; uses ‘signal-detection-like’ processes; behaves independently of recollection; is partially automatic; and is more sensitive to perceptual cues than recollection.

Ageing has also been shown to affect familiarity and recollection, and to disrupt recollection more than familiarity. Naveh-Benjamin (2000) showed that older adults had greater difficulty encoding and retrieving associations between items (conceptual information) than recognising items (perceptual information). However, Yonelinas
(2002) also states that some research indicates that ageing has a negative effect on recollection, but does not influence familiarity.

The field of recognition memory provides a very different perspective on familiarity than the field of consumer behaviour. The two areas considered by consumer behaviour researchers (familiarity and consumer decision making, and familiarity and trust) both infer that familiarity is based upon experience from the past, and is built on knowledge gained from those experiences. However, while the recognition memory field discusses familiarity in a similar way, it has a more rigorous view than consumer decision making research. In recognition memory, familiarity is regarded as a cognitive process that recalls information using signal-like, perceptual cues. It is a fast, partially automatic process (Yonelinas, 2002). There are similarities between this description of familiarity and Blackler’s (2008b) definition of ‘intuitive interaction’ (Section 2.2). Intuitive interaction is based on prior experience, and is a fast process (Blackler, 2008b). It is likely that intuitive interaction utilises the quick process of familiarity to retrieve information from memory for use during interactions, rather than the slower process of recollection.

### 3.1.3 Familiarity and Human Computer Interaction

Familiarity has appeared irregularly in Human Computer Interaction (HCI) literature for a considerable period of time. Familiarity was one of the principles applied to the design approach used in the Xerox 8010 “Star” workstation, the first commercial system integrating the desktop metaphor with the computer interface (Bewley et al., 1987). Bewley et al. (1987, p. 72) state: “There should be an explicit user model and it should be familiar (drawing on objects and activities the user already works with) and consistent.” This shows that Bewley et al. (1987) consider familiarity to be directly related to a user’s prior experience and knowledge.

Lim, Benbasat and Todd (1996) adopted a similar position. They investigated task familiarity in relation to user performance. They define a task as ‘familiar’ when it is “consistent with a user’s life experiences” (Lim et al., 1996, p. 9). They suggest that familiarity utilises existing knowledge structures that are triggered by relevant contextual stimuli. Lim et al. (1996) state that familiarity is a relative concept, and depends on the experience of the users: what is familiar to one user may not be familiar to another. They classify tasks as ‘familiar’ if the actions required to complete the task match the typical person’s experience with the real world. Lim et al. (1996, p. 29) found that presenting an interface in a way that is “consistent with a user’s real-life experience” leads to improved performance due to automaticity. Lim et al. (1996, p. 5) define ‘automaticity’ as “the ability to perform routine activities quickly, effortlessly, and without conscious awareness”.

Somerveir, Chewar and McCrickard (2004) discuss the role of ‘familiar interfaces’ as case studies is teaching HCI. In contrast with Lim et al. (1996), they do not provide a definition of what familiarity is, and assume the reader has a natural understanding of what is meant by ‘familiar’. The only insight given into their meaning of familiarity is the use of the phrase “pre-existing familiarity”, explaining why familiar interfaces and ongoing projects require less reading and preparation time (Somerveir et al., 2004, p. 5). Interestingly, Somerveir et al’s (2004) results suggest that the use of familiar interfaces in teaching HCI results in high levels of student engagement, student perception, and long-term retention. Another example of research that uses the term
‘familiarity’, yet does not define it is the work of Mitchell, Chen and Macredie (2005). They conducted research on the relationship between prior knowledge and hypermedia learning. They created an interactive software application teaching a module from an undergraduate Computer Science course. In their results, they suggest a negative relationship between familiarity and difficulties encountered, and that participants with higher familiarity did not need additional examples. Mitchell et al. also collected self-reported familiarity data in relation to the teaching module tested, and found a significant correlation between familiarity with the teaching module, and negative responses to a question asking if the tutorial was easier to understand than a book (Mitchell et al., 2005). Even though there is no definition provided in either of these publications, the results suggest that ‘familiarity’ improves interactions.

Turner (Turner, 2008a; Turner & van de Walle, 2006) and his colleagues are the most recent researchers to discuss the term ‘familiarity’ in HCI. Turner (2008a) turns to the philosophy of Heidegger to develop an understanding of familiarity. Turner (2008a, p. 448) suggests that we demonstrate our familiarity by “coping with situations, tools, and objects, or more specifically by understanding the referential whole.” The referential whole is the understanding of the interrelations of the physical world (Dreyfus, 1991). For example, we perceive a room, and understand that it is a room, through our knowledge of other rooms (Turner, 2008a). Turner (2008a) argues that we co-exist with technology, and have a level of intimacy with the interactive products we use. He reports on how older adults learning technology did not engage strictly with the technology, rather they engaged with how it could “[meet] the demands, hopes and aspirations of their everyday life” (Turner, 2008a, p. 453). Apart from helping us ‘cope’ with technology, Turner (2008a) does not mention the effects of familiarity on interaction. The research from Turner (2008a) and his colleagues (Turner, Turner, & van de Walle, 2007; Turner & van de Walle, 2006) primarily focuses on familiarising older people with information technology. They used interviews to collect their data about how learning to use computers and the Internet has affected participants’ lives (Turner & van de Walle, 2006).

3.1.4 Definition of Familiarity
Familiarity is treated differently across different domains, yet there is a general agreement, when it is defined, that familiarity is based on prior experience, and the knowledge collected from that experience. This basis on prior experience is often also inferred by the literature that fails to define what familiarity is. Across all domains reviewed, the literature considered familiarity to be beneficial, especially for the consumer research domain (e.g. Johnson & Russo, 1984), and for HCI (e.g. Lim et al., 1996). Thus, from the literature on familiarity, the following definition has been constructed:

Something is familiar when it is recognised and in some way understood as a result of prior knowledge. Familiarity, then, is a measure of how much is recognised and understood about a given context as a result of prior knowledge.

By the nature of this definition, familiarity is relational. It can only exist in the relationship between two parties. For this research, normally one party is an individual or a user, while the other party is a product, or system. It is important to note that the relationship is contextual. Familiarity occurs between the user and the
state that the product or system is currently in. However, what is familiar to one person is not necessarily what is familiar to another (Blackler, 2008b).

3.1.5 A Framework of Familiarity
As this research is focused on familiarity, it was necessary to construct a framework within which to understand familiarity particularly in relation to user interactions. A three-stage framework was created. The basis for the three stages of familiarity comes from skill acquisition literature. Most traditional models of skill acquisition have three stages (Taatgen, Huss, Dickison, & Anderson, 2008; VanLehn, 1996). All of the models reviewed by Taatgen et al. (2008) have some form of general strategy that is used initially in problem solving (Stage 1). They also all explain increase in performance speed and the reduction of errors with improvements to the efficiency of the initial strategy, through experience (Stage 2). The final stage of all of the models is the acquisition of specialised knowledge (Stage 3) (Taatgen et al., 2008). The model initially proposed by Fitts and Posner (Fitts, 1964, in Anderson, 1995; Fitts & Posner, 1967, in Ericsson, 2010) and developed by Anderson (1982; 1995) was used to build the levels of familiarity.

Based on these models, the first stage of the framework developed by Anderson (1995) is called the ‘Cognitive’ stage (Ericsson & Towne, 2010) and revolves around the general or base level knowledge required for a particular skill (Taatgen et al., 2008). Anderson (1982) claims that at this level an individual only learns facts about an action, and has not learned about the cognitive processes involved in performing this action. The learner often uses a set of instructions or is shown an example of how to perform the action. The knowledge that is utilised at this level is declarative, and is interpreted into appropriate action (Anderson, 1995). The characteristics of this stage include slow behaviour generation, and failures in memory and execution (Ericsson & Towne, 2010).

The second stage of the developed framework is referred to as the ‘Associative’ stage (Ericsson & Towne, 2010). This is the stage where the individual moves from the declarative representation they hold of the action in Stage 1, to a procedural or process based representation (Anderson, 1995). VanLehn (1996) states that the goals of Stage 2 are to correct any errors in domain knowledge, and to acquire experiential knowledge. Ericsson and Towne (2010) state that the improvements in this stage are focused largely on speed of execution and reducing effort. The transition from error prone, slow interaction to automatic, non-conscious interaction (Anderson, 1995; Ericsson & Towne, 2010) is made through practice and experience (Ericsson & Towne, 2010; Taatgen et al., 2008; VanLehn, 1996). The stage sees a change from general problem solving methods, to domain specific methods (Anderson, 1995). As practice is undertaken, individuals start to recognise what they previously need to work out (Anderson, 1995). The characteristics of this stage include the use of domain-based processes, execution of sequences of actions, increased speed, and reduced effort (Ericsson & Towne, 2010).

The third and final stage is the ‘Autonomous’ stage. At this stage, actions start to become more proceduralised (Anderson, 1995). Conscious control over individual behavioural aspects begins to wane (Ericsson & Towne, 2010). At this stage, the execution of the action is fast and effortless and an increase in experience will not
further improve performance of the behaviour (Ericsson & Towne, 2010). Automatic actions are also much more difficult to interrupt (Anderson, 1995).

These three stages of the skill acquisition framework reflect the spectrum of performance that was observed throughout the empirical investigations reported in this thesis. Uniform sequential progression through the three stages is, as VanLehn (1996) suggests, unrealistic. There are no distinct boundaries between stages, and different skills are developed at different stages in the framework (VanLehn, 1996). This is also characteristic of the current research. Due to the progressive nature of familiarity, it is difficult to define and pinpoint exactly how familiar an individual is with a particular task and product. Yet, it is useful to make the stage distinctions due to the different characteristics of each stage that can be captured empirically (VanLehn, 1996).

3.2 Experience

Experience is yet another term that is commonly used, yet difficult to define (Westerink, 2008). McCarthy and Wright (2004, p. 15) explain that experience is difficult to define because it is both “rich and elusive” at the same time. It is impossible to remove one’s self from experience and observe it impartially.

Westerink (2008) states that experience is formed with the help of psychological processes, which could include: perception, cognition, memory, emotion, behaviour and physiology. Experience is much more than the emotion related to what is happening. There is also the element of time, with experience building over a set of consecutive actions. Distinctions between internal experience and external experience can be made. This is a matter of experiencing something for oneself versus the observation of the experience of another. Experience is also context dependent. For example, the experience of driving to work will be very different if the driver is running late, compared with if they are on time (Hekkert & Schifferstein, 2008). A distinction can also be made between positive and negative experience (Westerink, 2008). Hekkert (2006) describes three levels of experience: the aesthetic, understanding, and emotional levels. He defines product experience as:

The entire set of effects that is elicited by the interaction between a user and a product, including the degree to which all our senses are gratified (aesthetic experience), the meanings we attach to the product (experience of meaning) and the feelings and emotions that are elicited (emotional experience). (Hekkert, 2006, p. 160)

Hekkert and Schifferstein (2008, p. 1) implicitly define product interaction as “people’s subjective experiences that result from interacting with products”. Product experience also has a variety of definitions across different authors (Hekkert & Schifferstein, 2008). This suggests that individuals can have vastly different experiences with the same product, and thus form different relationships with each of the three levels of experience described by Hekkert (2006).

There is an important distinction to make when discussing experience. This is the distinction between experience as ‘accumulated knowledge’ (Hanks, 1990, p. 435) and experience as a ‘set of effects’ (Schifferstein & Cleiren, 2005, p. 294) on an individual. In HCI, the latter is often referred to as the User Experience (UX) (Forlizzi
Forlizzi and Battarbee (2004, p. 264) describe UX as focusing on “the interactions between people and products, and the experience that results”.

Law and his colleagues conducted a survey of 275 members of industry and academia on their views of UX (Law, Virpi, Marc, Arnold, & Joke, 2009). The survey included a number of statements in relation to UX, and also a selection of existing definitions. Those surveyed concluded: 1) that UX considerations include experiences with products, services, systems and objects that are interacted with through a user interface; 2) that user experience is personal [it can be shared with a group, but each individual will have different feelings and emotions about the experience (Law et al., 2009)]; and, most importantly, 3) that “Prior exposure to an artefact shapes subsequent UX” (Law et al., 2009, p. 722).

These results show that UX does consider what has been termed as ‘prior experience or knowledge’ important and relevant to the users’ current experience. Yet, the authors do not discuss the implications of this, and focus more on the experience during and after interaction (Law et al., 2009). The authors do not provide a definition of user experiences themselves, but they do report and discuss a draft ISO definition. The draft definition of UX is: “A person’s perceptions and responses that result from the use or anticipated use of a product, system, or service” (Law et al., 2009, p. 727).

For this research, there needs to be a clear distinction between the two meanings of experience that have been discussed—between experience as ‘accumulated knowledge’ (Hanks, 1990, p. 435) and experience as a ‘set of effects’ (Schifferstein & Cleiren, 2005, p. 294). From this point on, experience as ‘accumulated knowledge’ will be referred to as prior experience, and experience as the present experience as a result of an interaction will be referred to as the user experience.

3.2.1 Prior Knowledge and Prior Experience
The literature reviewed on prior experience and prior knowledge shows that they are effectively treated as the same thing. Many researchers do not define what is meant by ‘prior experience’ (e.g. Langdon et al., 2009; Taylor & Todd, 1995) or by ‘prior knowledge’ (e.g. Shane, 2000). Even if the term is not defined, the meaning that is implied is very similar. Prior experience and prior knowledge, in relation to products and technology, are both based on the knowledge from previous use of products and technology (Blackler, 2008b).

It is suggested that the terms ‘prior knowledge’ and ‘prior experience’ are used interchangeably in the research literature. There is also a range of other terms that are used, including ‘technology experience’ (Hurtienne et al., 2010), ‘past experience’ (Blackler, Mahar et al., 2010; Southwell, Anghelcev, Himelboim, & Jones, 2007), ‘previous experience’ (Langdon et al., 2009; Southwell et al., 2007), ‘previous knowledge’ (Blackler, 2008b; Mieczakowski, Langdon, & Clarkson, 2009), ‘experiential knowledge’, ‘technology familiarity’ (Blackler, 2008b) and ‘general experience’ (Southwell et al., 2007).

Taylor and Todd (1995) discuss prior experience, but do not introduce what they mean by the term. They appear to equate prior experience to knowledge acquired from past behaviour (Taylor & Todd, 1995). Langdon, Lewis and Clarkson (2009)
also do not provide any explanation of what prior experience is. It is not clear exactly what Landon et al. (2009) mean by prior experience, yet they equate experience with knowledge, and refer to “the effect of previous experience” (Langdon et al., 2009, p. 8). Lewis, Langdon and Clarkson (2008) state that an individual’s ability to acquire, store and retrieve information from long term memory determines prior experience. In another paper, the same authors state that prior experience with a product facilitates future use of that product (Langdon et al., 2007). Experiences with products are stored in long-term memory, and the retrieval of relevant information from these experiences depends on the cues provided, and amount of previous experience. In one experiment (Langdon et al., 2007), a self-reporting questionnaire was used to measure participant experience with technology and products. Another experiment (Lewis et al., 2008) tested knowledge by questioning symbol recognition and button position. Lewis et al. (2008) suggest that testing knowledge is a more objective measure of experience, than the self-reporting method used by Langdon et al. (2007).

Mieczakowski, Langdon and Clarkson (2009) associate prior experience with what people already know, and with previous knowledge and experience. Prior experience has a positive effect on interaction, causing user/product interaction to be more intuitive, quicker, and less susceptible to error (Mieczakowski et al., 2009). Similarly, Blackler, Popovic and Mahar (2010) state that intuition is based on past experience and relies on experiential knowledge. The combination of existing knowledge and the appropriate perceived situation allows intuitive interaction to occur (Blackler, Popovic et al., 2010). Klein (1998) supports this and argues that prior experience allows for the subconscious recognition of patterns. This allows for the recognition of things that are familiar and typical, and things that are not. He states that “intuition grows out of experience” (Klein, 1998, p. 33).

Southwell, Anghelcev, Himelboim and Jones (2007) assessed the prior experience of university students with internet based applications by asking questions about past behaviour. Questions related to Internet use over the previous six months, and included questions relating to frequency of use and also if participants had watched a video or film over the Internet. Southwell et al. (2007, p. 556) also mention previous experience, and ‘a user’s general experience’. They also imply that more experienced users are likely to be able to take advantage of more complicated aspects of an interface, while the same features may overwhelm an inexperienced user. They state: “One’s past experience … moderates the translation of afforded control into realised control” (Southwell et al., 2007, p. 562). This suggests that the amount of prior experience a user has will dictate the extent to which they can use a product. This is support by O’Brien (2010), Blackler (2008b) and her colleagues (Blackler, Mahar et al., 2010), Langdon et al. (2007) and Kang and Yoon (2008), who all found that participants with more experience perform better. Hurtienne, Horn and Langdon (2010) also state that prior experience is one of the main contributing factors to product user interactions, and that the level of prior experience of target users needs to be considered in order to design successful and usable products (Hurtienne et al., 2010). Hurtienne et al. (2010) use ‘technology experience’ as a synonym for ‘prior experience’.

Shane (2000) discusses the role of prior knowledge in the discovery of entrepreneurial opportunities, although he does not define what prior knowledge is. Shane (2000) substitutes the term ‘prior information’ with the term ‘prior knowledge’.
Venkataraman (1997) also argues that the differences in everyday knowledge are what leads to differences in the ability of individuals to see entrepreneurial opportunity. Venkataraman (1997, p. 123) notes: “The possession of useful knowledge varies among individuals and these differences matter”. He also argues that specific knowledge alone may not be sufficient for a successful venture, but that “a set of skills, aptitudes, insight and circumstances that is not either uniform or widely distributed” are required to link knowledge with opportunity (Venkataraman, 1997, p. 124).

In an extensive review of the role of prior knowledge in learning, Shapiro (2004) does not define prior knowledge. Shapiro (2004) does infer, however, that prior knowledge is domain or topic knowledge that has already been acquired. Prior knowledge was found to be a higher determinant of a high score in post-reading comprehension tests than other variables such as reading skill, interest in domain, and education. In another review of prior knowledge and learning, Dochy, Segers and Buehl (1999, p. 145) state that “prior knowledge is an essential variable in learning”, and that prior experience is the foundation of an integrated knowledge base (Dochy et al., 1999). Dochy (1994, p. 4669; in Dochy et al., 1999, p. 146) defines prior knowledge as:

the whole of a person’s actual knowledge that: (a) is available before a certain learning task, (b) is structured in schemata, (c) is declarative and procedural, (d) is partly explicit and partly tacit, (e) and is dynamic in nature and stored in the knowledge base.

Mitchell et al. (2005) discuss research relating to prior knowledge in the context of hypermedia learning systems. They state that differences in prior knowledge result in different benefits from hypermedia learning activities, and that prior knowledge can affect how a user learns from hypermedia systems. The authors do not define what prior knowledge is, but they report that prior knowledge includes systems experience, and domain knowledge (Mitchell et al., 2005).

3.2.2 Establishing Prior Experience and Prior Knowledge

Interestingly, the majority of authors refer to prior experience and knowledge as if it is a simple construct. It is treated as if it is a regular entity that is seemingly one-dimensional. The question that is seemingly ignored by the majority of researchers is: What is prior experience/knowledge?

Of those who have considered the issue of prior experience and knowledge, Mitchell et al. (2005) propose that prior knowledge includes systems experience and domain knowledge. Also, Hurtienne et al. (2010) have very recently begun to investigate the facets of prior experience, and have identified three different aspects. They suggest that prior knowledge has multiple facets, two of which are exposure and competence. Exposure is made up of at least three smaller elements: (i) duration of use, (ii) diversity of use, (iii) and intensity of use (Hurtienne et al., 2010). This is derived from Smith, Caputi, Crittenden, Jayasuriya and Rawstorne’s (1999) Objective Computer Experience (OCE) measure. Smith et al. (1999) include other information sources such as the media and peers as additional elements, and also the opportunity of use, as another. In Hurtienne et al. (2010), a self-reporting questionnaire involving the three elements was used to measure exposure. Some of the three elements of exposure that Hurtienne (2010) discusses have been used in self-reporting questionnaires by
researchers in this area. Blackler’s (2008b) Technology Familiarity questionnaire asked participants about how often they use products (intensity) and how many product features they use (diversity). O’Brien’s (O’Brien, 2010) Technology Experience questionnaire also asked participants questions related to intensity of use and diversity of use.

Competence is a combination of prior knowledge and skill that is required to interact with a product (Hurtienne et al., 2010). Hurtienne et al. (2010) measured competence using a questionnaire focusing on self-efficacy with a specific technology, and interactive technology in general, and a computer literacy test. It is also possible to measure competence using subjective tests including one-item statements and multi choice questions, or to test it using objective measures, such as the test used by Lewis et al. (2008).

Lazonder (2000) conducted an empirical study on novice and experienced internet users, related to searching for and locating information on web sites. He noted that over the three set tasks, there were two different reasons that participants may fail at a particular task. The first was related to knowledge of how search engines work, and is referred to as ‘systems knowledge’. The other reason for task failure was the participants’ skill level with information seeking, such as key-word and Boolean operator usage (Lazonder, 2000). Mitchell et al. (2005) refers to the ‘systems knowledge’ as ‘system experience’, and participant’s skill level as ‘domain knowledge’. System experience relates primarily to navigation performance, and navigation behaviour. It is expected that a function performance and function behaviour also play a role in systems experience. Domain knowledge is the user’s understanding of the relevant content presented through the system (Mitchell et al., 2005).

Mitchell et al. (2005) conducted a study investigating how users interact with a hypermedia software tutorial. A total of 74 undergraduate students were involved in the study. Participants were required to answer a questionnaire, asking about computer usage behaviour, including experience and enjoyment, and some questions relating to perceived domain knowledge. A pre-test was also administered, targeting domain knowledge. The participants then used the hypermedia tutorial, and completed a post-test for domain knowledge. The results show that different types of prior knowledge affected the outcomes from the hypermedia tutorial in different ways (Mitchell et al., 2005). Those with higher levels of system experience navigated more successfully and had more confidence in their own abilities. Mitchell et al. (2005) found that users who enjoyed surfing the web were less likely to struggle with the non-linear nature of the software used. Higher domain knowledge leads to less disorientation problems, exploration deeper into subject hierarchy and, in general, superior performance (Mitchell et al., 2005).

The two different breakdowns of prior knowledge presented above show some level of agreement. System experience is the knowledge of the relevant system (Mitchell et al., 2005), while exposure addresses different elements of the use of products. Mitchell et al.’s (2005) system experience measures similar factors (such as frequency of use) to Hurtienne et al.’s (2010) exposure. Mitchell et al. (2005) also focus on the potential enjoyment of using technology. The two elements of the respective breakdowns of prior knowledge seem to refer to the knowledge about a product or
system; however, Mitchell et al.’s (2005) system experience explicitly states what is being addressed, while Hurtienne et al. (2010) are less clear. System experience is the knowledge of the system being used, where exposure looks at elements of usage behaviour, duration of use, intensity of use, and diversity of use.

In relation to hypermedia tutorials, domain knowledge is the existing understanding of the relevant content (Mitchell et al., 2005), while competence is the “knowledge and skills required to interact with a product” (Hurtienne et al., 2010, p. 124). Domain knowledge focuses on understanding, while competence focuses on what is needed to interact with a product. Mitchell et al. (2005) measured domain knowledge using only self-reported efficacy ratings, while Hurtienne et al. (2010) measured competence with self-reported efficacy ratings and a competence test. Mitchell et al. (2005) and Hurtienne et al. (2010) differ in their treatment of a question such as: How well do you think you can handle the product? (Hurtienne et al., 2010, p. 124). Hurtienne et al. (2010) consider this to be a competence issue, while under Mitchell et al.’s (2005) framework, this would be a system experience issue.

In summary, the existing research into prior knowledge suggests that at least two elements contribute to prior knowledge. The first of these is system based, and involves what individuals know in relation to the technology they are using. Mitchell et al. (2005) refer to this as systems experience, while Hurtienne et al. (2010) describe this as exposure. The second element is grounded in the relevant domain, or in what is known about the area of operation the system or technology has been applied to. There is some disagreement between the two models presented, as discussed above. The main difference is the division of the knowledge of the product or system, and knowledge of the domain. Mitchell et al. (2005) have these clearly separated, while Hurtienne et al. (2010) blur the two elements, and put less emphasis on knowledge of the domain. Regardless, the research presented demonstrates that there are several aspects to prior knowledge.

3.2.3 The Relationship between Prior Experience and Prior Knowledge

Prior experience and prior knowledge are often treated in the literature as being the same thing. However, it is important and necessary to make a distinction between them. This research treats prior experience as an experience or collection of experiences that an individual has had in the past. Prior knowledge, in turn, is made up of knowledge that has been acquired out of an individual’s collection of experiences, knowledge that can then be applied in the world. The distinction between experience and knowledge becomes evident when examining areas in learning such as implicit learning (Section 4.3). Two individuals can experience the same thing, but due to age-related deficits (Howard & Howard, 2001), or differences in relevancy to the individuals concerned, what they each learn from the experience may be very different.

3.3 Expertise

Expertise is interested in understanding and explaining “what distinguishes outstanding individuals from less outstanding individuals in that domain, as well as from people in general” (Ericsson & Smith, 1991, p. 2). This is directly relevant to this research as this research is investigating, among other things, the differences in familiarity between younger and older technology users. Blackler (2008b) has
reported that younger adults use products significantly faster and achieve more intuitive uses that older adults. Expertise may help explain why this occurs. Ericsson (2006a, p. 3) states that expertise is interested in the “characteristics, skills and knowledge that distinguish experts from novices and less experienced individuals.” To gain an understanding of expertise, it is necessary to examine the common characteristics, skills and knowledge of experts across different domains. This section will address these commonalities.

3.3.1 Characteristics of Experts
This section will provide a review of some of the characteristics that experts possess that are relevant to this research. These characteristics relate to domain knowledge, knowledge representation, awareness and perception, forward planning, and relative speed. It is important to note that superior expert performance only occurs in activities related to the expert’s field of expertise (Ericsson & Towne, 2010; Feltovich, Prietula, & Ericsson, 2006; Glaser & Chi, 1988). For example, Ericsson and Smith (Ericsson & Smith, 1991, p. 26) specifically state that: “Superior performance in different domains reflects processes and knowledge specific to that particular domain.”

Domain Knowledge
Mitchell (2005, p. 4) defines domain knowledge as an “existing understanding of [a] content area”. Ericsson and Towne (2010) use the word ‘domain’ to describe a particular field, such as law or medicine, within which an individual can gain skill and knowledge. This also applies to disciplines such as sport (e.g. tennis or swimming) and games (e.g. chess) (Ericsson & Towne, 2010). Those who are highly experienced in their domain possess high levels of domain knowledge. Experts have more sophisticated and complex representations of knowledge and situations from their domain than novices (Chi, 2006b; Ericsson & Towne, 2010). Experts have superior short-term and long-term memory in their domain, as less cognitive resources are required for them to perform (Glaser & Chi, 1988). Indeed, McPherson and Kernodle (2007) found that advanced beginner tennis players lacked action plans and event profiles. Entry-level professionals had more advanced representations than beginners. Put simply, experts know more about their domain than non-experts (Glaser & Chi, 1988).

Chi (2006a) describes how domain knowledge is the core of expertise, as the skills and understanding that are characteristic of an expert are the result of the expert possessing a large body of knowledge about their domain. For example, expert chess players are capable of reproducing layouts taken from real chess games much faster and more accurately than non-expert chess players. Yet, when the layouts are randomised, the performance of the experts is reduced to that of the novice (Gobet & Charness, 2006; Posner, 1988). These findings suggest that experts are able to recognise relevant structures in the layouts taken from real games more readily than novices, and that expert performance is closely tied to the domain (Chi, 2006a). The differences in the performance of experts and novices may be explained by the differences in the representation of knowledge (Chi, 2006a). There is a host of examples that further support the role of domain knowledge in expertise (Butterworth, 2006; Duggan & Payne, 2008; Durso & Dattel, 2006; Ericsson & Towne, 2010; e.g. Rhodes & McCabe, 2009).
Domain knowledge is one of the key elements of expertise. It is developed through training, and then continual practice over a long period of time (Ericsson & Towne, 2010). The accumulation of experience is considered to be crucial to the acquisition of high levels of domain knowledge (Chi, 2006a; Ericsson & Towne, 2010). The high level of knowledge is likely to be highly organised, with sophisticated knowledge representations that give rise to a number of benefits (Chi, 2006a).

Knowledge Representation

If differences in knowledge are to be discussed, Chi (2006a) suggests the use of an imprecise unit—‘bit’—as being useful to aiding this discussion. Chi (2006a, p. 178) states that a ‘bit’ of knowledge can be a factual statement, a chunk/familiar pattern, a strategy, a procedure or a schema. Practice and increases in experience result (generally) in an increase in the amount of information stored in each bit (Feltovich et al., 2006). These new bits that contain increased amounts of information are commonly referred to as ‘representations’ or ‘cognitive representations’ (Charness, 1991; Chi, 2006a; Ericsson, 2006b; Ericsson & Towne, 2010; Lajoie, 2003; Nevett & French, 1997; Reimann & Chi, 1989) or ‘chunks’ (Egan & Shwartz, 1979; Feltovich et al., 2006; Glaser & Chi, 1988; Gobet, 2005; Gobet & Simon, 1998). The term ‘representation’ will be used in this research, in reference to a bit that has had additional information added to it.

Experts have highly elaborate and complex representations of knowledge and situations related to their domain (Chi, 2006b; Ericsson & Smith, 1991; Ericsson & Towne, 2010). Ericsson and Towne (2010) state that there is compelling evidence that knowledge representations are the causes of superior performance by experts. Chi (2006a) argues that understanding these representations is crucial in understanding how experts operate, and how they differ from non-experts. Reimann and Chi (1989) state that while experts and non-experts form representations, the experts form richer and more abstract representations. The internal integration and representation of information is common in expertise across a wide range of domains (Ericsson & Smith, 1991).

Findings from a classic study by Chi, Feltovich and Glaser (1981) into the differences between novices and experts in the domain of physics confirm that experts use a different style of representation to non-experts. Chi et al. found that experts categorise physics problems in terms of the principle that will be used to solve the problem. Novices, on the other hand, categorise the problems based on the objects and situations in the problem itself (Chi et al., 1981; Ericsson & Smith, 1991). It is clear from these findings that experts have utilised a much higher and more abstract level of knowledge representation.

Another difference between novice and expert representations is hierarchy (Chi, 2006a). The ways that experts use their representations suggest that some representations exist within other representations (Egan & Shwartz, 1979). Tanaka (2001) shows that faces (and any object) can be recognised on multiple levels of abstraction. For example, a bird can be recognised as both an animal (more general), and a sparrow (more specific) (Tanaka, 2001). Within their domain, experts recognise the more specific levels just as fast and as often as the more generalised level (Tanaka & Taylor, 1991). The notion of a hierarchy of knowledge can be problematic,
however, as knowledge and its hierarchies are never static, because individuals consistently gather more knowledge (Chi, 2006a).

Situational Awareness and Perception
Experts have a different relationship with their environment to non-experts. Experts scan their environment differently, and they also perceive their environment differently to non-experts (Chi, 2006a; Durso & Dattel, 2006). The literature suggests that experts develop effective strategies for scanning their environment (e.g. Ward, Williams, & Bennett, 2002; Wikman, Nieminen, & Summala, 1998). Experts perceive and utilise relevant environmental cues that non-experts do not (Chi, 2006b; Huys et al., 2008). Durso and Dattel (2006) suggest that differences in perceptual performance can be explained by two characteristics. The first is that experts notice things that non-experts do not, and the second is that the interpretation of and reaction to a perceptual cue differs between experts and non-experts (Durso & Dattel, 2006; Ericsson & Smith, 1991). Experts can differentiate between similar situations, and this is a classic sign of expertise (Shanteau, Weiss, Thomas, & Pounds, 2002). Huys et al. (2008) have shown, for example, that providing more information may actually impede novices in making accurate predictions regarding tennis serves. It is suggested that novices have not yet developed the ability to identify the patterns that experts have (Huys et al., 2008). This relates to the definition of familiarity provided earlier. The expert has a deeper understanding of the context than the non-expert, and is thus more familiar.

Other elements that are important to awareness beyond the perception of information focus on comprehending the perceived information (Endsley, 2006). This includes interpretation, retention, and integration of the perceived information to a point where it is pertinent to the individual. Experts rely on the information obtained from the environment to make decisions regarding relevant future events (Endsley, 2006). Durso and Dattel (2006) comment that differences in performance between experts and non-experts in situational assessment depend on underlying knowledge.

The superiority seen in experts in relation to perception is also limited by domain, not by superior perceptual ability in general (Ericsson & Towne, 2010; Glaser & Chi, 1988). Experts perceive more, yet this is not caused by better visual acuity (Chi, 2006a). Durso and Dattel (2006) conclude that experts outperform novices in this area due to their higher levels of domain knowledge. This knowledge is applied through the recognition and recall of learnt situational patterns and the appropriate response to the recognised situation (Endsley, 2006). Glaser and Chi (1988) suggest that superior perception is another reflection of a large, highly structured knowledge base.

Forward Planning and Anticipation
Experts tend to plan more extensively than non-experts (Ericsson & Towne, 2010; Glaser & Chi, 1988). This type of behaviour is seen in expert typists, who look further ahead in the text they are currently typing than non-experts (Ericsson & Lehmann, 1996; Ericsson & Smith, 1991) and also in skilled musicians (Drake & Palmer, 2000; Hodges, 1992). Skilled musicians skip forward and recognise important chunks or units of information such as chords or melodic fragments, and skip over less important details (Hodges, 1992). The range (number of sequenced elements) of planning increases as skill increases in expert pianists (Drake & Palmer, 2000). Nevett and French (1997) found that higher levels of knowledge in young baseball players led to planning in advance, and higher quality plans. They also modified plans
as conditions changed. Players with less knowledge did not demonstrate these abilities. Expert ultra-endurance athletes have more performance related thoughts and are more proactive than non-experts (Baker, Côté, & Deakin, 2005). In chess, higher skill levels result in deeper search and planning of possible moves (Charness, 1981). This search and evaluation process places high demands on cognitive resources, which would be made much more manageable with the use of cognitive representations (Ericsson & Smith, 1991).

The ability to anticipate outcomes is characteristic of high levels of familiarity. Experts consistently plan their actions in advance (Ericsson & Towne, 2010). It has been found that more highly skilled tennis players were more accurate with their anticipatory judgements of where a shot would go (Huys et al., 2008). Huys et al. (2008) also found that the ability to perceive and use relevant information contributed to better anticipation.

Relative Speed
Superior speed is also associated with expert performance (Ericsson & Smith, 1991; Ericsson & Towne, 2010; Glaser & Chi, 1988). The increases in speed are the result of refined cognitive representations, and increases in fine motor control (Ericsson & Towne, 2010). Research has shown that practice results in improved task speed, and the ability to perform tasks in parallel with one another. Expert typists reach high speeds by overlapping the cognitive processing required for typing successive letters (Gentner, 1988). Other disciplines experts who exhibit faster speed include pianists, Morse code operators, and volleyball players (Drake & Palmer, 2000; Ericsson & Smith, 1991). Another possible explanation for faster performance by experts is that search time is reduced during problem solving, due to their complex representations of knowledge (Glaser & Chi, 1988). Ericsson and Towne (2010) state that the cognitive structure of representations contributes to speed.

3.3.2 Expertise and Intuitive Interaction
It is unreasonable to expect everyday users to undertake the amount of practice required to reach expert levels of performance with any particular device. It can take up to 10 000 hours or more to reach levels of expert performance (Ericsson, 2006c; Ericsson, Krampe, & Tesch-Romer, 1993). While users may never accumulate that amount of experience with a single product, this researcher suggests that there are potentially large benefits from tapping into the knowledge representations individuals have already constructed through interacting with products over their lifespan. By utilising pre-existing knowledge representations, benefits similar to those experienced by expert users may occur.

Blackler’s (2008b) and the IUUI group’s (Hurtienne & Israel, 2007) definitions of intuitive use state that intuitive interaction is grounded in prior experience. Expertise is also grounded very firmly in prior experience (Chi, 2006a; Ericsson & Towne, 2010). Blackler’s (2008b) definition of intuitive interaction states that intuitive interaction is a fast, non-conscious process. Experts often demonstrate superior speed to non-experts (Ericsson & Smith, 1991) and have complex knowledge representations (Chi, 2006b), which can lead to intuitive actions which are difficult to verbalise (Ericsson, 2006a).
Many of the characteristics discussed in Section 3.3.1 and reported in the literature can be observed in highly familiar product interactions. Reber (1989) agrees, stating that only after a base of representational knowledge has been established—an important element of expertise—can intuition emerge. The knowledge base is built by implicit learning experiences, and allows for a state which assists in decision making and engagement in particular activities (Reber, 1989). Blackler (2008b) describes intuition as a cognitive process that everyone uses, rather than as something that is only part of expertise.

3.4 Summary
This chapter has reviewed the existing literature on ‘familiarity’ across several domains. As Blackler (2008b) found with intuition, there is no agreed upon definition of familiarity. Of the literature reviewed, most agreed that familiarity is based on prior experience, and on the knowledge collected from that experience. The literature reports that familiar consumers advantages over new consumers, including improved encoding, superior domain knowledge, and decreased search time (Johnson & Russo, 1984). The cognitive process involved in familiarity uses perceptual information and is not effected by ageing (Yonelinas, 2002). Familiarity also differs between people. What is familiar to one person, may not be familiar to another (Blackler, 2008b; Lim et al., 1996). The definition of familiarity provided reflects this. Familiarity is based in the knowledge that has accumulated from previous experience. For this reason, familiarity is unique to the individual.

As familiarity is grounded in experience, it was also necessary to investigate this concept. Psychological processes that may include perception, memory, emotion and behaviour form experience. It is also context dependant. A distinction was made between experience as the experience of the present moment, and experience as accumulated knowledge. ‘Prior knowledge’ and ‘prior experience’ were introduced as terms that are commonly used in the same way as ‘accumulated knowledge’. This research, however, distinguishes between prior experience and prior knowledge, and treats them as separate elements.

Prior knowledge and prior experience was investigated further. Collectively, individuals’ experiences of the world form their prior knowledge. This knowledge, in turn, is used to form patterns that help with recognition and an understanding of the tasks of day-to-day living. Two ways of breaking prior knowledge down into independent facets was examined. The two sets of subcomponents examined both suggest that knowledge consists of knowledge of the system used, and knowledge of the domain that the task or goal comes from. This analysis also shows that there is more to prior knowledge than is generally acknowledged in the literature. This research treats prior experience as the set of experiences that an individual has, and treats prior knowledge as the knowledge gained from those experiences that can be applied in the world.

The domain of expertise was introduced. This domain involves the study of experts, or individuals with high levels of prior knowledge in a particular area. It is interested in understanding the differences in knowledge between experts and novices, and why experts perform better than novices. Experts display certain characteristics as a result of their high levels of prior knowledge, which is an essential part of developing familiarity. These high levels of prior knowledge could be used to help identify
familiarity in product interactions. Some of the characteristics of experts relevant to this research were introduced, and the relevance of expertise to intuitive interaction was then discussed.

Generally, research in Human Computer Interaction, and other design related fields, has taken the idea of prior knowledge at face value, and only a few studies are beginning to inspect the role of prior knowledge in interaction. The understanding developed here allows for a more thorough understanding of intuition, and is critical for developing studies to help answer the research questions.

The next chapter will discuss the people that this research focuses on. A definition of ‘older adults’ is explored, along with some of their characteristics. Some of the typical effects of ageing are also examined. Finally, the implications of these effects for interaction, and also for this research, are considered.
Chapter 4: Older Adults

4.1 Introduction
Older adults are the focus of this research, and thus it is important to understand the unique challenges that are faced by older adults as a demographic. More importantly, it is essential to understand the challenges that can be faced by the individual. Older adults are diverse, with differences not only between individuals, but also within an individual over time. Hawthorn (1998, p. 8) states that “any individual user will show a random mix of age-related problems”.

This chapter discusses the relevant literature on older adults and ageing. Some definitions of ‘older adult’ are presented, followed by an overview of many of the effects of ageing. The next section examines cognitive load and how this can impact intuitive interaction. The factors contributing to technology adoption by older adults are explored. This is followed by a review of Docampo Rama’s (2001) Generational Theory and the relevance of her research to this study. Finally, methodological considerations when researching with older adults are reviewed. When designing for and researching older adults, it is very important to understand the ageing process and how this affects them (Hawthorn, 2000; Howell, 1997).

4.2 Defining Older Adults
Before one can understand the ageing process in relation to older adults, it is necessary to understand what makes somebody an older adult. There is no set age range for older adults, and there is a general dissatisfaction with defining them in this way (Howell, 1997; Lloyd-Sherlock, 2000; Zajicek, 2004). There is also no generally accepted definition of an ‘older adult’ (Charness, 2008). Despite this, research focusing on older adults often refers to older adults as being 65+ (e.g. Lundberg & Hakamies-Blomqvist, 2003) or 60+ (e.g. Mynatt, Essa, & Rogers, 2000). Adults are sometimes considered to be ‘older’ if they are over 60, with this group further divided into ‘young-old’ if between 60 and 75, and ‘old-old’ if over 75 (Fisk et al., 2004). Age bands are frequently used to differentiate within the population of older adults, and are sometimes based on normative events, such as pension access (Charness, 2008). Some researchers refer to older adults, but provide no further definition of the group they are referring to (e.g. Demiris et al., 2004; Turner, Turner & Van De Walle, 2007).

Despite this, research focusing on older adults often refers to older adults as being 65+ (e.g. Lundberg & Hakamies-Blomqvist, 2003) or 60+ (e.g. Mynatt, Essa, & Rogers, 2000). Adults are sometimes considered to be ‘older’ if they are over 60, with this group further divided into ‘young-old’ if between 60 and 75, and ‘old-old’ if over 75 (Fisk et al., 2004). Age bands are frequently used to differentiate within the population of older adults, and are sometimes based on normative events, such as pension access (Charness, 2008). Some researchers refer to older adults, but provide no further definition of the group they are referring to (e.g. Demiris et al., 2004; Turner, Turner & Van De Walle, 2007).

It is important to consider the criteria that define older adults. Age obviously plays an important role, but should not be a defining factor, as age does not necessarily dictate the capabilities of an individual (Zajicek, 2004). Hawthorn (1998, p. 2) says: “Normal aging is a dubious concept”, and it is used as an indicator out of convenience. Fisk et al. (2004) concur, saying that there are no concrete and definitive boundaries between young and old, and that using a nominal variable to denote age is problematic. They continue to state that chronological age is only useful to identify specific behaviour changes that occur throughout the ageing process.

Keates and Clarkson (2003a) discuss a system measuring seven key capabilities, and then use this to determine a particular person’s disability score. While this current
research is not looking at disability, the method used by Keates and Clarkson (2003a) for defining disability is relevant to defining older adults. The abilities of those experiencing the effects of ageing should be considered, as each capability will change at a different rate for each individual (Hawthorn, 2000). Declines in human performance due to ageing start in the early 30s (Hawthorn, 1998). Hawthorn’s extensive review of the literature regarding ageing and the implications for interface designers focuses on those above the age of 45, as this is when the effects of age start to become noticeable (Hawthorn, 1998).

Sterns and Doverspoke (1998, in Kooij, de Lange, Jansen, & Dikkers, 2008) examined different ways of defining a worker’s age. By adding criteria to an individual’s age, age becomes a more meaningful and useful tool element to consider. Five different considerations of age in workers were used to help conceptualise what age can mean. The five considerations were: chronological age, function or performance-based age, psychosocial or subjective age, organisational age, and the lifespan concept of age. Chronological age is based upon calendar age. Performance-based age takes fluctuation in performance as an individual ages into consideration. Psychosocial age is based upon perceived age, both by society and the individual. Organisational age refers to ageing within an organisation and how that affects ageing. Finally, the lifespan concept of age focuses on behavioural change as a result of normative, biological or environmental factors (Kooij et al., 2008).

One of the most important things to consider is that as a group, older adults have a huge range of individual functionality in different areas, including cognitive, physical and sensory capabilities (Charness, 2008; Gregor et al., 2002; Hawthorn, 2000; Howell, 1997). The level of functionality in each of these areas is constantly changing, decreasing over longer periods of time, and also fluctuating in the short-term, as a result of such things as illness and general tiredness (Charness, 2008; Gregor et al., 2002; Zajicek, 2004). It is understood that this fluctuation of capabilities applies to everyone, but it may have a greater effect on the level of functionality of older adults.

While the reductions in these capabilities are important in defining older people (Gregor et al., 2002), it is unlikely that all of these declines have impacts on intuitive interaction. Cognitive declines are most like to have the biggest impact on intuitive interaction. This is because intuition is based on prior experience (Blackler, 2008b), which is based in memory (Bastick, 1982, 2003). Blackler (2008b) and her colleagues (Blackler, Mahar et al., 2010) have demonstrated that older adults use contemporary products less intuitively, and are slower than their younger counterparts. The cognitive declines experienced by some older adults have been shown to explain most of these differences, along with technology familiarity (Blackler, Mahar et al., 2010).

For the purposes of this research, an older adult is defined as anyone who is experiencing a reduction in any capability, be it sensory, physical, or cognitive, due to the ageing process. Although this definition removes age from the discussion, this research investigates older adults through the use of age groups. While this may seem contradictory to the current literature and definition—which holds that the use of age groups is not a suitable representation of older adults when considering skill level and the abilities of older adults to perform tasks, due to the variance in capabilities that are characteristic of ageing (Gregor et al., 2002; Hawthorn, 2000; Howell, 1997; Zajicek,
2004)–there are reasons behind this choice. Firstly, chronological age is often used by researchers as an indicator, as the research into, and understanding of, age-related changes does not yet allow for the use of other measure to specify appropriate grouping methodologies (Fisk et al., 2004). Secondly, while general prior knowledge is likely to increase with age as more experience is accumulated, specific prior knowledge focusing on the use of products is likely to vary across individuals. Different individuals are exposed to different technologies through different avenues, such as personal interests and hobbies, education, social circles and work. Age groups are used to examine if there are commonalities in prior knowledge across the different groups (Chapter 5).

4.3 Effects of Ageing

The ageing process is not something that starts when an individual turns some magical age; it is an ongoing process that begins at the earliest stages of life. Initially, it is about growth and development, until physical and mental peaks are reached in the early 20s (Huppert, 2003). From this point, some abilities start to decline, but by no means in a linear manner (Hawthorn, 2000; Huppert, 2003). The impacts of ageing are wide and varied (Gregor et al., 2002; Hawthorn, 2000; Keates & Clarkson, 2003; Mynatt et al., 2000). There is a substantial body of knowledge covering the effects of the ageing process (e.g. Klein & Scialfa, 1997). Some of this literature is concerned with the relevant implications for interaction design, such as legibility of on-screen text (e.g. Hawthorn, 2000).

The effects of ageing in later life include declines in many cognitive, physical, and sensory capabilities (Gregor et al., 2002), and also behavioural changes (Marr, 1997). Hawthorn (2000) outlines vision, speech and hearing, psychomotor abilities, attention and automated responses, memory and learning, and intelligence and expertise as factors that have implications for interface designers in HCI. While it is significant to consider each of these factors individually, older adults will experience multiple impairments at once when interacting with products in the real world (Hawthorn, 2000). It is important to note, however, that not all capabilities decline; many continue to develop during the ageing process, such as general knowledge and emotional control (Huppert, 2003).

Declines in physical abilities include less accurate execution of intended movements, decreased muscle mass, reduced coordination, reductions in strength, and lower movement speed (Larsson & Ansved, 1995; Ranganathan, Siemionow, Sahgal, & Yue, 2001; Vercruyssen, 1997). Larsson and Ansved (1995, p. 398) state that “the most commonly encountered type of muscle atrophy in man is that associated with senility”. Ranganathan et al. (2001) conducted a study with 55 participants, investigating the effects of ageing on hand function, using six different tests. The results of this study show significant declines in hand strength, finger strength, control of finger-pinches grips, consistency of applied force in finger-pinches grips, and tactile sensation with age (Ranganathan et al., 2001). Quality of life is affected by hand function, as it is associated with work-related functioning, hobbies and recreational activities, self-care activities, and many other daily activities (Carmeli, Patish, & Coleman, 2003; Ranganathan et al., 2001).

When putting this in the context of consumer products, the declines experienced by older people can increase difficulties with aspects of everyday life (Bieber, 2003).
Carmeli et al. (2003) note how many artefacts associated with modern everyday living, such as keyboards and mobile phones, do not consider the age-related declines in hand function experienced by older adults. Indeed, Hawthorn (2007) observed older adults having difficulties with the fine control of a mouse, directly affecting their ability to use computers. Nevertheless, however, older adults often compensate for the declines in physical abilities they do suffer by utilising adaptive behaviours, such as increasing following distance when driving (Lundberg & Hakamies-Blomqvist, 2003), and scanning ahead when typing (Bosman, 1993). The use of this adaptive behaviour will often put the older adult on par, or just below, a younger adult in terms of task performance (Czaja & Sharit, 1998). Vercruyssen (1997) states that age does not need to limit motor behaviour, and that the use of anticipation can reduce reaction time in young and old alike.

Research shows that aspects of cognitive function also decline with age. Decline in working memory is one of the most common changes in cognitive ability (Fisk et al., 2004). Working memory is the memory system that allows for temporary storage and manipulation of data (Baddeley, 2004), and it plays an important role in many day to day activities (Fisk et al., 2004). The central executive is the control system of working memory (Baddeley, 2003). Research points to two processes that are controlled by the central executive: firstly, the control of habitual behaviour patterns guided by cues in the environment; and, secondly, the control of specific attention which takes over when habitual behaviour is inappropriate (Baddeley, 2003). There are also three slave systems that interface with the central executive: the visuospatial sketchpad, the episodic buffer, and the phonological loop (Baddeley, 2003).

Salthouse and Babcock (1991) conducted two studies examining age-related working memory capabilities across 227 (from 20 – 87 years) and 233 (from 18 – 82 years) participants respectively. The results of the two studies show a negative relationship between age and performance on the experimental tasks designed to evaluate working memory function. The results of the second study further show that processing speed mediated performance on all other significant results in working memory, storage capacity, and processing efficiency (Salthouse & Babcock, 1991). They conclude that the age related declines in working memory might be the result of reductions in speed of processing speed. Findings from a later study by Fisk and Warr (1996) also found perceptual speed to significantly affect age-related declines in working memory. Controlling for central executive function did not affect the age-related declines in working memory (Fisk & Warr, 1996).

Other research has shown that under high working memory load, older adults are more affected by distractions than younger adults in a recognition task. Under low working memory load and for a recall task, this effect was not present (Gazzaley, Sheridan, Cooney, & D'Esposito, 2007). In a set of two studies of 64 participants each, Naveh-Benjamin, Craik, Guez and Kreuger (2005) examined the effects of divided attention on encoding and retrieval of information and ageing. Divided attention at encoding affected both younger and older adults equally. Divided attention at recall affected the performance of the older adults; however, it did not affect the performance of the younger adults. The results also suggest that encoding is more difficult for older adults when attention is divided at encoding (Naveh-Benjamin et al., 2005). However, while age has some negative effects on cognition, some of these can be reduced with cognitive training. Cognitive training has been shown to
help slow the decline seen in memory, reasoning and processing speed over a five year period (Willis et al., 2006). Individuals who participated in cognitive training reported fewer difficulties with activities associated with daily life (Willis et al., 2006).

Older adults have difficulty in learning relationships between items (Naveh-Benjamin, 2000; Ostreicher, Moses, Rosenbaum, & Ryan, 2010). This leads to problems with implicit learning (Naveh-Benjamin, 2000) where encoding of information occurs without active attention (Naveh-Benjamin, 2000), due to individuals becoming subconsciously aware of patterns that occur in repeated contexts (Howard & Howard, 2001). Howard and Howard (2001) found age-related deficits in implicit learning between older adults (60 – 80) and younger adults (20 – 23). Feeney, Howard and Howard (2002) have demonstrated that in a group of middle aged participants (35 – 52), the younger participants learn more implicitly than the older participants. Howard and Howard (2001, p. 798) imply implicit learning is “becoming sensitive to regularities without intending to do so”. The difficulties in learning relationships and learning implicitly experienced by older adults could lead to interaction difficulties with complex products that have multiple relationships that often change with software and firmware updates. Semantically linking information can help get around this issues, as this has been shown to help improve recall, especially in older adults (Castel, 2005).

While older people may have difficulties encoding knowledge regarding relations between entities (Ostreicher et al., 2010), increases in performance are seen if relations are semantically relevant, and tied to existing knowledge and associations (Naveh-Benjamin, 2000). For example, Castel (2005) found that older adults performed worse than younger adults when attempting to remember arbitrarily overpriced and under-priced grocery items; however, the older adults performed as well as younger adults when the prices were realistic. Many older adults have a lack of confidence due to age-related declines in abilities (Zajicek, 2004), and tend to consistently blame themselves for failed interactions (Hawthorn, 2007). Demiris et al. (2004) show that older people are concerned about their abilities to use products, and that they perceive they require tailored training to learn how to use them (Section 4.5.1).

4.4 Older Adults, Intuitive Interaction, and Prior Knowledge

There is an ever-increasing presence of ubiquitous computing and complex products in everyday life (Hawthorn, 2000; Hurtienne & Blessing, 2007). Older people can struggle with the tasks involved in normal, everyday life (Bieber, 2003), let alone with the use of contemporary information, communication, and entertainment devices, which many people have difficulty utilising (Czaja & Lee, 2007; Docampo Rama, 2001; Kang & Yoon, 2008). Blackler (2008b) and her colleagues (Blackler, Mahar et al., 2010) have shown that older adults use products less intuitively that younger adults. Individuals with more relevant experience generally perform better (O’Brien, 2010). Younger adults generally perform better with technology than older, but some older adults perform well (Kang & Yoon, 2008; O'Brien, 2010).

O’Brien’s (2010) research methods and the studies she conducted have been summarised in Section 2.2. O’Brien’s (2010) results show that while prior experience
helps to predict performance, it does not remove all age-related variance seen in the observations. Older adults also seem to use a different interaction style to the younger adults. O’Brien’s (2010) studies show greater variance between older adults, which is consistent with what is reported in the literature on ageing (e.g. Charness, 2008; Gregor et al., 2002).

Cognitive aspects play a large role in ageing and interaction. There is evidence that with age, the cognitive abilities for learning complex devices undergo change (Docampo Rama, 2001). Attention, working memory, and learning are just some of the cognitive functions affected by age (Hawthorn, 2000; Howard & Howard, 1997). Blackler et al. (2010) have demonstrated that a decrease in central executive function affects both time on task, correctness and intuitive interaction. Langdon et al. (2009) confirm that those with higher cognitive capabilities are faster to complete tasks than those with lower cognitive capabilities, which correlate with age. Hawthorn (2000) also agrees, stating cognitive decline can affect knowledge transfer across products and also increases susceptibility to distractions during interaction.

Reddy et al. (2010) have also identified a strong correlation between attention (a central executive function) and the use of complex interfaces. The study was designed to examine the relationship between prior knowledge and cognitive function in older adults. A total of 37 participants from 18 to 83 years old were involved in the study. Participants were required to fill out a technology prior experience questionnaire in two parts, before and after the observation, to avoid priming. Participants performed two tasks with a virtual prototype of a commercially available body fat meter, while delivering concurrent (think aloud) protocol. Reddy et al. found that age is negatively correlated to sustained attention, a function of the central executive. The results also show that sustained attention is negatively correlated to time on task and to errors. Prior experience with the technology was negatively correlated with errors (Reddy et al., 2010). These results show that declines in a subcomponent of the central executive—sustained attention—have an effect on elements of interface performance.

Blackler et al. (2010) conducted a study with 32 participants, using two virtual microwave interfaces (a commercially available microwave and a redesigned microwave). Participants interacted with the interfaces using a touch screen. Eighteen participants used each microwave, and the participant pool was split into three equal groups by age: ages 20 – 39, 40 – 56 and 57+. Participants were matched for technology familiarity after filling out a self-report technology familiarity questionnaire as part of the screening process, to measure prior knowledge with related products. Participants performed three tasks with the microwave, and then performed a range of cognitive tests. Blackler et al.’s (2010) results suggest that central executive function and technology familiarity are both important to intuitive interaction, time on task and correct uses. The results showed that variables related to cognitive decline have stronger relationships to the dependant variables—time on task, percentage intuitive correct uses, and percentage correct uses—than to chronological age. The dependant variables had significant relationships with variables that were related to central executive function and also had significant relationships with technology familiarity scores. This shows that technological familiarity and central executive function both contribute to intuitive interaction in older adults, while age is less relevant (Blackler, Mahar et al., 2010). While age is related to cognitive decline, the rate of decline varies between individuals (Hawthorn, 2000).
The differences in performance between older and younger adults are reduced with practice (Langdon et al., 2009). Sterns (2005) has also demonstrated the positive effects of training on older adults. In an experiment controlled for prior knowledge, Kang and Yoon (2008) found little difference between the rate of task completion between younger and older adults. In an experiment not controlled for knowledge, Ziefle and Bay (2005) found older adults complete tasks less frequently than younger adults. The combination of these two findings suggests that task completion may be related to prior knowledge (Kang & Yoon, 2008). O’Brien (2010) supports this, stating that prior knowledge of similar technologies helps to predict performance, but does not explain all differences in performance in age groups. Older adults make different types of errors than younger adults, suggesting age-related differences in performance as well as differences based on prior experience (O’Brien, 2010).

Kang and Yoon (2008) conducted a study comparing younger adults (21 – 29) and ‘middle-aged’ adults (46 – 59) in the use of Portable Multimedia Players and MP3 players. Prior experience was measured with a questionnaire surveying ‘background knowledge’ with similar technologies (Kang & Yoon, 2008, p. 429). They found that both age and prior experience affect interaction behaviour. Prior experience aided in the correct use and selection of features, and also in the use of input devices (interface controls). Older adults required more steps to execute tasks than younger adults (Kang & Yoon, 2008; Ziefle & Bay, 2005). Kang and Yoon (2008) attribute this to higher rates of error among older adults and state that older adults often failed to derive appropriate or relevant meaning from the feedback given by the device. This suggests a lack of knowledge, as one of the characteristics of expertise is perception and the understanding of relationships within a domain (Durso & Dattel, 2006).

An important finding from Kang and Yoon (2008) relates to the multi-modal use of interface controls (such as short or long holds, double clicks, etc.). They found significant differences in the use of such operations between younger and older adults. This could possibly be partially explained by difficulties in motor control that were observed in older participants (Kang & Yoon, 2008). As discussed above, decreases in motor control can occur as a result of ageing (Hawthorn, 2000). Multi-modal interface inputs are likely to place additional load on cognitive resources, as their functionality often needs to be remembered. Also, multimodal controls can be less visible, with only small icons indicating the possible functions. Kang and Yoon (2008) recommend that multi modal use of interface controls should be avoided as much as possible, as this decreases the likelihood of a successful interaction, regardless of age.

Despite the difficulties older adults have with technology, Schoeni, Freedman, and Martin (2008) see the increased use of assistive technology by older people as a likely contributor to the decreasing rate of late-life disabilities between the early 1980s and the early 2000s. It is suggested that older adults adapt their behaviours with the help of both assistive and mainstream technology, which may compensate for some functional decline (Schoeni et al., 2008). Considering the difficulties that older adults have with poorly designed products, the improvements in usability from the widespread introduction of truly intuitive product interfaces would be beneficial.
In summary, it has been shown that age affects performance in the use of contemporary products (Blackler, 2008b). Furthermore, it has been shown that cognitive decline affects performance with contemporary products (Blackler, Mahar et al., 2010; Langdon et al., 2009; Reddy et al., 2010). Cognitive decline is an effect of ageing, but it does not affect everyone linearly (Gregor et al., 2002; Hawthorn, 2000). However, age does not explain all performance related differences between younger and older adults (Kang & Yoon, 2008; O'Brien, 2010). Prior knowledge is another important element that contributes to the performance of older adults with contemporary products (Blackler, Mahar et al., 2010; Kang & Yoon, 2008; O'Brien, 2010; Reddy et al., 2010).

4.5 Older Adults and Technology Adoption
It is common knowledge that older adults do not use technology as much as younger adults. Even then, the older adults who are using the technology have a much lower level of access than younger adults. For example, older adults tend to stick to emails and basic searching on the internet, whereas younger adults create and post content, use video chat, and engage in digital communities (Fox, 2004; Hanson, Gibson, Coleman, Bobrowicz, & McKay, 2010). This trend is currently changing, with a 22% increase in social media use in 50 – 64 year olds in the US, and a 13% increase with those 65 and older in the US between April 2009 and May 2010 (Madden, 2010).

However, while technology usage by older adults in the United States is on the rise, they typically have more difficult in learning and using technology (Czaja et al., 2006).

There are a number of factors contributing to technology adoption amongst older adults. These include education, socioeconomic status, attitude toward technology, perceived benefits, access to technology, and cognitive ability (Czaja et al., 2006; Fox, 2004). Anxiety is an important factor that affects many other elements contributing to technology adoption (Czaja et al., 2006). Czaja et al. (2006) found that, in general, those with higher levels of computer anxiety had lower levels of experience with computers and the internet, and were less likely to use technology.

Czaja et al. (2006) state that attitudinal issues play a crucial role in technology adoption. Hanson et al. (2010) agree that attitudinal issues play a significant role. They both specify a disinterest in digital technologies as the single largest reason for the lower levels of technology adoption encountered amongst some older adults. Lenhart, Horrigan, Rainie, Allen, Boyce, et al. (2003) report that 8 in 10 seniors will not adopt technology unless their perceptions of technology change, or until their needs and interests are met by more considered technology. For older adults to learn to use a new technology, they must perceive it as helping to meet needs in their lives, and that it is easy to use (Hanson, 2010). Melenhorst, Rogers, and Bouwhuis (2006) suggest that older adults need to understand the benefits before they will start using a new technology. Older adults may be driven by perceived benefit rather than perceived cost (Melenhorst et al., 2006).

Through interviews, Coleman, Gibson, Hanson, Bobrowicz and McKay (2010) also found that perception of a product plays a role in the acceptance by older adults. If a product looks less like a computer and more like an updated version of an existing technology, such as a digital TV, then the product is generally well received, and is often highly satisfactory. Coleman et al. (2010) argue that the more a new product
looks like something that plays a role in their lives, and the less they perceive it to be a computer, the more likely it is to be used and accepted by older adults. It would appear that it is the perception and beliefs that the older adults have—and these are likely to be based on negative experiences—that is preventing them from adopting new technology.

Although research is beginning to identify factors that affect technology adoption, there are also many stereotypes regarding older adults and the use and adoption of technology. Older adults often support these stereotypes by adopting and believing in them (Hawthorn, 2007). Traditional roles of the old teaching the young are often reversed when considering new technologies (Docampo Rama, 2001). Yet, there is no evidence that older adults are particularly adverse to learning and adopting new technologies (Goodman & Lundell, 2005). A large body of the research explores what inhibits technology adoption, rather than examining what fosters it. With this in mind, Hanson (2010) mentions the importance of focusing her future research on the strengths of older users, instead of concentrating on the weaknesses of the user group.

In an investigation into the attitudes of older adults to smart home technologies, Demiris et al. (2004) discovered that there was a large number of applications where older adults would be willing to adopt new technology, provided the system was adequately designed. Their concerns include: ease of use, replacement of human contact by technology, and training/documentation tailored to the needs of older people (Demiris et al., 2004). Fisk et al. (2004) have also found that older adults are not actively trying to avoid new technology, and Coleman et al. (2010) found that individuals were open to adopting new technologies, as long as they could see a direct benefit in doing so.

Older adults may not be aware of the possible applications of technology (Eisma et al., 2003; Zajicek, 2004). Many older adults base their opinion of technology on a limited number of experiences, which often include stories from other people (Eisma et al., 2003). They often have concerns with learning how to use the new technology, but are still willing to try new technologies if they can see the benefits of using them (Collins, Bhatti, Dexter & Rabbit, 1992; Demiris et al., 2004; Eisma et al., 2003). If people understand what can be achieved with technology and see how it can benefit them, they are more likely to have the motivation to learn how use it (Eisma et al., 2003; Hawthorn, 2007). Finally, Czaja et al. (2006) have found that experiencing repeated success is an important element in building confidence in engaging with technology.

4.5.1 Self-efficacy, Fear and Confidence

The literature would suggest that some of the issues surrounding usability and older adults revolve around self-efficacy with technology (Czaja et al., 2006). Stewart (1992) suggests that these fears are often well founded in bad experiences. Coleman et al. (2010) found that older adults have a fear of technology, and the possibility of negative experiences with it. These concerns have developed out of personal experience, and from the experiences of people close to them (Coleman et al., 2010). Similarly, Hawthorn's observations of older adults in computing classes suggest that they display low levels of confidence when dealing with technology (Hawthorn, 2007). Eisma et al. (2003) provide an example where an older user was utilising a television based email system, yet when asked if she used computers, she said she
could never use a PC. This shows the perception the user had of PCs, and the associations she had with them.

The negative experiences that older adults have had with products range from unpredictability of features, to inability to remember all of the necessary steps for an operation (Turner et al., 2007). People also often blame themselves when the design/er is at fault (Norman, 2002). Hawthorn (2007) discusses the differences between assumptions made by designers regarding the needs and capabilities of older adults, and what older adults actually need, commenting that assumptions are necessary to the design process. However, the assumptions that designers make in regard to how similar users are to themselves begin to break down when applied to older adults. Many researchers touch on this idea, but do not fully discuss it (e.g. Dickinson, Arnott & Prior, 2007; Eisma et al., 2003; Gregor et al., 2002; Zajicek, 2004). Demiris et al. (2004) show that older adults have concerns with the user-friendliness of technological devices; it is thought that this shows that older adults are implicitly aware that designers do not often cater for their needs. Each of the numerous differences between older adults and their younger counterparts can lead to interaction difficulties if incorrect assumptions are made, such as assumptions about fine motor skills (Hawthorn, 2007).

Hawthorn (2007) describes a very noticeable difference in the level of achievement in older adults when learning to use computers via a carefully designed tutorial, which considered aspects of ageing and a general beginner’s class, particularly in regard to enthusiasm and engagement. He reports that this appears to be the result of largely positive interactions with an interface that has been designed specifically for the needs of older adults (Hawthorn, 2007). It has been shown that providing some reassurance to older adults as they interact with the systems results in an increase in confidence (Gregor et al., 2002). Czaja et al. (2006) also note the importance of positive feedback and specially designed training programs and contexts. Individual confidence levels were found to significantly increase following a markedly successful interaction, and decrease following particularly bad interactions (Gregor et al., 2002).

Older people often lose track of technological developments, and thus miss out on the opportunity to try them (Docampo Rama, 2001; Eisma et al., 2003; Hawthorn, 2007). Language contributes to this, with widespread use of technical terms that are very difficult to describe otherwise (Eisma et al., 2003; Hawthorn, 2007). Indeed, older adults often come up with their own terminology for the abstract concepts required when utilising technology, such as ‘the file thingy’ (Hawthorn, 2007).

4.6 Generational Theory and the Formative Years
Docampo Rama (2001) discusses the role of the formative years as a possible way of explaining some of the difficulties that older adults experience when interacting with contemporary electronic devices. She defines the formative years as the period from the age of 10 until the age of 25 (Docampo Rama, 2001). This period sees the majority of behaviours, values and attitudes shaped into what they will be for the remainder of people’s lives (Docampo Rama, 2001). After this period has passed, it has been shown that behavioural change in less likely (Cutler & Kaufman, 1975).
Weymann and Sackman (1993) have demonstrated that the formative years see the development of a relationship with the technology of that era. In order to develop more intuitive products for older adults, one must understand what it is they are familiar with. By investigating the interface styles of products longitudinally, it is possible to document the changes that have occurred (Docampo Rama, 2001). The two relevant interface styles discerned by Docampo Rama and her colleagues are the Electro Mechanical style and the Software style.

The main characteristic of the Electro Mechanical interface style is a flat, one layered interface. A push button TV is an example of a product with an Electro Mechanical interface style, and this period began roughly in the mid-1950s. The Software interface style is based on a structured interface, with multiple layers. A TV with a remote control is an example of a Software based interface style, and this style started to become common in the mid-1980s (Docampo Rama et al., 2001). The Electro Mechanical style is relevant, as this is the type of interface that many older adults used in their younger years, and the Software style is important, as this is the interface style that most contemporary products use. This investigation was focused on the diffusion of these interface styles in the Netherlands only (Docampo Rama, 2001), and the applicability of this study to other cultural contexts is unknown. Also, the study focused only on the diffusion of the telephone, television, and the video recorder.

Such a change (from the Electro Mechanical style to the Software style) in the paradigm of human product interaction suddenly creates problems for a large number of users who have no experience with the new style. While all users are in the same situations at the beginning of the paradigm shift, those still in their formative years are able to adapt to the complex interactions, while older users have their behaviours more firmly set (Docampo Rama & Kaaden, 2001). According to Docampo Rama (2001), those past the age of 25 will base their interactions with products from the new paradigm on their experiences from their formative period, which are all from the old paradigm.

Those that share generation-specific knowledge are referred to as a ‘Technology Generation’ (Docampo Rama, 2001). The application of the formative years theory to the paradigm shift from Electro Mechanical to Software interface styles gives us a rough year at which the Technology Generation changes, namely 1960 (Docampo Rama, 2001; Docampo Rama et al., 2001). This would suggest that a person born before 1960 is likely to have more difficulty in learning and using products that have a software style interface than a person born after 1960 (Docampo Rama, 2001).

When comparing interaction performance, the differences in knowledge as a result of technology generations manifest as ‘a generational effect’. A generational effect is discontinuous and appears as a large change in performance (Docampo Rama, 2001). Comparatively, a continuous relationship between performance and age is expected to be the result of age-related declines (Docampo Rama, 2001; Lim, 2010; Salthouse, 2004). Thus, when comparing interaction performance, Docampo Rama (2001) recommends a large number of subjects with an evenly distributed coverage of a wide age range.

Lim’s (2010) findings support Docampo Rama’s (2001) findings. He conducted two studies examining generational effects. The first used a semi-structured interview
style with 12 participants, half from the Electro Mechanical generation (46+), and half from the Software generation (45 and below). Analysis revealed that older adults have more difficulties using products when compared with younger adults, and that those difficulties were due to “unfamiliarity and lack of experience with present day devices”. Lim’s (2010) second study used an observational method, where participants used a selection of six products from three product categories. Participants were split into six age groups. The variables used were time on task, and successful completion of task. Time on task increased linearly with age, suggesting an age-related effect. There were significant differences between the four younger age groups (< 25, 26 – 35, 36 – 45, and 46 – 55) and the two oldest age groups (56 – 65 and 66+). Lim (2010) states that the oldest two age groups had lower levels of experience, as a result of belonging to a different technology generation. A survey conducted with the participants of the second study identified that the two oldest age groups had less prior experience with digital products than the four younger age groups.

The problem with Docampo Rama’s (2001) approach to older users is that it disregards individual experience. Everyone has different experience, and as intuitive use of a product relies on prior experience (Blackler, 2008b), different people of the same age will use the same product differently. Docampo Rama (2001) seems to make the assumption that individual prior experience is of little importance. Instead, Docampo Rama assumes that individuals from each technology generation will have similar experiences with interface paradigms because of common experience with technology. This leaves little room for individual variation in technology usage, and thus, variety in experience. Results from Blackler et al. (2010), on the other hand, show variance with self-reported technology familiarity within age groups across all three ages groups measured.

While there is a number of limitations to the research in the area of generational theory (some of which have been discussed above), it is nevertheless useful in developing an understanding of some of the reasons why older users may find contemporary electronic devices difficult to use (Djajadiningrat, Wensveen, Frens, & Overbeeke, 2004). It is useful, for example, to think of the concept of Technology Generations as a guide to assess if a user may or may not have difficulties with a particular interface. However, as intuition is based on prior experience (Blackler, 2008b), any individual user may have the ability to interact efficiently and effectively with a contemporary interface, irrespective of their generation, and given that they have the relevant experience. Indeed, Turner and Turner (2010) have conducted research investigating Docampo Rama’s generational theory. Their findings suggest that regardless of what interactive technology their participants grew up with, their current usage was supported by the knowledge gained from experience at home or work. They describe the usage of technology by the 35 to 45 age group as unproblematic as it “is facilitated by the similarity of tools at home and work” (Turner & Turner, 2010, p. 7). Turner and Turner (2010) conclude that all age groups studied have a “widespread and homogenous use of, and engagement with a range of interactive technologies” (p. 9), and that all who wish to use technology do so successfully by transferring knowledge from another area of their life (from work to leisure, for example).
4.7 Summary
It is clear that there is a need to address the problems that society is facing as a result of having population demographics shift more and more towards an older society (Demiris et al., 2004; Goodman & Lundell, 2005; Lloyd-Sherlock, 2000). The effects that come with ageing can begin earlier than often imagined, and are extremely diverse and varied between individuals (Section 4.3). This makes it particularly difficult to define when a person becomes an ‘older adult’, as there are many different characteristics that define an older adult, and none of them are based solely on age (Section 4.2).

The declines related to ageing are important to this research, as this work is focusing on the older adult. Motor skills decline with age, and hand strength and dexterity are part of the decrease in motor capabilities. This is likely to have carry-over effects into the interactions that older adults have with products. Cognitive abilities also decrease with age, and cognitive decline has been shown to affect some aspects of interaction. These aspects need to be considered when constructing research, and will be outlined in the next chapter.

Research has shown prior experience can generally predict performance, but it does not remove all age-related variance. Age has been show to be less relevant to intuitive interaction than familiarity and central executive function. Younger adults generally perform better than older adults, but some older adults also perform well. Performance differences between younger and older adults reduce with practice. Researchers have also commented that older adults have a different interaction style to younger adults, and older adults struggle more with multi modal interface controls.

There are several misconceptions regarding older adults, held both by them and by the general public. Older adults are thought to be afraid to adopt new technologies. However, this is most often not the case, and if they are aware of what the technology can do for them, they often make the decision to learn how to use it. On the other hand there is a perception amongst older adults that they cannot use contemporary devices as a result of bad experiences with technologies that were very difficult to use (Section 4.5.1).

A theory that may help to explain some of the difficulties older adults face with contemporary products is generational theory. It suggests that the products individuals grow up with define the way they interact with products in the future. This creates ‘technology generations’ as the way technology is interacted with changes. When aligning this idea with the definitions of intuitive interaction, and familiarity, it can be seen that older adults may not have the knowledge that is need to interact effectively with the contemporary products.

The following chapter will examine some of the existing methodologies used in relevant empirical studies, and discuss some of the difficulties involved in examining familiarity and procedural knowledge. The research plan will be outlined, and the experimental approach, methods and analysis techniques will be discussed.
Chapter 5 – Research Methodology

5.0 Introduction
This chapter begins by discussing the impacts of ageing on research methods selection. It then goes on to discuss methods that have already been used in similar fields, and some of the positive and negative aspects of these methods are introduced. The overall plan for empirical work is then explained. The methods used in these empirical studies are discussed and the tools and methods used to analyse the collected data are presented. Finally, the coding heuristics are reviewed, and a familiarity framework is introduced.

5.1 Research Methods
This section will review literature that helped to shape the methodological framework used in the empirical studies conducted for this research. As this research was focusing on older adults, it was necessary to consider the methodological implications of the effects of ageing, and to attempt to reduce potential bias as a result of age-related declines. It was also necessary to ensure that older adults could complete the studies comfortably. Methods from similar studies in this area have also been reviewed.

5.1.1 Impacts of Ageing on Research Methods Selection
The changes that occur as a result of the ageing process have impacts on the suitability of research methods for use with older adults (Dickinson, Arnott, & Prior, 2007; Zajicek, 2004). Appropriate experimental design is a crucial aspect of any research seeking high quality data from older adults (Dickinson et al., 2007). Hawthorn (2007) shows how the adaption of existing methodologies can result in the development of successful interfaces for older adults. Introducing measures to counter the effects of ageing is important, and knowledge of the ageing process is required in order to do so (Hawthorn, 2007).

Inglis, Szymkowiak, Gregor, Newell, Hine, Shah, Wilson and Evans (2003) found focus groups to be a valuable method of investigating user requirements. While older adults responded well to the technology being discussed when getting hands on with the product, it was found that focus groups with more than three individuals became difficult to manage due to varying capabilities amongst the older adults (Inglis et al., 2003; Lines & Hone, 2004). Zajicek (2004) also found that hands on elements improved interaction in focus groups. Older adults sometimes wander off topic in focus groups, and it can be difficult to keep the conversation on the subject at hand (Eisma et al., 2004; Lines & Hone, 2004; Zajicek, 2004). Lines and Hones (2004) found that the effectiveness of focus groups increased as structure was put in place. Due to politeness and higher social skills, older adults often try to involve the researcher in the focus group, which can be problematic in formal research situations (Dickinson et al., 2007). Conversely, Demiris, Rantz, Aud, Marek, Tyrer, Skubic and Hussam (2004) utilised focus groups to elicit detailed information from groups of five older adults, and do not report any of the difficulties mentioned above. These participants lived in the same residential complex (Demiris et al., 2004); this may have contributed to a level of comfort, allowing for smoother and more insightful discussions which are otherwise representative of a smaller user group.
Self-reporting methodologies such as questionnaires can be affected by age-related cognitive decline (Eisma et al., 2004). Older respondents will use a ‘don’t know’ or ‘neutral’ response more often than younger people (Eisma et al., 2004). Dickinson, Arnott, and Prior (Dickinson et al., 2007) state that delivering concurrent (think aloud) protocol can increase the difficulties that older adults experience when using unfamiliar interfaces, and lack of detail in self-reporting often occurs.

There is some agreement in the literature that one-on-one methods are the most appropriate to obtain qualitative information (Dickinson et al., 2007; Eisma et al., 2004). Eisma et al. (2004) found that one-on-one discussion was the most effective way to elicit information in a tutorial situation; however, this disruption tended to break the workflow of older adults. Lines and Hone (2004) suggest that individual interviews, or focus groups with no more than three older participants may be more appropriate than larger focus groups, yet they are more time consuming than large focus groups. Dickinson et al. (2007) comment on the flexibility of semi-structured interviews as an excellent method which allows the interviewer to tailor the approach for each individual participant. This method also allows the interviewee to explain relevant examples in detail, with no concerns about the engagement of other participants (Dickinson et al., 2007).

Cognitive testing is useful to establish if older participants are experiencing memory or processing issues as a result of the ageing process (Dickinson et al., 2007). Hawthorn (2007) recommends including controls for levels of education, eyesight, medication and training effects in all studies. For example, Blackler et al. (2010) used a range of measures to control potential bias as a result of ageing, and also as variables to examine the relation between cognitive decline and intuitive interaction. These included tests for visual acuity, balancing for gender, education levels and technological familiarity, testing of central executive function and other cognitive aspects, and coordination.

It is important to realise the effects that subjecting older adults to such tests may have (Dickinson et al., 2007). Older adults are generally less confident due to the reduction in capabilities as a result of ageing (Zajicek, 2004). Thus, it is very important to communicate to older participants if failure in a test is expected, and that it is normal (Dickinson et al., 2007). Self-confidence of older people regarding technology can create problems in research utilising focus groups, so it is important to communicate the value of the opinions and knowledge that the participants have (Eisma et al., 2004). It is also important to communicate that the participants’ contribution is valuable to the particular research project (Eisma et al., 2004).

One of the most important measures in ensuring the comfort of older participants in research situations is timing (Dickinson et al., 2007). Hawthorn (2000), for example, notes that older adults experience a slowing of several capabilities. These include reductions in the speed of speech, complex motor tasks, visual tracking, and response time. To counter this, it is important to allow more time than expected for all aspects of the experiment. This includes time for arrival at the study location, for reading and explanation of procedures, and task time (Dickinson et al., 2007). As well as allowing for older participants to be slower, it is necessary to allow for the tiring of older participants.
There are also issues in getting a representative sample of older users (Dickinson et al., 2007; Hawthorn, 2000). Older adults are an extremely diverse group (Gregor et al., 2002; Howell, 1997), yet those who volunteer for experiments are generally younger and healthier (Dickinson et al., 2007). Eisma et al. (2004) agree that it takes a great deal of effort to recruit an appropriate group of older adults, stating issues such as reduced mobility, greater isolation, and more time at home, when compared with younger cohorts. Hawthorn (2007) comments on general bias in volunteer populations due to elements such as high levels of education, and better careers, and suggests that bias is increased in older populations, as those that have reduced capabilities are less likely to volunteer. He found that representative users of a population find more flaws in interface designs, and flaws of a different nature, than typical volunteers; this resulted in a design which is better for a wider range of older adults, as a wider range of problems had been addressed (Hawthorn, 2007). As older adults are themselves a diverse group, so are their motivations for participating in research. There is a general agreement in the literature that some older adults utilise experiment situations as social opportunities (Eisma et al., 2004; Hawthorn, 2007). Other motivations include wanting to learn about new technologies (Dickinson et al., 2007). It is important to be mindful of this during interactions with the participant, and especially if participants are interacting with one another. If participants are focusing on interacting socially with the researcher or with other participants, rather than on what is required of them in the context of the study, this creates excess data and could even skew results. Thus, there is a wide range of issues to take into consideration when designing research with older adults as participants. A general knowledge of the ageing process can assist the researcher in finding the appropriate methodologies to gain the data required (Hawthorn, 2000). This understanding is crucial to this research, as older adults are the focus. It is essential to develop experiments which avoid bias due to cognitive ability as much as possible, and that provide robust data. These principles have been applied to the experiments for this research.

5.1.2 Existing Methods in Intuitive Interaction Research

There are a number of researchers working in the areas of intuition, prior experience and prior knowledge across the globe. They all acknowledge that prior knowledge is a crucial element in the interaction of people with products (Blackler, 2008b). The majority of studies in this area use observation as the core data collection method (Blackler, 2008b). Examples of other methods include self-reporting surveys (O'Brien, Rogers, & Fisk, 2010), retrospective protocols (Lewis et al., 2006), and testing of cognitive abilities when applied to older people (Blackler, Mahar et al., 2010; Lewis et al., 2008; Reddy et al., 2010). The methodologies are generally similar. The main method of data collection is observation supported by concurrent protocol. The observations are conducted with a real product (e.g. Blackler, 2008b; Langdon et al., 2007; O'Brien et al., 2010) or a digital prototype (e.g. Blackler, Mahar et al., 2010; Marsh & Setchi, 2008; Reddy et al., 2010) and recorded on video camera.
Observation

An observation involves watching a participant partake in an activity. Observation, compared with methods such as interviews or questionnaires, reduces the responsibility of the participant to provide meaningful data (Armstrong, Brewer, & Steinberg, 2002). As a method, it bypasses the opinions and self-reflective interpretations of an individual’s attitudes and behaviours. Instead, it focuses on the evaluation and interpretation of actions and behaviours in situ (Gray, 2009).

Some distinctions in observational methodologies include overt and covert observation, and participant and non-participant observation. Covert observation involves the participants being unaware that an observation is taking place, while participants are aware that they are under observation in an overt observation. Covert observation prevents participants from altering behaviours, as they are unaware of the fact they are under observation. Participant and non-participant observation refers to the role of the researcher, and is usually associated with ethnography. If the researcher integrates into a context or community and is an active participant in that context or community, then this is considered participant observation. In a non-participant observation, the researcher remains outside of the context or community (Gray, 2009). This research used overt, non-participant observation.

Structured observations often result in more robust data than non-structured observations (Gray, 2009). Participants should be observed executing a specific task or series of tasks (Armstrong et al., 2002). In observations of product user interactions, the use of observation allows for the easy identification of design flaws, and also of the differences between participants. Due to the speed of interaction, it is often necessary to record observations on video, to ensure that nothing is missed (Chi, 2006a). The video recording of interaction is common practice in this field (Blackler, 2008b). Video recordings capture the actions and behaviours of a participant, but do not provide much insight into the decision making process underlying those actions and behaviours.

This research uses various methods to identify familiarity, and observation coupled with concurrent protocol is the primary method. Blackler (2008b) and her colleagues (Blackler, Mahar et al., 2010) have shown this method to be crucial in identifying familiarity. [For a full review of Blackler’s methods and the reasoning behind them, see Blackler (2008b)]. Furthermore, Langdon et al. (2007; 2009), Lewis et al. (2006; 2008), Kang and Yoon (2008), Reddy et al. (2010), and O’Brien et al. (2010) all use observation as a central method in examining prior knowledge and intuition.

Popovic (2003) describes how product interaction can mediate knowledge generation. It is argued that the true nature of individuals’ prior experience and knowledge is expressed through their interaction with the physical environment. Thus, the research presented in this thesis utilises interaction as an expression of knowledge to investigate how people use their knowledge and how familiarity contributes to interaction. Through observation (and concurrent protocol), an understanding can be developed about the knowledge an individual possesses.
Concurrent Protocol

Almost all studies reviewed used some form of verbal protocol to extract additional information from the participant (Blackler, 2008b). The most commonly used is concurrent protocol (also known as think-aloud protocol), where the participant verbalises their thought processes during a task. The second form of protocol used is a retrospective protocol, where the participant talks about what they did, and the thought processes behind their actions. Occasionally, a retrospective interview will be used where the participant is asked questions about their interaction with the product. Both retrospective protocol and retrospective interviews are also self-reporting methods.

Concurrent protocol (also known as think aloud, or talk aloud protocol) is a method that is often used in research in this area (e.g. Blackler, 2008a; Lawry et al., 2010; Reddy et al., 2010). It is used to supplement the observation, and access information that the observation alone could not yield, such as more details on cognitive processes (Blackler et al., 2003b). Simon and Kaplan (1989) report that concurrent protocol has been shown to be an acceptable reflection of the thought process.

Chi (2006a) describes concurrent protocol as typically used in the context of a cognitive task, and says that “The goal of protocol analysis then is to identify which sequence of states a particular participant progresses through” (Chi, 2006a, p. 177). In the context of these experiments concurrent protocol helps to indicate how familiar participants are with the action they are currently performing. It is important to note that during the analysis of concurrent protocol, interpretation is sometimes needed, as there can be subjectivity to a participant’s self-reporting and expert knowledge is often implicit.

Ericsson (2006b, p. 227) states that the main assumption of concurrent protocol is that “it is possible to instruct subjects to verbalize their thoughts in a manner that does not alter the sequence and content of thoughts mediating the completion of a task and therefore should reflect immediately available information during thinking”. Ericsson and Simon (1993) show research supporting this assumption. Thus, if the assumption is correct, concurrent protocol is an ideal technique for this research, as it does not alter the thought process of the individual, and provides an insight into their thought and decision making process. Kuusela and Paul’s (2000) findings show that concurrent protocol is well suited to investigating decision-making processes.

Blackler (2008b) chose to use concurrent protocol as it prevents the participant potentially omitting something that they could have forgotten during a retrospective protocol. Kuusela and Paul (2000) conducted an empirical comparison of concurrent and retrospective protocol. Concurrent protocol was found to elicit more responses and give more insight into the decision making process (Kuusela & Paul, 2000). Often, a silent group is used as a control to test the validity of the concurrent protocol (Russo, Johnson, & Stephens, 1989). In this research, however, the analysis of the concurrent protocol is critical to understanding the observation, and the verbalised thought process is a critical data collection tool and a central performance measure. Thus, a control group is inappropriate in the methodology for this research (Blackler, 2008b).
Self-Reporting
Most studies use observation and concurrent or retrospective protocol as the primary data source (e.g. Langdon et al., 2007; O'Brien, 2010). Secondary measures are used to capture additional data that is then compared to the data collected from the observation and concurrent or retrospective protocol. A common secondary method used by other researchers in this area is self-reporting questionnaires (e.g. Blackler, 2008b; O'Brien et al., 2010). This research has avoided this type of self-reporting measure as much as possible, for two reasons.

The first reason is the possibility of inaccurate data resulting from self-reporting. This could lead to results which are biased or do not accurately represent what is occurring. However, almost all studies in this area use self-reporting to examine prior experience with technology. Torkzadeh and Lee (2003) state that participant perceptions are not always accurate, and that participant can misrepresent their skills, whether it is deliberate or not. Adams, Soumeri, Lomas and Ross-Degnan (1999) report that self-reporting methodologies may lead to bias. There is the possibility that similar bias may have occurred in the self-reporting methodologies used by previous studies (e.g. Bettman & Park, 1980; Blackler, Mahar et al., 2010; Johnson & Russo, 1984; Langdon et al., 2007; Langdon et al., 2009; O'Brien et al., 2010). Although self-reporting questionnaires were used, Blackler (2010) has shown statistically significant relationships between technology familiarity and intuitive correct uses, and time on task. Langdon et al. (2007) has also shown that there is a significant relationship between experience (as measured by a self-reporting questionnaire) and age. The concern with this methodological approach for examining prior experience is that it is open to individual interpretation, and it may not be a completely accurate reflection of experience levels. Experience is important in forming prior knowledge, but is not a direct reflection of prior knowledge. This is why self-reporting methods are considered inappropriate for this research. O'Brien et al. (2010) suggest methods that access knowledge sources directly are likely to be more accurate in evaluating participant knowledge. Some researchers have integrated a symbol/icon evaluation form into their testing methodologies which is likely to demonstrate actual familiarity in relation to symbols and icons (Langdon et al., 2009; Reddy et al., 2010).

The second reason for avoiding self-reporting methods is that self-reporting can only capture knowledge that is accessible to the participant. O'Brien (2010), for example, mentions the reliance on self-reporting as a limitation to the studies she has conducted. Most importantly, this research is particularly interested in procedural knowledge, and this type of knowledge is implicit (Anderson, 1995) and is often difficult to verbalise. Furthermore, research in implicit learning has demonstrated that experience does not necessarily result in usable knowledge (Howard & Howard, 2001; Howard & Howard, 1997b). Thus, self-reporting techniques need to be carefully applied to be of any use. Therefore, this research primarily uses the application of knowledge in context to investigate demonstrated familiarity, rather than self-reported familiarity.

The second research question is looking at how designers can identify familiarity, to facilitate intuitive interaction. To do this, designers need to be able to identify the process that users are familiar with. Self-reporting methodologies, as used by some previous studies (e.g. Blackler, 2008b; Langdon et al., 2009; O'Brien, 2010), while producing statistically significant results, do not provide the level of detail required to
identify the processes that users are familiar with. Generalised user knowledge is of limited use, and utilising it requires assumptions to be made.

Retrospective Protocol and Interviews

Some studies have used retrospective protocols to elicit additional data about an interaction after the fact (e.g. Langdon et al., 2007; Langdon et al., 2009; Lewis et al., 2006). However, retrospective protocol or interview is also a form of self-reporting and the literature raises some issues with retrospective methodologies. Ericsson (2006b), for example, reports on instances where participants are asked to describe their methods after a series of tasks, often leading to incorrect reporting on what actually happened. Pedgley (2007) discusses the types of behaviours individuals can indulge in during retrospective protocol, such as: speculation; streamlining; insistence on executing a task one way (when they really did it a different way); and attempting to make themselves ‘look good’ by altering reports or behaviour. Participants may behave in a more socially desirable manner, or ‘clean up’ and describe a more coherent strategy than they actually executed (Kuusela & Paul, 2000). As retrospective protocol is primarily based on recall, differences in participants’ memory function and ability to verbalise can lead to problems with validity. While retrospective data should be collected as soon as possible after task completion to minimise loss of data from short term memory (Kuusela & Paul, 2000), Ericsson (2006b) argues that even if this occurs, participants struggle to describe a single strategy if multiple strategies have been used in the task.

Performance Measures

As observation is the foundation of the methodology used in this research, it is necessary to consider what is being observed and how to measure performance. Most methodologies reviewed had error-based performance criteria and time-based performance criteria. Errors have been found to have significant relationships to both age and experience (Kang & Yoon, 2008). However, this is a negative focus. In order to really understand all aspects of interactions between individuals and products, a positive focus is needed. This is a focus on highly successful interactions, and on explaining why these interactions occur. This focus is very similar to the focus of expertise in various domains (Ericsson & Towne, 2010). Chi (2006b), for example, states that one way of looking at expert performance is to examine how well experts perform tasks. If there is an interest in understanding and improving usability, a focus on the positive behaviours around interactions is necessary. Neilson (1993) says that usability is not a single characteristic or property of an interface; it has multiple attributes, including satisfaction and efficiency.

O’Brien (2010) uses a 3 tier scale to measure interaction success (Table 5.1).

<table>
<thead>
<tr>
<th>Success Level</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimal</td>
<td>Task completion without error or intervention</td>
</tr>
<tr>
<td>Successful</td>
<td>Ultimately achieved task goals, with errors and/or intervention</td>
</tr>
<tr>
<td>Partial</td>
<td>Achieved at least one, but not all task goals</td>
</tr>
</tbody>
</table>

While O’Brien’s optimal measure suggests the best level of interaction, it does not consider other aspects of usability. This is an example of the focus that the majority of research in the field takes: a focus only on the negative aspects of the interaction, such
as error and level of help required (intervention), with no consideration of the positive aspects of the interaction such as low reasoning, high levels of certainty, and swift interactions.

Blackler and her colleagues are the only researchers in this area who are incorporating the behaviour of use into the analysis of interactions (see Blackler, 2008b; Blackler, Mahar et al., 2010; Lawry et al., 2010; Reddy et al., 2010). Not only was the correctness of the action considered, but also the nature of the action’s execution. This provides a more holistic analysis of the interaction, which is necessary if the body of knowledge in this field is going to improve the usability of products. Georgeff and Lansky (1986, p. 5) agree, stating: ‘The ability to represent both successful and failed behaviours is very important in commonsense reasoning…’. A focus on what is going wrong is not sufficient. Supplementing it with what is going right provides a more complete understanding of the interaction, and of how to improve products and make them more usable.

It is widely known that one of the results of ageing is a reduction in both motor skills (Vercruyssen, 1997) and cognitive abilities (Gregor et al., 2002). Often literature is cited stating age-related declines in cognition and/or motor speed (e.g. Langdon et al., 2009; O’Brien et al., 2010). There is a large body of knowledge documenting such changes (e.g. Klein & Scialfa, 1997; Vercruyssen, 1997) and the associated, required considerations for interface design (e.g. Hawthorn, 2000). Despite this knowledge that older adults are going to be slower, all studies reviewed use ‘time on task’, or ‘time to complete’ as a measure of performance.

Docampo Rama et al. (2001) found that task duration increased linearly with age, and was not related to prior knowledge. Kang and Yoon (2008) found age had a significant effect on error rate, and interaction steps, both elements that would affect time on task, while prior knowledge did not have a significant effect on error rate or interaction steps. The differences in speed are likely to be affected by declines in motor response, and also in declines in cognitive processing speed. Research has shown that younger adults have faster reaction times than older adults, and that older adults have greater variation within reactions time (Fozard, Vercuyssen, Reynolds, Hancock, & Quilter, 1994; Hultsch, MacDonald, & Dixon, 2002). Hawthorn (2000) also reports on declines in the speed of processing of visual information and also in the speed of general processing. However, while these two elements will contribute to increased time on task, it is unlikely that these two elements alone can explain the differences in time on task seen between younger and older adults in research in this area (e.g. Blackler, 2008b). It is thought that familiarity may play a role in the increases in time on task between younger and older adults.

In experiments looking at older adults and comparative performance, cognitive measures are also often used. These are a set of cognitive tests designed to examine aspects of brain function. Blackler et al. (2010) and Reddy et al. (2010) applied cognitive measures using Baddley’s (1998) model of working memory. They tested Central Executive, Phonological Loop, and Visual-Spatial Sketchpad functionality. Hand-eye coordination and sustained attention were also measured. Langdon et al. (2009) used a free online intelligence test (www.intelligencetest.com) which tested IQ and various other abilities, including verbal, mathematical ability, spatial, logic, pattern recognition, general knowledge, and short term memory. O’Brien (2010) used
a Digit Symbol Substitution test, Reverse Digit Span test and Shipley Institute of Living vocabulary test. O'Brien also attempted a ‘cognitive orientation procedure’ in an attempt to make the participant feel more familiar, and behave in a more casual manner.

Other Methods used in Intuitive Interaction Research

Other methods have also been used to conduct investigations into intuitive interaction. O'Brien (2010) conducted a journal based study, with participants recording their daily interactions with products. The journal was conducted over ten consecutive days and was focused on technology that was not commonly used, and on any technology that the participant had difficulty using. An interview was used after the ten-day period to retrieve additional information about the events recorded in the journal. The goals of this study were to understand the range of technology used by participants, and to understand the problems that they encountered, and how they dealt with them. The study also looked at how familiar different age groups were with a range of everyday technologies (O'Brien, 2010).

Hurtienne used custom software to test the metaphorical extensions of image schemas (Section 2.2). For Studies 1 and 2, the software would present a word or statement, priming the participant in relation to an image schema. A dialogue box would then appear and the participant would interact with it. Study 3 used an automated process to test similarities or differences between values presented either numerically or visually. The values were displayed in a 3x3 grid. Study 4 built on the methodology used in Study 3. The participant was required to make a judgement call between two values, based on similarities or differences from a base number. The software automatically measured and recorded trial conditions and response times (Hurtienne, 2009).

Hurtienne’s (2009) final three studies used a more qualitative approach. Study 5 used a focus group style workshop to generate a list of real world examples of image schemas from the ‘Force’ category. The examples from this list was refined and then presented to four participants who specified which image schema applied to the example. This study examined the consistency with which the image schemas were applied. Study 6 saw two participants specify image schemas to the workflow process of commercially available accounting software. Again, the consistency of the application of schemas was examined. The final study involved a redesign of the software interface from Study 6. Image schemas were used during the redesign process, and users of the original software evaluated the new interface designs.

Influence of Expertise

The research methodologies used in the study of expertise have influenced the design of this research. Ericsson and Towne (2010) detail two approaches from the study of expertise. The more traditional approach uses longitudinal studies to measure changes in individuals as they progress from novice to expert. The other is called the expert-performance approach. It focuses on reproducible superior performance in a particular domain (Ericsson & Towne, 2010) and the analysis of that performance (Ericsson & Smith, 1991). This approach is used in domains where there are no objective measures of expert performance. It is focused on the successful reproduction of representational situations in the specific domain (Ericsson & Towne, 2010).
The expert-performance approach has three distinct stages. The first is to capture superior expert performance. Representative tasks are used to capture performance in a laboratory setting (Ericsson & Smith, 1991; Williams & Ericsson, 2005). The second is to analyse the expert performance and identify the underlying mechanisms. Methods used included the use of think-aloud (concurrent) protocols, and expert-novice comparisons (Ericsson & Smith, 1991). The third step is to determine how expertise was developed (Ericsson & Smith, 1991; Williams & Ericsson, 2005).

5.2 Research Plan

The focus of this research is to identify if there are any differences in product familiarity between younger and older adults and, if there are any differences, to come to an understanding of them. There is an emphasis on the importance of making knowledge and methods available to the design professional, in order for the outcomes of this research to be applied to artefact design. The primary research question addressed in this thesis is:

How can familiarity be identified in order to facilitate intuitive interaction for older adults?

Two sub-research questions focused the broader research questions. These questions focused on two different aspects of the primary research question.

1. How familiar are older adults with contemporary products, and how does this differ from the familiarity of younger adults?

2. How can designers readily identify what interaction processes older adults are familiar with?

The aim of this research is two-fold. Firstly, it is to provide researchers and designers with an understanding of the role of product familiarity in interaction, and how product familiarity varies with age. Secondly, it will provide methods for designers to use to determine what users are familiar with. This knowledge can then be integrated into the design process, which should result in more intuitive products. The research itself consisted of two experiments.

Field Experiment 1 was designed to test participants’ interaction with products that they deemed they were familiar with. The individual processes within the interaction with the product were examined for familiarity. The experiment was conducted in participants’ homes with a product that they considered themselves to be familiar with. A questionnaire was used to attempt to identify product usage, and a semi-structured interview was then conducted, going into more depth about the chosen product. The participant was then required to describe how they performed a common task with the product. The participant then performed that task, while delivering concurrent protocol. A retrospective protocol was completed after the observation. An in-depth explanation of the methodology follows in Section 6.2. The data was coded using Atlas.ti and Noldus Observer, and then analysed (Section 6.3).

Experiment 2 built on Field Experiment 1. This study focused on the use of products that the participants were not familiar with. Four products were selected for all participants to use. The methodology for Field Experiment 1 was adapted to suit a
consistent set of products across all participants. Participants read a task sheet, and were then shown the product briefly. Participants then explained how they thought they would perform the specified task. Participants then performed the task while delivering concurrent protocol. After the observation, a short retrospective interview was conducted. This process was repeated for each product. An in-depth explanation of the methodology follows in Section 7.2. The data was coded using Noldus Observer, and then analysed (Section 7.3)

![Research Plan Diagram]

Figure 5.1: Research Overview
After the data were analysed, the methods used in the two studies were reviewed. A method was developed that would allow researchers or designers to identify a user’s level of familiarity with a specific task, and with a product in general. Several criteria for the method were determined during its development. It needed to be: easy to use, low cost, fast, highly mobile, and flexible. Alongside the method, an information pack was developed to convey the knowledge necessary to allow its effective use.

5.2.1 Experimental Approach
The experimental approach applied to this research was one that focused on ensuring that the required data could be collected, while making it as easy as possible for the participants to actually be involved in the study. It is necessary to consider the characteristics of older adults when conducting research with them (Hawthorn, 2007), to ensure high quality data (Dickinson et al., 2007). One of the most crucial aspects for this research was mobility. To ensure that mobility did not exclude older adults from participating in the research, the experiments were designed to be mobile. This created a more representative sample of the older age groups.

Physical products were used in both experiments, as this research was examining familiarity. Using any form of prototype or mock-up would remove the participant from the product and their knowledge of it, potentially skewing the data. The use of real products ensures ecological validity (Blackler, 2008b), and also bypasses the issues detailed by Blackler (2008a) with using prototypes. The issues include: difficulties in creating suitable software prototypes, representing and conveying a three dimensional object in two dimensions, prototype and interfacing sizing and scaling, and representations of LCD displays on a touch screen (Blackler, 2008a).

This research examined familiarity and prior knowledge, and methods to elicit relevant prior knowledge from participants that would be suitable for designers to use in an industry context. For this reason, a variety of data collection methods were used. To assure research rigour, a triangulation approach was implemented.

5.3 Data Analysis
This research is necessarily a hybrid of quantitative and qualitative methods. As Blackler (2008b) discusses, a mix of quantitative and qualitative approaches are necessary when capturing rich and complex data. Using a combination of quantitative and qualitative methods also assists in supporting the validity of the conducted research. The majority of data collection methods used in this research are qualitative. Applying a coding scheme to qualitative data transforms it into data that is quantitative.

There are issues with coding rich data when what the researcher is looking for is highly pervasive, and is incorporated fully into the behaviour of the participant. Familiarity exhibits this very high level of pervasiveness. No single aspect of a participant’s behaviour alone can justify a particular code. The decision to code a particular action as ‘familiar’ or not is, therefore, a multi-faceted decision, relying on a combination of many aspects of the participant’s behaviour. The main performance measure used for this research was familiarity. Familiarity is at the core of the interaction, and thus is conveyed in the behaviours surrounding product usage.
Noldus Observer

To extract data from the observations in a manner suitable and robust enough was a significant challenge. Noldus Observer XT software was used to apply the coding scheme to the observational and concurrent protocol data. Noldus Observer allows the importation of multiple pre-recorded video files and the application of a coding scheme to those observations (Zimmerman, Bolhuis, Willemse, Meyer, & Noldus, 2009). It can also be used to visualise the data. There are three main activities undertaken when using Noldus Observer: configuration, observation and analysis.

The configuration process involves specifying the independent variables and entering the coding scheme. The observation includes the uploading of video files into Noldus Observer, and the application of the coding scheme to those files. The analysis involves specifying what aspects of the data to consider, and then exporting the relevant data. That data was imported into Microsoft Excel, where it was sorted and converted into the appropriate form. This was then imported into the Statistical Package for Social Sciences (SPSS) for statistical analysis.

Atlas.ti

Atlas.ti software was used to code transcripts of the concurrent and retrospective protocols of Field Experiment 1. The audio tracks were removed from the video and transcribed verbatim. The transcriptions were uploaded into Atlas.ti. The coding scheme used is identical to the scheme used for the observational data, with the exception of the modifier codes. The data were quantified in Atlas.ti, and further analysis was conducted with Microsoft Excel.

5.4 Coding Heuristics

The coding scheme was initially derived from Blackler’s (2008b) coding scheme, and thorough a review of the literature. The coding scheme was adapted to suit this particular research. Once data was collected, the coding scheme was further refined using an inductive process. One of the underlying assumptions of the inductive approach is that the analysis is determined by the research objectives and by multiple uses and interpretations of the raw data (Thomas, 2006). The specific aims of this research (understanding and identifying product familiarity and how it can contribute to more intuitive products for older adults), experience from coding other studies in closely related areas (see Blackler, Mahar et al., 2010; Reddy et al., 2010), conducting the current research, and viewing the raw data repeatedly, all contributed to the construction of the coding scheme.

The coding schemes used in Field Experiment 1 and Experiment 2 have the same foundation; nevertheless, they are different, as the experiments differ. The full coding schemes and related heuristics will be explained for each experiment in the respective chapters (Chapters 6 and 7). The foundation of the coding scheme is familiarity and procedures. The heuristics for these will be outlined below, as the same cues are used to interpret familiarity across both experiments. Field Experiment 1 was coded by the author, with a procedure that involved coding every observation twice, with a break in between codings to enhance reliability (Section 6.3). This method was adapted from procedures used by Blackler (2008b). The author coded Experiment 2, and a second rater was used to code 30 of the 32 participants. Near perfect agreement was found between the two raters (Section 7.3).
5.4.1 Familiarity Heuristics

All raw data has been coded with three levels of familiarity: ‘Very familiar’, ‘moderately familiar’ and ‘not familiar’. These three levels were introduced and explained in Section 3.1.6. This section will outline many of the behaviours and verbal cues that contribute to the decision of coding an action for familiarity. Some of Blackler’s (2008b) heuristics for coding intuition have been integrated into this heuristic for coding familiarity. The heuristics were refined inductively through use in pilots and test cases.

The literature from expertise research shows that acquired knowledge representations mediate expert performance (Ericsson & Towne, 2010). These representations allow individuals to perform faster, more accurately, and more consistently. Chi (2006b) also states that it is assumed that the differences in the performance levels between experts and non-experts are the result of the differences in the way they represent domain specific knowledge. Characteristics of experts helped to form an understanding of what very familiar behaviour looks like. Some of these characteristics include increased recognition of patterns, high levels of domain knowledge and faster skill performance (Glaser & Chi, 1988; Klein, 1998; Kolodner, 1983). The coding heuristics for familiarity are based on the use of knowledge representations. For a more in-depth review of the expertise research that contributed to the heuristics identified here, see Section 3.3.1.

Forward Planning and Anticipation

Participants highly familiar with a string of actions will often integrate the following step into the step that they are currently executing. Anticipation has increasingly been acknowledged as an important element of high performance across multiple disciplines (Williams & Ward, 2007). Forward planning and anticipation were seen to occur in instances of high familiarity with participants of both experiments. This would often manifest in preparatory actions that would make the following step easier and faster. An example of this is positioning a finger over a button that executes the next task, while waiting for a system to perform a particular action. Another example of this is shutting the SD card compartment door of the digital camera while turning the camera over at the same time, so that the ON/OFF button is easily accessible. Any actions taken that suggest an active awareness or knowledge and prepare the participant for the next task are considered to be forward planning and anticipatory actions, and suggest a higher level of familiarity.

Relative Speed

The combination of forward planning and anticipation can result in interaction that is faster than a less familiar participant normally exhibits. The cognitive representations allow the participant to anticipate what is going to happen, and plan their next move accordingly, thus increasing speed within the domain (Ericsson & Towne, 2010). Klein’s (1993) Recognition Primed Decision (RPD) model explains how highly experienced individuals make quick, robust decisions. A characteristic of this decision making behaviour is that if individuals recognise a certain situation, then they usually know how to respond to it (Klein, 1993). (See Section 2.1 for a more in depth explanation).

Blackler (2008b) uses latency (speed of each feature use) as one indicator of intuitive uses of interface features. She argues that speed taken to locate and use a feature is a
reflection of the thought process of the individual. Relativity is also considered as a factor due to the variation in cognitive and physical abilities of individuals (Hawthorn, 2000; Vercruyssen, 1997; Zajicek, 2004). This heuristic is particularly useful if the participant shows a lot of variance in the speed at which they perform actions. The relative speed of behaviour suggests familiarity: an action that is slower than other actions may indicate a lower level of familiarity, and a faster action may indicate a higher level of familiarity. If a participant’s performance speed is fairly linear, then other heuristics can be utilised.

High Levels of Domain Knowledge
Both highly detailed verbalisation and a lack of verbalisation can be viewed as a sign of high levels of familiarity. With regard to highly detailed verbalisation, Chi (2006a) suggests that experts have more meaningfully integrated representations, which are expressed in verbalisation. Glaser and Chi (1988) support this, stating that experts use deeper and more principled representations than novices. Experts often verbalise more about more subtle and complicated elements in a domain (Chi, 2006a). During task execution, very familiar participants would occasionally verbalise multiple options for a particular task, sometimes citing various situations in which those options would be applied. Verbalisation that reflects a high level of comprehension of the task, product, or domain is a sign of high familiarity.

Very low to no verbalisation can also suggest very high familiarity. Anderson (1995) states that, as people improve skills in a particular area, they often lose the ability to verbally describe the skill because cognitive involvement with the skill declines. Blackler (2008b) supports this, stating that participants would often have low verbalisation levels when processing intuitively. Chi (2006b) reports that experts sometimes fail to recall more superficial features, and will often miss smaller details. Often, participants would perform tasks with high familiarity and not verbalise at all, even though they had been instructed to do so.

Low verbalisation can also suggest low levels of familiarity. Novices lack the knowledge to discuss the interactions in great detail (Anderson, 1995; Chi, 2006a). It was observed that verbalisation was lowest when participants were struggling to identify the next step to take. It is suspected that they were experiencing high cognitive load [See (Sweller, 2011) for a review of this phenomenon]. It is suggested that the lack of verbalisation occurs because all cognitive resources are being utilised to solve the problem at hand. Often, once the problem had been solved, participants would start to verbalise again, as if nothing had happened. When a participant had low or no verbalisation, other heuristics were used to identify if this was a sign of low or high familiarity.

Situational Awareness and Perception
Situational awareness and perception is most apparent when the participant does not have a high level of situational awareness and does not recognise important information in the product they are using. Participants would often overlook crucial functions and misunderstand icons or other embedded knowledge. Alternatively, familiar participants would know exactly what a button did without more than a glance, could tell if an SD-Card was inserted properly by the feel of the click in the camera, or would know intuitively where a control would be.
5.4.2 Applying the Heuristics

The heuristics are applied in the coding schemes of Experiment 1, Experiment 2, and in the FIT tool through both the presence, and the absence of the heuristics. The heuristics described in Section 5.4.1 are characteristics of high levels of familiarity. The absences of the heuristics demonstrate lower levels of familiarity. For example, if an individual is surprised by the result of an interaction, then they are demonstrating poor anticipation, and this a low level of familiarity. Moderate familiarity is present when a heuristic is demonstrated in such a way that it shows the characteristics of the heuristic, but not to their full extent. Depending on the situation, one heuristic, or several heuristics may be used to decide on how to code a particular interaction. If the heuristics do not provide enough guidance on how to code a particular interaction, then the surrounding steps are used to help reach a decision about how the interaction should be coded.

5.5 Summary

This chapter presented the methodological position taken in this research. It has discussed the methodological approach adopted in past studies by researchers in this area. The individual methods that were used have been presented and discussed, and the tools used to analyse the data have also been introduced. The framework used to evaluate the levels of familiarity has been proposed, along with the theoretical work in which it is grounded. The heuristics upon which the coding of familiarity was conducted were also introduced. This provides an in-depth look at how familiarity was coded over both Field Experiment 1 and Experiment 2.

Chapter 6 will explain the application of much of what has been discussed in Chapter 5 to Field Experiment 1. The details of the experiment design, methods, apparatus, procedures, and participants will be presented. The analysis of the data is then introduced. The findings are discussed in detail, and final conclusions from Field Experiment 1 are presented.
Chapter 6: Field Experiment 1

6.1 Introduction
This chapter covers Field Experiment 1, which was undertaken to examine the two research sub questions:

1. How familiar are older adults with contemporary products, and how does this differ from the familiarity of younger adults?

2. How can designers readily identify what interaction processes older adults are familiar with?

Blackler (2008b) found that older adults used products more slowly and less intuitively than younger adults. This was also found by more recent research (Blackler, Mahar et al., 2010; Reddy et al., 2010). This research is aimed at identifying any differences in familiarity between younger and older adults and identifying if these differences play a role in user–product interaction.

As intuitive interaction is based on prior knowledge (Blackler, 2008b), it is logical to start investigating differences in younger and older adults that may lead to differences in intuitive interaction. Thus, Field Experiment 1 looked at the relationship people of different ages had with familiar products. It then probed their procedural knowledge related to product use in three different ways. The intention was to examine prior knowledge and familiarity from multiple angles, and to establish the differences—if any—in prior knowledge between younger and older adults.

6.1.1 Objectives
The objectives of this field experiment were to:

1. Examine differences in familiarity across age groups
2. Develop an understanding of familiarity across age groups
3. Investigate how familiar different users are with products they own
4. Examine how to effectively investigate familiarity.

6.2 Methods
The methodological and theoretical foundations of this experiment have been discussed in Chapter 5. This section will present the details specific to Field Experiment 1.

6.2.1 Experiment design
This experiment utilised a mixed methods approach. While it was based on Blackler’s (Blackler, 2008b; Blackler, Popovic, & Mahar, 2004) experimental approach, the methodology differed slightly to reflect the difference in focus. Blackler’s (2008b) work focused on investigating intuitive use of product features, while this work focused on the procedural knowledge involved in the processes and sub processes of product interaction.
This focus on the processes of the interaction, and specifically on the behaviours involved in these processes, means that the measures of performance are different from those used in other research in this area. The focus here is on behaviour with a product familiar to the participant. Thus, the constant is a familiar product, rather than a specific product. This focus on behaviour allows flexibility of product and task choice, which is reflected in the experiment design. Other studies in this area use the same product across all participants (e.g. Blackler, 2008b; Kang & Yoon, 2008; O’Brien, 2010; Reddy et al., 2010).

Behaviour with familiar products among individuals is likely to be very different. ‘Familiar behaviour’ of people using products cannot be treated the same across individuals as it assumes that people have similar levels of prior knowledge with the device that they selected as familiar. This is unrealistic for a number of reasons. Firstly, different products require users to have different ‘amounts’ of knowledge, and also different types of knowledge to be used in very familiar ways. For example, displaying high levels of knowledge about a washing machine requires knowledge about the relationship between how dirty the clothes are and the settings required to get them clean, and then how to program the settings in the machine. On the other hand, a digital camera requires knowledge from the domain of photography, including what particular icons represent, and how to navigate menus and understanding the mapping of physical controls their digital behaviours. The knowledge required to use these two products is different. For users to demonstrate high levels of familiarity for the washing machine and the digital camera, they need to have two sets of knowledge. ‘Familiar behaviour’ is not consistent across users, as users do not have the same knowledge. Secondly, it does not consider the accuracy of the participants’ evaluation of ‘a familiar product’. Torkzadeh and Lee (2003) state that participant perceptions are not always accurate, and that participant can misrepresent their skills, whether it is deliberate or not. The purpose of Experiment One was to investigate differences in familiarity between younger and older adults. The characteristics of high levels of familiarity are constant across participants, not the behaviours that are associated with reported levels of high familiarity.

6.2.2 Methods

The experiment consisted of three parts. Part 1 examined the relationship that participants had with common contemporary electronic devices and went into more detail with one product they deemed they were familiar with. Part 2 examined how familiar the participant was with the familiar product they selected. Part 3 provided additional information about the relationship the participant had with the product and their level of familiarity with the task they were performing. This structure can be seen in Figure 6.1. For more details of the methods used in this experiment, see Section 5.1.3.

Field Experiment 1 used a combination of the methods outlined in Chapter 5. Part 1 included the Questionnaire, Semi-structured Interview and Task Recall data collection methods. The Questionnaire was administered, and then the participants selected a product they felt they were familiar with. The Semi-structured Interview was focused around the products that the participants selected. The participants then selected a familiar task to perform with their chosen product. This task was used for the Task Recall, which occurred after the interview. Here the participant described how to do the task from memory, with no prompts given.
The methods used in Part 2 were Observation and Concurrent Protocol. Participants were recorded while executing the selected task with their chosen product, and Concurrent Protocol was delivered during the interaction. During Part 3, participants delivered Retrospective Protocol. The muted video file was viewed on a laptop computer; the participants delivered Retrospective Protocol while watching the video of their task execution. Each of these methods employed in Field Experiment 1 will now be explained in more detail.

Self-Reporting Questionnaire
A Self-Reporting Questionnaire (Appendix A) was administered to participants, as similar measures had been used in other studies (e.g. Blackler, 2008). The researcher conducted the questionnaire with the participant. If there was ambiguity in an answer, the researcher was able to probe with questions until a satisfactory answer was reached. The questionnaire measured frequency of use, length of ownership, and importance of the product to the participant. It considered an array of products in the categories: Lounge, Kitchen/Laundry, Personal Use, Out and About, Medical, and General.

Semi-structured Interview
Semi-structured Interviews were used to develop an understanding of the relationship participants had with the products they chose to use. Specific questions were set, and were designed to probe the relationship the individual had with the product, and their ability to apply knowledge in related contexts (Appendix B). The questions were open-ended and the researcher encouraged discussion. Other research in this area has also used an interview process to expand on data collected about product usage (O'Brien, 2010), feature familiarity and expectations (Blackler, 2008b), and input preferences (Kang & Yoon, 2008). This method contributed to the overall picture of familiarity of the user with the product.

Task Recall
The Task Recall method is a slight adaptation of a relatively common and robust methodology in the study of expertise (Chi, 2006a). Chi (2006a) reports that experts are exceptionally good at recalling data from their domain, and are often faster and
more accurate than novices. The Task Recall required participants to verbally construct a step-by-step process of how to execute a particular task with a given product. It was hypothesised that the participants’ verbalisations would demonstrate their actual level of familiarity with the task that they were describing (Chi, 2006a). The aim of the Task Recall was to gain insight into the level of familiarity the participant had with the particular task before its execution, by using the recall as a comparison to actual performance during analysis.

Observation
As this research focused on interactions between people and products, it was necessary to observe this process in great detail. Video recordings were used rather than live observation, as the interactions could then be viewed multiple times, from different perspectives; this can enhance the understanding of what is occurring. Video recordings capture the actions and behaviour of a participant, but do not provide any insight into the decision making process underlying those actions and behaviours.

The Observation attempted to establish a realistic measure of familiarity to compare other measures against. Through the Observation and coding of the behaviour of the participants, it was anticipated that an understanding of their level of familiarity could be developed. The Observation was conducted with the selected familiar products.

Concurrent Protocol
The aim of the Concurrent Protocol was to gain insight into the thought processes of participants as they executed the task. The verbalisations were used to help make decisions when coding the behaviours for familiarity and correctness. The way participants spoke about particular actions alluded to the way they represented knowledge.

Retrospective Protocol
Retrospective Protocol was used in this experiment as a comparison to the Task Recall and the Concurrent Protocol. The aim was to identify if there was any relationship between familiarity and the verbalisation from the Retrospective Protocol. It was also used to identify familiarity through the way the participant talked about particular interactions, as in the Concurrent Protocol.

6.2.3 Apparatus
A wide range of products was used, as participants chose a product that they were familiar with to use during the experiment. The products ranged from iPods and cell phones, to washing machines and TVs. Table 6.1 shows the range of the products used and the frequency with which they were selected. Not only was a range of products used, but the tasks that were executed with the products also varied. Participants chose a task that they were familiar with. This resulted in a range of tasks, even when the products used were from the same product category.

The Questionnaire, Semi-structured Interview and Task Recall were recorded using a Sony Digital MP3 Recorder. The Questionnaire and interview were also recorded with pen and paper, and this data was then transferred to Microsoft Excel 2008. The Observation was recorded with a video camera that was always positioned so that the controls and interaction could be viewed. A laptop computer was used to show the video for the Retrospective Protocol that was also captured using the video camera.
The camera was focused on the screen of the laptop, showing the video of the task being performed.

Table 6.1 Range of products selected in Field Experiment 1

<table>
<thead>
<tr>
<th>Product</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile Phone</td>
<td>7</td>
</tr>
<tr>
<td>Microwave</td>
<td>7</td>
</tr>
<tr>
<td>Television</td>
<td>5</td>
</tr>
<tr>
<td>Stereo</td>
<td>4</td>
</tr>
<tr>
<td>DVD Player</td>
<td>3</td>
</tr>
<tr>
<td>Washing Machine</td>
<td>2</td>
</tr>
<tr>
<td>iPod</td>
<td>1</td>
</tr>
<tr>
<td>Home Theatre PC</td>
<td>1</td>
</tr>
<tr>
<td>Computer</td>
<td>1</td>
</tr>
<tr>
<td>DVD Recorder</td>
<td>1</td>
</tr>
</tbody>
</table>

6.2.4 Procedure

The overall structure of Field Experiment 1 is displayed in Figure 6.1. The researcher arrived at the participant’s place of residence at the prearranged time, with all of the required equipment. The researcher introduced himself to participants, and gave them the necessary paperwork, including the informed consent form (Appendix C). Participants then had any questions answered and signed the consent form. Once they were ready to begin, the researcher started the MP3 Recorder and started to run through the Questionnaire. Once the Questionnaire was finished, the researcher asked participants to choose a product that they felt they were familiar with. If participants were unsure what to choose, suggestions were made based on their responses to the Questionnaire. Once the participant had chosen a product, the researcher administered the Semi-structured Interview. After the interview, the researcher asked participants what tasks they felt they were familiar with when using their selected product. Once the participant had selected a task, the Task Recall was performed. Participants were given the following request: “Without looking at the product, tell me how you do that task”. Participants delivered the procedure as they recalled it. The next step was to conduct the Observation of the task execution.

The researcher instructed participants on how to deliver Concurrent Protocol, and an example was given. Participants fetched the selected product, or the participant, researcher, and the necessary equipment moved to the product. This occurred mainly with larger products such as TVs and microwaves. The video camera was positioned in such a way that the selected product controls and the participants’ hands could be viewed. The video camera was started, participants were reminded to deliver Concurrent Protocol, and then instructed to start the task.

Once the task was completed, the video camera was stopped. The video was imported onto a laptop computer and converted into the appropriate format for the Retrospective Protocol. The video file was loaded into a media player, and the sound was muted. The video camera was set up, focusing on the screen of the laptop computer. Participants were instructed to: “Describe what you were doing”. The video camera (recording) was started, and the video was played on the laptop. Participants were instructed to start describing what they were doing. When participants finished delivering the Retrospective Protocol, the video camera was stopped. Participants
were informed the study was complete and thanked for their time. The equipment was packed away and the researcher left the residence.

6.2.5 Participants
A total of 32 participants were recruited for this experiment. The only requirement for participation was that they were living independently. Four age groups were utilised: 18 – 44, 45 – 59, 60 – 74, and 75+. The age groups were balanced for gender, with four male and four female participants in each age group. Section 4.2 discusses some of the factors that define ‘older adults’, and suggests that age is an inappropriate measure of capabilities. However, age is used as a measure here to compare familiarity with, and prior knowledge of, products as these are very likely to differ with age. While these factors differ among individuals also, Docampo Rama (2001) shows that older adults born within the same technology generation have similar usage characteristics.

6.3 Analysis
This section will describe how the data collected during Field Experiment 1 was analysed. The analysis techniques used for each part of the experiment will be introduced and the coding scheme will be introduced and explained. Table 6.2 explains the dependent variables used in Field Experiment 1.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-structured interview score</td>
<td>A score constructed from answers to the Semi-structured Interview (Appendix B)</td>
</tr>
<tr>
<td>Percentage of total steps coded as grouped</td>
<td>The percentage of total steps executed during the Observation that were described as a grouping during the Task Recall</td>
</tr>
<tr>
<td>Percentage of total time in procedure</td>
<td>The percentage of overall time that the participant spent executing procedures (Section 6.3.4)</td>
</tr>
<tr>
<td>Percentage of steps in procedure coded as grouped</td>
<td>The percentage of steps executed in procedure during the Observation that were described as a grouping during the Task Recall</td>
</tr>
<tr>
<td>Percentage of total steps occurring in procedure</td>
<td>The percentage of total steps that were executed within procedures during the Observation</td>
</tr>
<tr>
<td>Percentage of groupings occurring within procedure</td>
<td>The percentage of total steps coded as grouped (Section 6.3.4) that were executed in procedure</td>
</tr>
</tbody>
</table>

One rater coded Field Experiment 1. To enhance reliability, there were two two-week breaks during coding. All 32 participants were coded. A two-week break from coding was taken, and then the first eight participants coded were recoded. Every participant was then double checked after a further two-week break, to ensure that the coding scheme had been correctly applied. This method was derived from the method used by Blackler (2008b) to ensure reliability.

6.3.1 Questionnaire
The data from the Questionnaire was examined in two ways. First the data relating to importance of product was compared to frequency of use. Each product was compared and this data was collated. The results were not based on age or any other
measure. The second way the data was used was to compare the length of product ownership by age group.

6.3.2 Semi-structured Interview
The data collected from the Semi-structured Interview was quantified and compared. The characteristics of the comments resulting from Questions 2 and 3 (Appendix B) were coded using the schema outlined in Table 6.3. The characteristics were derived from reviewing all answers to Questions 2 and 3. For example, one participant mentioned “Its ease, [pause] its convenience” as two positives aspect of his Blackberry. This comment was specified as relating to usability and convenience. When asked what she didn’t like about her DVD player, another participant commented that she “didn’t know how to use it properly”. This was specified as a comment relating to usability. Whether the comment was positive or negative was disregarded, as the focus was on the characteristic the participant was commenting on.

An overall score was created from the relevant interview answers from the Semi-structured Interview. All questions, with the exception of Questions 2 and 3, were converted to a score (Appendix B). Questions 2 and 3 could not be appropriately scored, as they were open-ended and resulted in a broad cross section of answers. Scores were totalled for each participant, and were used in an ANOVA to compare groups. Each question was scored out of a maximum of 3 or 4, with higher scores relating to higher levels of familiarity. (Refer to Appendix B to view the questions, the categorisation of answers, and details of how the score was constructed.)

6.3.3 Coding
A relational coding scheme was used to code the relationship between the described behaviour in the Task Recall and the actual verbalised and reported behaviour seen during the task execution (Figure 6.1).

![Figure 6.2: Coding: The methods, resulting behaviour, and analysis](image)

Table 6.3 shows the codes used in the analysis of the observational data. It shows the name of the code, a brief explanation of what the code is, and some brief interpretation parameters. The accuracy class is a behaviour class, and correctness and familiarity classes are both modifier classes that apply to the accuracy class. In other words, every time any code from the accuracy class was used, a correctness and familiarity code were also applied.

Each step performed by a participant during the Observation was coded. Steps constituted any action the participant made that involved the product they interacted
with, such as picking up a remote, or entering a time on a microwave. Data input, such as entering a phone number or time in a microwave, was coded as a single step, rather than multiple steps. Each observed step was coded for accuracy against what the participant had described during the Task Recall. There were five codes within the accuracy behaviour class: accurate description, inaccurate description, not described, grouping, and failure to execute (Table 6.3). The cells with white backgrounds are behaviour codes, and the cells with grey backgrounds are modifier codes.

The grouping code was used when the step performed was described in a manner that included multiple steps in a single description. The grouping code is a particularly important code to understand. It can be thought of as a verbalised chunk or representation (Section 3.4). It was used when a participant described multiple separate tasks with a higher order description. For example, changing gears (in a manual car) is a higher order description of the process of depressing the clutch, taking the car out of gear, putting the car into the new gear, and then releasing the clutch and applying the accelerator simultaneously.

Table 6.3: Coding Scheme

<table>
<thead>
<tr>
<th>Category/Code</th>
<th>Explanatory statement</th>
<th>Heuristic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accurate description</td>
<td>The specific step was described correctly beforehand</td>
<td>The specific step was described accurately and precisely</td>
</tr>
<tr>
<td>Inaccurate description</td>
<td>The specific step is described incorrectly beforehand</td>
<td>The specific step was described beforehand, but was not described correctly</td>
</tr>
<tr>
<td>Not described</td>
<td>The specific step was not described beforehand</td>
<td>No mention of the step during described</td>
</tr>
<tr>
<td>Grouping</td>
<td>The step was described in a manner that groups multiple steps together</td>
<td>Generalisations, including multiple actions in one sentence</td>
</tr>
<tr>
<td>Failure to execute</td>
<td>Step was described but not performed</td>
<td>Step is described beforehand, but the participant does not perform it during the interaction</td>
</tr>
<tr>
<td><strong>Procedure identification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure</td>
<td>Identifying groupings of steps</td>
<td>Consecutive ‘very familiar’ steps with no interaction break</td>
</tr>
<tr>
<td><strong>Correctness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct</td>
<td>The step is correct for the activity</td>
<td>The step takes the participant closer to the required outcome</td>
</tr>
<tr>
<td>Incorrect</td>
<td>The step is incorrect for the activity</td>
<td>The step takes the participant further away from the required outcome</td>
</tr>
<tr>
<td>Inappropriate</td>
<td>The step is inappropriate for the activity</td>
<td>The step is not performed at the right time</td>
</tr>
<tr>
<td><strong>Familiarity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very familiar</td>
<td>The step is very familiar to the participant</td>
<td>Highly process-based interaction. Fast, shows little reasoning</td>
</tr>
<tr>
<td>Familiar</td>
<td>The step is moderately familiar to the participant</td>
<td>Some certainty. Has some knowledge of process</td>
</tr>
<tr>
<td>Not familiar</td>
<td>The step is not familiar to the participant</td>
<td>Uncertain, slow interaction. Knowledge of facts, rather than processes. Error prone</td>
</tr>
</tbody>
</table>

Procedures were instances of exceptional performance. As with the grouping code, the procedure shows the use of represented knowledge, but through action rather than verbalisation. Procedures were state codes—which measure a period of time rather than
a single behaviour—rather than behaviour codes and consisted of at least two steps. State procedures were coded separately to any other codes. Thus, any steps in a procedure were coded for familiarity and any other relevant elements and then the procedure was coded, capturing the duration of the interaction. The code was started at the start of the first step in the procedure, and was ended after the final step. For a series of actions to be coded as a procedure, all steps had to be first coded as very familiar. There had to be a smoothness to the interaction, with a maximum of two seconds between interaction steps, following Gobet and Simon’s (1998) confirmation of Chase and Simon’s (1973) two second chunk boundary. A procedure is coded when two or more consecutive steps of the interaction demonstrate most of the characteristics from Section 5.4.1.

6.3.4 Verbal Data

The participants performed Concurrent Protocol while they were actively engaging with the devices to complete a task. They also delivered Retrospective Protocol while watching the video recording of the Observation they performed. The video was muted during the Retrospective Protocol. The primary difference between the two contexts is the level of engagement with delivering protocol. During the Observation, attention was split between delivering protocol and performing the selected task. During the Retrospective Protocol, delivering protocol was the only task.

Both the Concurrent Protocol and the Retrospective Protocol were coded in relation to the prior description of the task. This compared what the participants said they would do (Task Recall) with what they said they were doing (Concurrent Protocol) or said they did (Retrospective Protocol). If the participant did not verbalise a particular part of the task execution, then it was not possible to analyse this part.

Concurrent protocol was a secondary task to all participants. The primary task was what the participant was doing with their product. Thus, if difficulties were met when using a product, additional resources from working memory were allocated to the primary task. If the participant was struggling enough with the primary task, the resources that had been allocated to the secondary task (delivering concurrent protocol) were reallocated to solving the problems involved in the primary task. In other words, if participants were struggling, they would instinctively stop delivery concurrent protocol and focus on the primary task, and would not be aware they had done so. This occurred with both young and old participants. Therefore the concurrent protocol was used to evaluate familiarity, and was used in combination with other behaviours to identify familiarity.

The Concurrent Protocol was separated from the Observation as it was hypothesised that the Concurrent Protocol might reveal some characteristics of familiarity in relation to verbalisation. This enabled easy comparison of the Concurrent Protocol with other verbal data. The audio tracks were removed from the audiovisual data and transcribed verbatim. The transcriptions were then uploaded into Atlas.ti 5.0 (2010) and a coding scheme was applied to the data. The coding scheme was identical to the scheme used to code the observational data (Table 6.4), with the exception of the modifier classes, correctness and familiarity. These codes were left out of the coding scheme applied to the verbal data, as correctness and familiarity cannot be adequately gauged by verbalisation alone. Additional cues from the visual data are required for these codes. Correctness requires the context of the action, and familiarity requires the
subtleties outlined in the heuristics in Section 5.6.2. Both correctness and familiarity have already been measured and coded in the analysis of the audiovisual data.

Data was coded for accuracy using the accurate description, inaccurate description, incorrect description, groupings, and no description codes. Due to an extremely low occurrence level of the inaccurate description and incorrect description codes across all methods, they were removed from the analysis. The codes were considered as a percentage of the total number of occurrences coded for each participant.

If a participant verbalised a step during the Observation, and had also described it as a single step beforehand, it was coded as accurate description. For example, a participant described a step as “cycle through until cold is selected in water temperature”. During the interaction, the participant verbalised the step as “scroll down here for cold”. As the step they verbalised matched the step described beforehand, it was coded as an accurate description. A grouping is very similar to this, except that in the prior description, the participant described a collection of steps together as a single event. An example of this is where a participant described a step as “Then I just navigate to the video section”. The described action contains multiple steps, including actually navigating to the appropriate place, and using a button to select the desired menu item.

The analysis of the verbal data investigated participants’ ability to verbalise about a task in three different contexts: before performing the task, while executing the task, and while watching a video of the task after they have performed it. The differences in verbalisation in these three contexts demonstrated how familiar an individual was with various parts of the interaction. It did this by highlighting how they represented the knowledge involved in the process.

6.4 Results
The results from each method will be discussed in the same order as they were performed during the experiment. The results from the Questionnaire will be discussed first, followed by the results from the Semi-structured Interview. The data extracted from the familiar task execution will then be discussed. This includes measures of familiarity from both the Observation and Task Recall comparison, and then the Retrospective Protocol and Task Recall comparison.

ANOVA’s were used to compare age groups for each dependant variable. The data used in the ANOVA’s are displayed using box plots. The ‘whiskers’ coming out of the box display the minimum and maximum values. The lower and upper edges of the box display the lower and upper quartiles respectively. The horizontal line running through the box displays the median value. The inaccurate description code had a low occurrence rate, and thus was discarded from the analysis. Correlations were used to investigate the relationships between variables. The range of products used for the interview and task execution are illustrated in Table 6.1, which shows the most common products used were mobile phones, microwaves and televisions. Combined, these products account for 59% of all products that the participants selected.

Table 6.4 shows the distribution of the products (shown in Table 6.1) amongst the age groups. The two youngest age groups have the greatest variance in the products they selected. This variance declines over the two oldest age groups. The younger age
groups chose more products with deeper interfaces, such as mobile phones and computers. The oldest age group chose products with shallow interfaces, such as microwaves and televisions. Thus, the oldest age group seems to use products that are older, while the younger age groups are adopting newer technology.

Table 6.4 Range of products selected by age group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Product</th>
<th>Number of times selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>18-44</td>
<td>Mobile Phone</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>iPod</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Washing Machine</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Stereo</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Home Theatre PC</td>
<td>1</td>
</tr>
<tr>
<td>45-59</td>
<td>Microwave</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Computer</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>DVD Player</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Washing Machine</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>TV</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Video Recorder</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Mobile Phone</td>
<td>1</td>
</tr>
<tr>
<td>60-74</td>
<td>Mobile Phone</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>TV</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>DVD Recorder</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Stereo</td>
<td>1</td>
</tr>
<tr>
<td>75+</td>
<td>TV</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Stereo</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>DVD Player</td>
<td>1</td>
</tr>
</tbody>
</table>

The effect of gender on the variables was assessed via t tests. The t tests revealed that gender had a significant effect on percentage of inaccurate description overall, \( t(30) = -2.877, p < .01 \). It is suspected that this is the result of a very low occurrence level of the inaccurate description code. Gender also had a significant effect on the percentage of inaccurate descriptions within procedure, \( t(26) = -2.479, p < .05 \). The t tests also revealed that gender had a significant effect on the percentage of no description codes, \( t(30) = 2.436, p < .05 \). Women had significantly higher occurrence of inaccurate descriptions than men. This is contrary to the literature, which suggests that women outperform men on episodic memory retrieval tasks, especially when verbalising (Lewin, Wolgers, & Herlitz, 2001; Nyberg, Habib, & Herlitz, 2000). Men have a higher occurrence of the no description code; this conforms to the findings of Lewin et al. (2001) and Nyberg et al. (2000).

An ANOVA revealed significant differences between education levels for the percentage of total steps in procedure code, \( F(2,28) = 5.421, p < .01 \) \( (E^2 = .28, \text{power} = .80) \). The effect size of this is low, so this result may not be relevant. Tukey post hoc tests revealed significant differences between those who had an undergraduate qualification and those who only had school education \( (p < .01) \), yet there were no significant differences between those with post-graduate qualifications, and those with school education \( (p > .05) \). This may be because 90% of those who had school as their highest level of education were over 60, and 79% of those who had
undergraduate as their highest level of education were under 60. There are significant differences between the 18 – 45 age group and the 60 – 74 and between the 18 – 44 age group and the 75+ age groups for the same variable (Section 6.4.3). No other significant differences were observed in other variables (p < .05).

Groupings were used where verbalisation was about a process. Much literature from expertise supports the idea of changes in verbalisations with increase in levels of domain knowledge (e.g., Chi, 2006). Groupings showed no correlation with level of education in the correlations that were conducted, p < .05.

6.4.1 Questionnaire
The results discussed in this section address all products examined using the Questionnaire. The frequency of use was compared to the importance rating given by the participant. The general trend, as could be expected, is that the more important a product is to an individual, the more frequently it is used. It could also imply that the more frequently a product is used, the more important it is. The least important products were also used least frequently. This data is displayed in Appendix D, Figure 1. ‘Most important’ was scored as a 5, and was described as “can’t live without it”. ‘Least important’ was scored as a 1, and was described as “could throw it out”.

Upon examination of the data related to length of ownership, some predictable patterns emerged. It is important to note that length of ownership refers to how long the participant has owned the product, not how old the product is. Thus, someone could state that they have owned a product for less than a year, yet the product could actually be ten years old. Figure 2 (Appendix D) shows the breakdown of length of product ownership across the four age groups.

The youngest age group had newer products overall. Of all products owned, 27% had been owned for less than a year and 97% had been owned for six years or less. The newest products were generally rated as being more important. This age group possessed fewer products that were rated with an importance of 1 or 2 than all other age groups, except the 75+ age group. The longest time a product had been owned was eight years. There were no remarkable differences among the other three age groups, and there is no obvious linear pattern related to age.

The results from the Questionnaire show that important products are used more often, and less important products are used less often; or that products that are used more are more important than products that are not used as much. The youngest age group owns newer products than the other three age groups. There does not appear to be a relationship between age and length of product ownership.

6.4.2 Semi-Structured Interview
A score was created for each of the participants based on their answers to the interview questions (For more detail, see Section 6.3.2). An ANOVA was conducted and Levene’s test demonstrated significant differences in variance, F(3,29) = 3.162, p < .05, among age groups for the Semi-structured Interview score. A strict alpha level of .025 was adopted following Keppel and Wickens’ (2004) recommendation. An ANOVA found a significant variation between scores across the four age groups, F(3,29) = 4.973, p < .01 (r² = .35, power = .87). The Tukey post hoc tests showed a significant difference between the 18 – 44 age group and the 60 – 75 age group (p <
and between the 18 – 44 age group and the 75+ age group ($p < .05$). There were no significant differences among the three oldest age groups. These results can be seen in Figure 6.3.

![Figure 6.3: Semi-structured Interview Score, by Age Group](image)

Younger people used their products to do more things. On average, an individual in the 18 – 44 age group did 4.25 different activities. The 45 – 59 age group used their product for 3.75 different activities. The 60 – 74 age group used their products for 2.75 different activities and the 75+ age group only used theirs for 2.5 different activities. This data is demonstrated in Figure 3 of Appendix D.

Of the participants in the 18 – 44 age group, 38% reported difficulties with the product they selected. The 45 – 59 age group had the most difficulty with their products, with 75% of group members reporting some difficulty with the product they had selected. The 60 – 74 age group had 50% of its group members reporting difficulties. The 75+ group reported the least difficulty out of all of the age groups, with only 12% reporting difficulties.

The youngest age group drew comparisons to products within a brand as being similar, and commented on specific products and product categories that reminded them of their product. The other age groups only drew comparisons with product categories. Furthermore, as age increased the ability to draw comparisons with other products decreased. The youngest age group responded with the most responses (ten) when asked if there was anything else they would like the technology to be able to assist them with. The 45 – 59 age group had a total of four responses from its participants. Both the 60 – 74 and 75+ age group had three responses to the question.

The Semi-structured Interview score, constructed from the answers given by participants (Appendix B), demonstrated significant differences between the youngest age group and the other three age groups. The 18 – 44 age groups used their products for more activities, could relate their product to other products better than older adults.
could, and could also see more ways that technology could assist them than older adults. This suggests that there are differences between the youngest and older adults, and these differences could be the result of product familiarity.

6.4.3 Task Recall and Observation
By examining the coded observational data, it was possible to identify the differences in familiarity across the selected age groups. It is important to note that time is not a relevant variable for this experiment. Participants chose a product that was specifically relevant to them, and performed a task that was also specifically relevant to them. Thus a comparison of time among individuals or age groups is inappropriate. This experiment was designed to investigate the differences in how people remember, execute, and reflect upon a familiar task, in order to identify prior knowledge.

The percentage of total steps coded as grouped (Figure 6.4) was compared across age groups using an ANOVA. Levene’s test demonstrated significant differences in variance, $F(3,29) = 4.3069, p < .05$, among age groups. Again, a strict alpha level of .025 was adopted following Keppel and Wickens’ (2004) recommendation. The ANOVA revealed significant variation among the age groups, $F(3,29) = 5.139, p < .01$ ($E^2 = .36$, power = .88). Tukey post hoc tests revealed significant differences between the 18–44 age group and the 60–74 age group ($p < .05$), and between the 18–44 age group and the 75+ age group ($p < .05$). There are no significant differences between the three oldest age groups. This suggests that younger adults use groupings to describe their familiar task more than the two oldest age groups. The three oldest age groups used groupings in similar ways when describing the familiar task. Surprisingly, there were no significant differences among age groups for total percentage of executed steps as accurate descriptions, total percentage of executed steps as inaccurate descriptions, and total percentage of executed steps as no descriptions.

![Figure 6.4: Percentage of Total Steps Grouped, by Age Group](image)

The percentage of total time in procedure (Figure 6.5) was examined across the four age groups. An ANOVA showed there were significant differences among the age groups, $F(3,29) = 8.468, p < .01$ ($E^2 = .48$, power = .99). Tukey post hoc tests revealed significant differences between the 18–44 age group and the 45–59 age group ($p < .05$), and between the 18–44 age group and the 75+ age group ($p < .05$).
between the 18–44 age group and the 60–74 age group ($p < .01$), and between the 18–44 age group and the 75+ age group ($p < .01$). The 45–59 age group also showed significant differences from the 75+ group ($p < .05$). This shows that younger people spend significantly more time proportionally in fluid, effective interaction than all other age groups.

The percentage of total steps in procedures that were coded as grouped steps is shown in Figure 6.6. In other words, this displays the percentage of steps that occur within procedures that were described beforehand as ‘a grouping’. An ANOVA showed significant differences among age groups for the percentage of steps in procedure coded as grouped $F(3,29) = 3.196, p > .05$ ($E^2 = .285$, power = .663). A post hoc Pairwise comparison showed significant differences between the 18–44 age group and the 60–74 age group ($p < .05$) and between the 18–44 age group and the 75+ age group ($p < .05$). There were no significant differences among the three older age groups. Younger people perform significantly more of the steps they described as groupings as procedures than older adults. This suggests that younger adults may be more likely to convert high levels of familiarity demonstrated through verbalisation to high levels of familiarity demonstrated through product interaction.
There were also significant differences in the percentage of total steps (Figure 6.7) that occur within procedures among the four age groups, $F(3,29) = 5.584, p < .01 \ (E^2 = .37, \ power = .91)$. Tukey post hoc tests show significant differences between the 18 – 44 age group, the 60 – 75 age group ($p < .05$) and the 75+ age group ($p < .05$). The 45 – 59 age group was also significantly different from the 60 – 74 age group ($p < .05$). There were no significant differences between the two older age groups, or between the 18 – 44 and the 45 – 59 age groups. Younger people executed significantly more steps in procedure than older adults, suggesting that younger people have a faster, smoother interaction than older people.

![Figure 6.7: Percentage of Total Steps That Occur in Procedure, by Age Group](image)

The percentage of grouped steps from the Task Recall that actually occurred in procedures was examined (Figure 6.8). An ANOVA revealed that there were significant differences among age groups, $F(3,23) = 6.265, p < .01 \ (E^2 = .45, \ power = .93)$. Tukey post hoc tests revealed significant differences between the 18 – 44 age group and the 60 – 74 age group ($p < .01$), and between the 18 – 44 age group and the 75+ age group ($p < .01$). There were no significant difference between the 18 – 44 age group and the 45 – 59 age group. There were also no significant relationships among the three older age groups. Younger people execute grouped steps as procedures significantly more than older adults. This suggests that there are differences between the younger and older age groups, and that the Task Recall may be suitable for identifying familiarity with younger adults, but not with older adults.
Correlations were used to investigate the relationships between variables other than age group. There were significant correlations between procedures and groupings. Percentage of time in procedure had a very significant positive correlation with percentage of total steps grouped, \( r(\text{df} = 32) = .645, p < .001 \). Percentage of total steps in procedure also had a very significant positive correlation with \% of total steps grouped, \( r(\text{df} = 32) = .624, p < .001 \). There was also a very strong and very significant positive correlation between percentage of total steps grouped and percentage of grouped steps that occur in procedures, \( r(\text{df} = 28) = .949, p < .001 \). This shows that almost all grouped steps occur within procedures and that there is a strong link between groupings and procedures.

There was a significant negative relationship between accurate descriptions and percentage of time in procedure, \( r(\text{df} = 32) = -.413, p < .05 \), and accurate descriptions and percentage of total steps in procedure, \( r(\text{df} = 32) = -.465, p < .01 \). There were also significant negative correlations between accurate descriptions and the percentage of groupings overall, \( r(\text{df} = 32) = -.714, p < .001 \), and percentage of groupings in procedure, \( r(\text{df} = 32) = -.681, p < .001 \). There was also a negative correlation between accurate descriptions and percentage of time in procedure, \( r(\text{df} = 32) = -.413, p < 0.05 \). This suggests that high levels of accurate descriptions relate to a lower level of familiarity, given that both procedures and groupings demonstrate familiarity.

The data shows a significant difference between the 18 - 44 age group and the 60 – 74 and between the 18 – 44 age group and the 75+ age groups across multiple variables. There are no significant differences between the 18 – 44 age group and the 45 – 59 age group across those same variables. There is only one significant difference among the three older age groups across all of the variables, and between the 45 – 59 age group and the 60 – 74 age group for the percentage of total steps in the procedure variable. The accurate description code has several strong correlations that will be discussed later.
6.4.4 Verbal Data
The data from the Concurrent Protocol and from the Retrospective Protocol were analysed using ANOVAs. All six ANOVAs found no significant differences among age groups for the accurate description, grouping and no description codes for both the Concurrent Protocol and the Retrospective Protocol (Table 6.5).

Table 6.5 ANOVA Results for Retrospective and Concurrent Protocol

<table>
<thead>
<tr>
<th>Code</th>
<th>ANOVA results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F(3,29) =$</td>
</tr>
<tr>
<td>Retrospective accurate</td>
<td>.069</td>
</tr>
<tr>
<td>Retrospective grouped</td>
<td>1.364</td>
</tr>
<tr>
<td>Retrospective no description</td>
<td>.923</td>
</tr>
<tr>
<td>Concurrent accurate</td>
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<tr>
<td>Concurrent grouped</td>
<td>.434</td>
</tr>
<tr>
<td>Concurrent no description</td>
<td>1.515</td>
</tr>
</tbody>
</table>

6.5 Discussion
The results of Field Experiment 1 will be discussed and compared with the existing research reviewed in the previous chapters of this thesis. Four areas will be focused on, the differences between younger and older adults, the accurate description code, groupings and procedures and the results from the different methods.

6.5.1 Differences between Younger and Older Adults
The strongest findings of this study were the differences across many variables between the 18 – 44 age group and the 60 – 74 age group, and also between 18 – 44 age group and 75+ age group. Across all of the measures that demonstrate familiarity (the Semi-structured Interview score, total percentage of steps coded as grouped, percentage of total time spend in procedure, percentage of grouped steps in procedure), ANOVAs showed significant differences between the 18 – 44 age group and the two oldest age groups. The three oldest age groups showed no significant differences across the same variables, with one exception. The 45 – 59 age group performed significantly more steps in procedure than the 60 – 74 age group. There were no significant differences between the 18 – 44 age group and the 45 – 59 age group.

This suggests that the youngest age group was much more familiar with the products they selected than the two oldest age groups were. O’Brien (2010, p. 150) found that younger adults “achieved the highest level of success” across all products tested when compared with older adults. O’Brien states that those with higher self-reported prior knowledge also performed better. However, O’Brien did not use an age group that is comparable to the 45 – 59 age group used in this study (O’Brien, 2010). The results from the current study suggest that the 45 – 59 age group has a level of familiarity that is somewhere between the high familiarity of the 18 – 44 age group, and the low familiarity of the 60 – 74 and 75+ age groups.

Kang and Yoon (2008) found that 46 – 59 year olds made significantly more errors, and required significantly more interaction steps with a Portable Media Player and an MP3 player than 20 – 29 year olds. Their findings suggest that age, rather than prior
knowledge, is the reason for these differences. This could be as a result of using a self-reporting measure of prior knowledge rather than measuring it objectively. This current research did not specifically examine number of steps, as participants used a variety of products in this study. Errors were also not focused upon. Kang and Yoon’s (2008) findings would suggest that error and number of interaction steps could be related to ageing. Hawthorn (2000) states that the effects of ageing start to appear from about 45 onwards, suggesting that the middle aged group used by Kang and Yoon (2008) may be affected by some age-related declines.

The results of Field Experiment 1 are similar to previous findings obtained when comparing familiarity across adults of all ages (Blackler, 2008b). Blackler’s (2008b) 3rd experiment also found significant differences among three age groups for intuitive uses. The age groups were 18 – 29, 30 – 39 and 40+. Across multiple variables, the 40+ age group was significantly different from either one, or both, of the younger age groups. There were no significant differences between the two youngest age groups across all variables. The relationships among the age groups in Blackler’s (2008b) third study are similar to those seen in the results of this study. Therefore, the existing research supports the findings of this current study. However, none of the studies reviewed conducted a comparison of prior knowledge across a cross section of adults over the age of 18.

Docampo Rama (2001) and her colleagues (Docampo Rama et al., 2001) conducted research into technology generations (Section 4.6). Docampo Rama et al. (2001) describe the effect of generation as a discontinuous effect, while the effect of age is continuous, or linear. The results of this current experiment demonstrate a discontinuous effect over multiple variables. This suggests that the differences in performance are a result of prior knowledge with products. Docampo Rama’s (2001) also found no significant differences between the three older age groups when generational effects were present.

6.5.2 Accurate Description
The accurate description variable had significant correlations with elements that were associated with familiarity. Both percentage of time in procedure and percentage of total steps in procedure had significant negative correlations with the accurate description code. Also, percentage of total steps as groupings, and percentage of groupings within procedures had very significant negative correlations. This suggests that accurate descriptions are a signifier of lower levels of familiarity, as both procedures and groupings suggest higher levels of familiarity. This also fits with the skill acquisition model (Anderson, 1995). As a skill moves from the cognitive stage to the associative stage, and then on to the autonomous stage, the level of verbalisation in protocol decreases. This may mean that as the skill level increases, the verbalisation of the skill is less likely to be coded as an accurate description, and more likely as a grouping, as the corresponding knowledge representation evolves. Accurate descriptions are likely to reflect lower order knowledge representations, that have not yet had additional information encoded as a result of experience (Feltovich et al., 2006).

6.5.3 Groupings and Procedures
Groupings are the integration of a series of steps (which would be executed during a task) into a single description during Task Recall. For example, a participant
described the process of entering all of a new contact’s data into his mobile phone as ‘Input’. The participant condensed the six consecutive steps he executed when performing the task into a single word description. It is suggested that this grouping occurs with a high level of familiarity. Participants know the process so well that, in their minds, the series of steps required to execute that part of the task is only a single action. This is similar to the ‘Automated’ stage of Anderson’s (1995) skill acquisition model. Such knowledge representations are considered to be a characteristic of an expert, and Ericsson and Towne (2010) describe such representations as being primary mediators of expert performance. There were significant differences between the youngest age group and the two oldest age groups for percentage of total steps grouped, suggesting high levels of knowledge and familiarity for the youngest age group.

Procedures are the integration of a series of disparate steps executed during a task into a single fluid action. Some signs of a procedure displayed by the participant can include: no hesitation when starting a procedure, no or very little verbalisation during the procedure, brief verbalisation once the procedure is complete, fluid or flowing movements, and no pauses in between individual task steps. It is suggested that a procedure is a demonstration of familiarity, as procedures exhibit many of the characteristics of intuitive interaction that Blackler (2008b) discusses. As discussed earlier (Section 2.2), familiarity is an important aspect of intuitive interaction. Participants also demonstrate many or all of the heuristics for the very familiar code (Section 5.6.2). There were significant differences between the youngest age group and the oldest two age groups for percentage of total steps in procedure. The 45 – 59 age group was also significantly different from the 60 – 74 age group.

There is a very strong link between groupings and procedures. There are significant relationships between total percentage of groupings and both percentage of time in procedure, and percentage of total steps in procedure. Also, there is a very strong and very significant relationship between percentage of total groupings and percentage of groupings that occur within procedures. This suggests that both of these measures are potentially grounded in prior knowledge. It is considered that both groupings and procedures utilise prior knowledge. The grouping was captured before the interaction took place, and the procedure was captured during the interaction. There are significant differences in the percentage of groupings that then occurred within procedures among age groups.

Younger adults performed significantly more grouped steps in procedure than older adults. This may mean that groupings could be a signifier of familiarity for younger adults but are not a reliable measure for older adults. This suggests that identifying groupings using the Task Recall method could be used to identify familiarity and prior knowledge, but it should only be used with younger adults.

6.5.4 Methods
The results from the Semi-structured Interview demonstrate significant differences among age groups. There were significant differences for the interview score between the 18 – 44 age group and the 60 – 74 and between the 18 – 44 age group and the 75+ age groups. There were no significant differences among the three older age groups. This reflects the differences between age groups found in procedures and groupings. It is suggested that these results were achieved as the interview focused on probing
knowledge sources, rather than surveying participants directly. O’Brien et al. (2010) suggest probing knowledge may be a more accurate way of measuring prior knowledge. The results suggest that the Semi-structured Interview could be a suitable method to identify familiarity.

The Task Recall was analysed in conjunction with the Observation. The Observation captures close-to-normal behaviour, as it was set in a familiar environment with a familiar product and a familiar task. Correlations were used to compare variables, and ANOVAs were used to investigate the differences in age groups across variables. The results show significant correlations between the grouping code, which was grounded in the primed Task Recall, and the procedure code, which was grounded in the Observation. The ANOVAs also show very similar results. When investigating further, it was found that younger adults convert significantly more grouped steps into procedure than older adults. Older adults tended not to convert grouped steps into procedures. These results would suggest that together the Task Recall and the Observation elicit familiarity and prior knowledge in a consistent way, but for younger adults only. The results from the comparison of the Concurrent and Retrospective Protocols suggest that the Retrospective Protocol is not useful in identifying familiarity.

6.6 Summary

This chapter explained the objectives of Field Experiment 1, in the form of the two research sub questions and the specific methods used to meet those objectives. Details of the experiment design were outlined, and the procedure was explained. The methods of analysis for each methodology were outlined, and the coding scheme used for this research was explained.

There are a number of important results from this study. They relate back to the research sub questions, discussed at the beginning of this chapter. The sub questions are:

1. How familiar are older adults with contemporary products, and how does this differ from the familiarity of younger adults?

2. How can designers readily identify what interaction processes older adults are familiar with?

This research shows that older adults have a significantly different relationship to familiar contemporary products, than younger adults, thus addressing sub research question 1. The findings suggest that this is primarily a result of a much higher level of knowledge of contemporary products among younger adults. It is suggested that this knowledge is not limited to specific knowledge about products they own, but includes a more generalised knowledge about how to interact with products in general. The findings from the Semi-structured Interview support this view, with the youngest age group providing more comprehensive answers to questions relating to comparisons between products, and answering questions about the potential for expansion of functionality. The youngest age group also used their familiar products for more activities that any other age group, thus suggesting a high knowledge of product functionality.
The observational data showed that younger adults were the most familiar with their selected product and that familiarity differs considerably between the youngest and the oldest age groups. Also the differences in familiarity among the three oldest age groups are largely negligible. The results suggest that both Procedures and groupings are the result of a high level of familiarity.

The Semi-structured Interview score yielded results that are comparable with the results from the Observation. It is proposed that the Semi-structured Interview could be used to identify familiarity with products. However, the interview does not identify familiarity with specific features and processes, which is likely to be most useful for designers creating new interfaces. In effect, sub research question 2 has been answered, yet more research is needed. Observation is not considered to be a practical way for designers to identify familiarity, and it would seem that the Semi-structured Interview identifies familiarity, but only at a product level.

The next chapter will report on Experiment 2. This experiment was based on the method established here, but some changes to the methodology have been made. The major modifications revolve around the change to uniform products across the experiment, rather than to products the participants owned themselves.
Chapter 7: Experiment 2

7.1 Introduction
This chapter covers Experiment 2. The results of Field Experiment 1 demonstrate that younger adults are significantly different, in terms of variables related to familiarity, than older adults, and that the three groups of older adults are not significantly different from one another across the same variables (Section 6.5). Experiment 2 was undertaken to further investigate familiarity with contemporary products. It addressed the same research sub questions as Field Experiment 1, but had a stronger focus on the second research sub question:

1. How familiar are older adults with contemporary products, and how does this differ from the familiarity of younger adults?

2. How can designers readily identify what interaction processes older adults are familiar with?

7.1.1 Objectives
The objectives of Experiment 2 were to:

1. Confirm findings related to age and familiarity from Field Experiment 1
2. Develop a further understanding of familiarity across age groups
3. Investigate effectiveness of methods used to identify familiarity.

7.2 Methods
The methodological and theoretical foundations of this experiment have been discussed in Chapter 5. This section will present the details specific to Experiment 2. The methods used for this study will be introduced and explained, as they vary slightly from Field Experiment 1. The apparatus used will be discussed, and the procedure used for the experiment will be outlined.

7.2.1 Experiment design
Experiment 2 used a mixed methods approach that is based on the methodology used for Field Experiment 1 (Section 6.2.2). The experiment design was changed in order to cater for some changes in the methodology. The most important change between Field Experiment 1 and Experiment 2 was the products used. Field Experiment 1 saw the use of products that the participants owned. In Experiment 2 every participant used the same four products, and conducted the same four tasks. This was done to investigate familiarity from a slightly different angle, which would help develop a more thorough understanding of familiarity across age groups. It was hypothesised that this approach would give a broader view of generalised familiarity, and that lower levels of familiarity were more likely to be exhibited, as no participant had used any of the products before (even though they may have used similar models). The experiment was conducted in a laboratory environment (where possible) and in two senior citizens centres, with conditions controlled as much as possible.
7.2.2 Methods
Experiment 2 used a different combination of methods to Experiment 1. The procedure involved three distinct steps (Figure 7.1). The first step was the Primed Task Recall. The participants were given a series of tasks, and primed with the relevant product. They then delivered protocol on their interpretation of the necessary actions to complete the tasks. The second step was the Observation, which saw the participant complete the tasks with the product, while delivering Concurrent Protocol. The final step was the Retrospective Interview. This process was repeated for each product. Triangulation of methods was used to ensure validity and rigour.

Figure 7.1: Outline of Experiment 2

Primed Task Recall
The Primed Task Recall is very similar to the task recall from Field Experiment 1 (Section 6.2.2), except it was with a product that the participant did not own. Participants were primed by showing them a product for three seconds. They were then required to explain how to perform a set of tasks using the product they saw. Priming works on the assumption that items in memory are activated (or primed) when related cues are in the environment (Anderson, 1995). The findings of Chase and Simon (1973) suggest that chess masters do not find the best chess moves by searching through a range of possible moves, but by cue recognition and recall. The Primed Task Recall aimed to emulate this effect.

The aim of the Primed Task Recall was to draw out what the participant knew about the product, thus gaining insight into the level of familiarity the participant had with the task and the product. By priming participants with the product, the Primed Task Recall aimed to activate associated items in memory. The task description would then result in participants accessing the activated prior knowledge, and revealing it through verbalisation. The process of verbalising the knowledge reveals how participants structure their knowledge, and research in expertise suggests that differences in knowledge representation are what differentiate experts and non-experts. The Primed Task Recall was used before the Observation of the task execution.

Observation and Concurrent Protocol
Experiment 2 utilised the same Observation method as Field Experiment 1 (Section 6.2.2). Concurrent Protocol was integrated into the Observation to help identify underlying thought processes (Ericsson, 2006b). As in Field Experiment 1, the Observation was designed to establish a baseline measure of familiarity that the other methods were compared against. Familiarity was measured through the Observation and was based on the heuristics and coding scheme from Field Experiment 1. Unlike
Field Experiment 1, the Observation took place with a uniform set of products and tasks.

Retrospective Interview
Initially, a Retrospective Protocol, as in Field Experiment 1, was used in a pilot study. The video of the protocol was much longer than the video in Field Experiment 1, as it included four interactions with products not owned by participants. Some older adults struggled to remain engaged with the Retrospective Protocol, and found it overwhelming. It was also a very time consuming process. It was decided that the Retrospective Protocol was an unsuitable method for this experiment, and thus the Retrospective Interview was developed.

The Retrospective Interview focused on one area only to reduce the discrepancies between reported behaviour and actual behaviour that can occur with Retrospective Protocol (Ericsson, 2006b). The question was focused solely on the negative to make recall easier, as research shows that negative memories are recalled better than positive memories (Baumeister, Bratslavsky, Finkenauer, & Vohs, 2001). Skowronski and Carlston (1987, p. 696) found that “Negative behaviours were better recalled than positive behaviours … and extreme behaviours were better recalled than less extreme behaviours”. Baumeister et al.’s (2001) comprehensive review shows that negative events have a greater impact than positive events on a wide range of areas, ranging from relationships to learning. Participants are most likely to recall the most negative aspects of their experience first, following Skowronski and Carlston’s (1987) findings. It is more likely that participants will successfully and accurately recall if the focus is on negative experiences only, than if the Retrospective Interview is focused on the entire interaction. Furthermore, it is particularly important to increase ease of recall with older adults, due to the cognitive declines experienced in their memory function.

The Retrospective Interview was developed to investigate which tasks and sub-tasks the participants found difficult, and what aspects of the product they struggled with. The verbalisation also demonstrated familiarity, based on the representations of knowledge shown. The method took advantage of comments that pilot participants were naturally making after finishing the interaction, and the Retrospective Interview was designed to extract additional information. The method was used after each product Observation. It was tightly focused on one aspect and was started immediately after the Observation ceased, as recommended by Kuusela and Paul (2000). The interview question was: “What did you find difficult or challenging about that?” If participants responded with “Nothing”, then participants were asked: “Why did you find it easy to use?” Participants were allowed to speak for as long as they chose to, and this determined the length of the interview.

The Retrospective Protocol differed from the Retrospective Interview in two ways. Firstly, in the Retrospective Protocol, participants were shown a muted video of the Observation, while they described what they were doing. During the Retrospective Interview participants had to rely on memory. Secondly, the Retrospective Protocol focused on the actions that the participant took. The Retrospective Interview, on the other hand, focused only on what the participant found difficult or challenging.
7.2.3 Apparatus
There were two product categories chosen for Experiment 2: cameras and alarm clocks. Within each product category, a newer product and an older product were chosen. The newer and older camera had very similar operations, while the newer and older alarm clock had very different operations.

The two cameras used in this experiment were a new compact digital camera and an older 35 mm camera. The digital camera used was Canon PowerShot A3000 IS, and the 35mm camera was a Pentax Espio (AF Zoom 35mm – 70 mm). The digital camera used a standard SD Card, and was a typical compact digital camera (Figure 7.2). The 35mm camera had an automatic loading mechanism, and a display showing the number of photos taken and any functions that had been activated (Figure 7.3). These two cameras were chosen because the operations of the cameras to perform the specified tasks are almost identical (with the exception of loading the respective storage mediums and feedback on the screens).

Figure 7.2: Canon PowerShot Digital Camera

Figure 7.3: Pentax Espio 35 mm Camera

The two styles of alarm clock used in this experiment were a digital alarm clock, and an analogue style electric alarm clock. The digital alarm clock was an Avanti CR-01 Digital Alarm Clock Radio (Figure 7.4); the analogue style alarm clock was a Degree 30 I. Both products were selected, as they were typical examples of products of that style. The analogue style clock was a modern version, powered by battery (Figure 7.4). A calculator was used to acquaint participants with the procedures used.

Figure 7.4: Avanti Digital Alarm Clock and Degree Analogue Alarm Clock
The experiment was captured using two video cameras. One camera was in front of participants and captured the whole scene. The second camera was positioned over their right shoulder. The researcher focused this camera on the participant’s hands in order to capture the necessary detail for analysis. The Digital Video Cameras used were two Canon Legria HF21 HD cameras. They were used with tripods. One camera captured audio using a Crown Sound Grabber II PZM microphone, while the other captured audio using the built-in microphone. All aspects of the experiment were captured using this equipment.

Each product had an associated task sheet (Appendix E). All task sheets were printed on A5 paper. The product name was at the top of the page in 24-point text, and all tasks were numbered and set in 18-point text. They were positioned on the desk; face down, in the order that that particular participant would use the products.

7.2.4 Procedure
Before the participant arrived, all of the paperwork was arranged. This included, informed consent, a participant information sheet, and the researcher’s business card (Appendix F). The cameras were set up on their tripods. All of the products were checked to ensure that they were in the required neutral state, and then placed under cover. Participants were invited into the test environment. They took a seat, and read the relevant paper work. Any questions the participant had were addressed and informed consent was obtained. The next step was to introduce the participants to the process, and to give them an opportunity to learn what was required of them. This was done by running through the entire process with an unrelated product. The product chosen was a calculator, because it was a simple product and was unlikely to prime the participant for any of the products that were to be used. During the test run, each step of the experiment procedure was explained before the participant actually ran through the step. Participants were asked if they had any questions, and then the experiment was started.

First, participants were handed a task sheet with the required tasks on it and were instructed to read through the sheet. Next, participants were shown the product for approximately three seconds. Then, participants were asked to perform the task recall. They were then instructed on Concurrent Protocol, and given the product to execute the required task. Once participants had finished the task, they were asked if they “found anything challenging or difficult about using the product”. The process was repeated for each of the four products. After the Retrospective Interview of the final product, the video cameras were turned off and the participant told that the experiment was finished. They were thanked, and then left.

7.2.5 Participants
The structure used in Field Experiment 1 was used again in Experiment 2 (Section 6.2.5). Additionally, each age group was split into two smaller groups to counterbalance and control any order effects or training effects. The details of the groups can be seen in Table 7.1. Participants were recruited from a participant pool that was established through the use of university networks, social networks, and local seniors clubs (with the assistance of two local senior citizens centres). All participants had no existing relationship with the researcher.
Blackler (2008b) found no significant correlation between level of education and time to complete tasks, or between level of education and intuitive uses. However, education has been found to contribute to the rate of technology adoption of older adults so it was controlled in this research (Czaja et al., 2006; Fox, 2004). Due to the significant differences between education levels seen in Field Experiment 1, it was necessary to balance for education. The groups were also balanced for gender. Table 7.1 illustrates the breakdown of the participant groups.

<table>
<thead>
<tr>
<th>Age Group</th>
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<th>Older Products First</th>
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<tbody>
<tr>
<td></td>
<td>Gender</td>
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<tr>
<td>18 - 44</td>
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</tr>
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### 7.3 Analysis

The analysis of Experiment 2 differed slightly from the analysis of Field Experiment 1. Some of the differences in the analysis were a reflection of the differences in the design of the experiment, while some were the result of adjustments to the methodology. The most important difference was that Field Experiment 1 was based on relational coding (Section 6.3.3). Instead of coding the accuracy of the relationship between what was recalled and what was actually done, this experiment focused on coding familiarity within each method. Another important difference was that Experiment 2 used the same tasks with the same products across all participants. This allowed for different aspects of the interaction to be measured.

All of the data were captured on video, and Noldus Observer was the only software used to code the data. All data were exported to Microsoft Excel, where they were sorted, converted and analysed. Statistical analysis was conducted in SPSS. The researcher coded all participants, and a second rater was used to code 30 of the 32 participants. An inter-rater reliability analysis utilising the Kappa coefficient was performed in Noldus Observer XT to determine consistency among raters. Observer XT has a limit of twelve pairs per analysis; so three analyses of ten participants each were performed. Participants were listed alphabetically, and were formed into three groups of ten from this list.
7.3.1 Coding Scheme
This section will introduce the coding scheme used to code the data collected in this field experiment. A coding scheme based on the familiarity framework (Section 3.1.6) was applied to all methods used. Due to the differences between these methods, familiarity was interpreted slightly differently. The coding scheme and these interpretations are explained in Table 7.2. The coding scheme was applied to actions performed during the Observation. The list of actions was specified beforehand, and some actions consisted of several steps (e.g. inserting the SD card into the digital camera), while others were a single action (e.g. turning the camera on) (Appendix G).

Table 7.2 Coding Scheme and Dependent Variables for Experiment 2

<table>
<thead>
<tr>
<th>Code</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primed Task Recall</strong></td>
<td></td>
</tr>
<tr>
<td>Recalled very familiar</td>
<td>Participant is familiar with the specific actions related to utilising this concept</td>
</tr>
<tr>
<td>Recalled familiar</td>
<td>Participant is familiar with the concept required for this task. They may have a vague understanding of the actions required for this concept</td>
</tr>
<tr>
<td>Recalled not familiar</td>
<td>Participant does not demonstrate familiarity of concept with required task. This is often demonstrated as a repetition of the instruction given on the task sheet; e.g. “I turn the flash off”</td>
</tr>
<tr>
<td>Not recalled</td>
<td>The participant does not describe a particular step or has included it in the description of another step; e.g. “I insert the card into the slot in the card compartment”</td>
</tr>
<tr>
<td><strong>Observation</strong></td>
<td></td>
</tr>
<tr>
<td>Observed very familiar</td>
<td>Participant exhibits high levels of knowledge about the task</td>
</tr>
<tr>
<td>Observed familiar</td>
<td>Participant exhibits some knowledge, but is a little hesitant and is not immediately clear on what has to be done</td>
</tr>
<tr>
<td>Observed not familiar</td>
<td>Participant has very little or no knowledge about what is required to execute this task.</td>
</tr>
<tr>
<td><strong>Retrospective Interview</strong></td>
<td></td>
</tr>
<tr>
<td>Retrospective very familiar</td>
<td>Participant says there was nothing difficult. Comments regarding how easy it was, etc.</td>
</tr>
<tr>
<td>Retrospective familiar</td>
<td>Negative comments focusing on one or two parts of the interaction</td>
</tr>
<tr>
<td>Retrospective not familiar</td>
<td>Negative comments focusing on most of the interaction</td>
</tr>
</tbody>
</table>

7.3.2 Primed Task Recall
The Primed Task Recall was coded primarily for familiarity (Table 7.2). The task sheet provided a certain amount of knowledge of the process, so occasionally a participant would use the knowledge presented on the task sheet as a baseline. If a participant verbalised the process as it appeared on the task sheet, it was coded as not familiar, unless it was clear through other cues that they were familiar. While the coding of the Primed Task Recall was based primarily on what the participant verbalised, occasionally a participant would use gestures to communicate. It was necessary to take these gestures into consideration when coding the data.
The heuristics for these codes build on the familiarity heuristics outlined in Section 5.4.1. Two specific elements have been added to help identify familiarity. These elements were derived from the execution of the task recall. The two elements are: the concept of the task, and the specific actions related to the task. The concept of the task refers to the understanding the participant had of what the specified task actually implied. For example, if participants said they needed to open the compartment to insert the SD card on the digital camera, they understood the concept of the task. The specific actions related to the task refer to the physical movements, locations of the functions, or the actions required to execute the task. It was found that those who were more familiar could describe the actions required to perform the task. Those less familiar conveyed an understanding of the concept. For example, a more familiar digital camera user may say, “I slide the card compartment open and push the card in until it clicks into place”, while a less familiar user may say “I probably have to look for some sort of slot to put the card in”. Participants who were not familiar did not display any knowledge of actions or any understanding of the concept of the task.

7.3.3 Observation
The analysis of the Observation is very similar to the analysis of the Observation in Field Experiment 1. The main difference was with how the steps were coded. The observed steps were coded independently for familiarity in this experiment (Table 7.2), whereas, in Field Experiment 1, steps were coded in relation to the Task Recall. The coding scheme for the Observation is based upon familiarity and actions, as with the Primed Task Recall; however, the codes are applied slightly differently.

To code for familiarity, the Task Recall (Section 6.2.2) relied on what participants verbalised, and sometimes, on the actions and gestures that accompanied the described actions. The Observation utilised cues from the way participants executed the required task (Section 5.4.1), and also from the Concurrent Protocol they delivered.

7.3.4 Retrospective Interview
The Retrospective Interview was coded primarily for familiarity, and this was coded based on the nature of what the participant discussed. Comments that were positive in nature, such as “no, it was easy to use”, suggested higher levels of familiarity; comments that were negative in nature, such as “it wasn’t obvious how to turn the flash off”, suggested lower levels of familiarity (See Table 7.2 for an overview of the Familiarity behaviour class).

7.4 Results
As with Field Experiment 1, box plots are used to display the data (See Section 6.4 for an explanation of box plots). t tests revealed no significant differences for gender on seven variables (Appendix H). Field Experiment 1 was not controlled for education, and some significant differences were found between education levels. Experiment 2 was controlled for education, but ANOVAs revealed significant differences between education level for the variables recalled not familiar, $F(2,29) = 4.135, p < .05$ ($E^2 = .22$, power = .68), and retrospective not familiar, $F(2,29) = 3.409, p < .05$ ($E^2 = .19$, power = .60). Both ANOVAs have moderate power, and effect sizes are small, so there is the possibility of a Type II error. These differences in both
instances were between those that had School as their highest level of education, and Undergraduate as their highest level of education ($p < .05$).

A closer inspection of the distribution of the education levels across the age groups reveals that the youngest age group had the highest number of participants with undergraduate education levels and the lowest number of school education levels of any group. The other age groups all have more participants educated at a school level, and less at an undergraduate level. When considered in light of other results of this study, showing that younger adults are more familiar than older adults, the differences in the level of education could be related to age group. This suggests that level of education was not controlled strongly enough; however, it is argued that the distribution is an accurate representation of society. Controlling education levels more stringently would have also made participant recruitment extremely difficult.

A second rater coded 30 of the 32 participants in Experiment 2. The two raters were compared for inter-rater reliability using the Kappa coefficient. The inter-rater reliability analysis was conducted over three groups of ten participants. The Kappa values are $\kappa = 0.85$, ($p < .001$), $\kappa = 0.89$, ($p < .001$), $\kappa = 0.94$, ($p < .001$), for Groups 1, 2 and 3 respectively. Landis and Koch (1977) describe a Kappa coefficient of between 0.81 and 1 to demonstrate an almost perfect level of agreement between raters. These results suggest that the data obtained are reliable. These results can be seen in Table 7.3. The direct percentage of agreement for each of the three groups and the agreement across all 30 participants is also presented.

<table>
<thead>
<tr>
<th>Group</th>
<th>$\kappa$</th>
<th>$P$ value</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Participants 1 – 10</td>
<td>0.85</td>
<td>$P &lt; .001$</td>
<td>88%</td>
</tr>
<tr>
<td>2: Participants 11 – 20</td>
<td>0.89</td>
<td>$P &lt; .001$</td>
<td>92%</td>
</tr>
<tr>
<td>3: Participants 21 – 30</td>
<td>0.94</td>
<td>$P &lt; .001$</td>
<td>95%</td>
</tr>
<tr>
<td>All Participants</td>
<td>N/A</td>
<td>N/A</td>
<td>92%</td>
</tr>
</tbody>
</table>

The Very Familiar and Not Familiar variables were compared across the Primed Task Recall, Observation, and Retrospective Interview. There were no significant correlations between the Familiar codes across all methods. It is thought that this is because the Familiar code covers a large proportion of behaviours, while the Very Familiar and Not Familiar codes cover the top and bottom end of the spectrum respectively.

7.4.1 Primed Task Recall

All data collected from the Primed Task Recall were converted to a percentage of total codes in the Primed Task Recall for each participant. The youngest age group has the highest level of the recalled very familiar code, with a mean of 37%. The means for the other three age groups sat between 12.3% and 12.8%. Levene’s test shows a significant difference in variance, $F(3,29) = 6.685$, $p < .01$ A strict alpha level of .025 was adopted, following Keppel and Wicken’s (2004) recommendation. The ANOVA revealed significant variation among age groups in terms of the recalled very familiar variable, $F(3,29) = 3.825$, $p < .025$, ($E^2 = .29$, power = .76) (Figure 7.5).
Tukey post hoc tests reveal a significant difference between the 18 – 44 age group and all three older age groups \( (p < .05 \text{ for all age groups}) \). There were no significant differences among the three older age groups. This suggests that in the Primed Task Recall, younger adults demonstrate higher levels of familiarity than older adults, and that the older adults do not differ significantly from one another. This could be because younger adults learnt how to interact with these products during their formative years (Docampo Rama, 2001), giving them a deeper understanding of how to interact with them (Section 3.3.1).

![Figure 7.5: Recalled Very Familiar Code, by Age Group](image)

A one-way ANOVA showed a significant difference between age group and the recalled not familiar code, \( F(3,29) = 4.225, p < .05 (E^2 = .31, \text{ power } = .80) \) (Figure 7.6). Tukey post hoc tests demonstrated a significant difference between the 18 – 44 age group and the 45 – 59 age group \( (p < .05) \), and also between the 18 – 44 age group and the 75+ age group \( (p < .05) \). No significant difference existed between the 18 – 44 age group and the 45 – 59 age group. There were no significant differences among the three older age groups. This suggests that younger people know how to perform the tasks better than older people, as they recalled more detailed aspects of the interaction process.

![Figure 7.6: Recalled Not Familiar code, by Age Group](image)
7.4.2 Observation
The data collected from the Observation was converted to a percentage of total executed steps for each participant. An ANOVA for the observed very familiar code and Age Group showed a significant difference, \( F(3,29) = 22.496, p < .001, (E^2 = .71, \text{ power} = 1.00) \) (Figure 7.7). Tukey post hoc tests showed significant differences between the 18 – 44 age group and all other age groups (\( p < .001 \) for all groups). Furthermore, there were no significant differences among the three older age groups. However, Figure 7.7 shows that the least familiar youngest adult was approximately on par with the most familiar participants from the three oldest age groups. This demonstrates that younger adults performed tasks generally with a higher level of familiarity than older adults; however, there were some exceptions to this. The mean level of familiarity demonstrated during task execution did not vary much among the other three age groups, suggesting that an age-related effect was not present for this variable; there was a nonlinear trend associated with generational effects, not age-related effects (Docampo Rama, 2001).

Figure 7.7: Observed Very Familiar code, by Age Group

A one-way ANOVA demonstrated a significant difference between age groups in terms of the observed not familiar code, \( F(3,29) = 17.369, p < .001 \) (\( E^2 = .65, \text{ power} = 1.00 \) \( \)) (Figure 7.8). Tukey post hoc tests showed significant differences between the 18 – 44 age group and all three older age groups (\( p < .001 \) for all groups). As with the observed very familiar code, there were no significant differences among the three older age groups. This demonstrates that all three groups of older adults were demonstrating lower levels of familiarity than younger adults. As above, there were similar levels of performance among the three groups of older adults, suggesting that there was not an age-related effect, as the pattern demonstrated is nonlinear (Docampo Rama, 2001).
7.4.3 Retrospective Interview

There were significant differences among age groups for the retrospective very familiar code. Levene’s test demonstrated significant differences in variance, $F(3,29) = 3.608, p < .05$. Again, a strict alpha level of .025 was adopted following Keppel and Wicken’s (2004) recommendation. The ANOVA revealed significant variation among age groups for the retrospective very familiar code, $F(3,29) = 6.897, p < .01$ ($E^2 = .43$, power = .96), (Figure 7.9). Tukey post hoc tests showed a significant difference between the 18–44 age group and the 60–75 age group ($p < .01$) and between the 18–44 age group and the 75+ age group ($p < .01$). There was no significant difference between the 18–44 age group and the 45–59 age group. There were also no significant differences among the three older age groups. This demonstrates that, upon reflection, younger adults found the product interaction a positive experience far more often than the two oldest groups, suggesting that older adults had more difficulties with the products than the younger adults. The three older age groups showed similar levels of positivity, again suggesting that an age-related effect is not present, as the pattern is nonlinear (Docampo Rama, 2001).
An ANOVA demonstrated significant differences between age groups in terms of the retrospective not familiar code, $F(3,29) = 4.321, p < .05$, ($\eta^2 = .32$, power = .81) (Figure 7.10). Tukey post hoc tests showed a significant relationship between the 18 – 44 age group, and the 60 – 74 age group, $p < .01$. The 18 – 44 age group did not have significant differences from the 45 – 59 age group, or the 75+ age group. The three older age groups did not have any significant differences.

Figure 7.10: Retrospective Not Familiar Code, by Age Group

Overview of Familiarity Statistics

An examination of the results of the ANOVAs comparing the age groups with the different methods, contributes to an understanding of how the different methods compare. The results of the Tukey post hoc tests show no significant differences among the 45 – 59, 60 – 74 and 75+ age groups across all variables. Not all differences between the 18 – 44 age group and the other three age groups were significant, but most were. Table 7.3 illustrates these differences. Significant relationships are white, and non-significant relationships are grey.

<table>
<thead>
<tr>
<th>Method, Code</th>
<th>$p$ value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 – 44 and</td>
</tr>
<tr>
<td></td>
<td>45 – 59</td>
</tr>
<tr>
<td>Primed Task Recall, Very Familiar</td>
<td>$p &lt; .05$</td>
</tr>
<tr>
<td>Primed Task Recall, Not Familiar</td>
<td>$p &lt; .05$</td>
</tr>
<tr>
<td>Observation, Very Familiar</td>
<td>$p &lt; .01$</td>
</tr>
<tr>
<td>Observation, Not Familiar</td>
<td>$p &lt; .01$</td>
</tr>
<tr>
<td>Retrospective Interview, Very Familiar</td>
<td>$p &gt; .05$</td>
</tr>
<tr>
<td>Retrospective Interview, Not Familiar</td>
<td>$p &gt; .05$</td>
</tr>
</tbody>
</table>

7.4.4 Methodological Validation

This section will review the similarities and differences in familiarity across the three methods. The occurrence rate of each code was converted to a percentage of the total number of codes for each method. Recalled Familiarity refers to familiarity coded
during the Primed Task Recall. Observed Familiarity refers to familiarity coded during the Observation. Retrospective Familiarity refers to familiarity coded during the Retrospective Interview. Observed Familiarity is considered to be the most accurate representation of participant familiarity. This is because Observed Familiarity was coded based on the participant executing the task, rather than on memory recall, as with the Primed Task Recall and the Retrospective Interview.

**Very Familiar**
The very familiar code has a strong positive correlation between observed very familiar and recalled very familiar, \( r(df = 32) = .543, p < .01 \). The observed very familiar codes also correlate strongly with retrospective very familiar, \( r(df = 32) = .753, p < .01 \). The very familiar codes from the Primed Task Recall and the Retrospective Interview correlate strongly with the very familiar codes from the Observation. The very familiar codes from the Primed Task Recall and the Retrospective Interview have no significant correlation, \( r(df = 32) = .239, p > .05 \).

**Not Familiar**
The not familiar code has similar results to the very familiar code. The observed not familiar code has a strong significant relationship with the recalled not familiar code, \( r(df = 32) = .531, p < .01 \). The observed not familiar code also has a strong significant correlation with the retrospective not familiar code, \( r(df = 32) = .655, p < .01 \). There is a significant correlation between the recalled not familiar and retrospective not familiar codes, \( r(df = 32) = .353, p < .05 \).

The Observation has significant correlations with the Primed Task Recall and the Retrospective Interview. The Primed Task Recall and the Retrospective Interview has no significant correlation for the very familiar code, but no significant correlation for the not familiar code.

**7.5 Discussion**
The results of Field Experiment 1 will be discussed and compared with the existing research reviewed in the previous chapters of this thesis, and with Field Experiment 1. Two areas will be focused on, the differences between younger and older adults and the results from the different methods.

**7.5.1 Differences between Younger and Older Adults**
The findings of this study show that younger adults are significantly different from the three older age groups, and that the three older age groups are not significantly different from each other. The findings from Experiment 2 are very similar to Field Experiment 1, except that there are even more significant differences between the youngest age group and the three older age groups.

Individual familiarity varied across age groups, especially across the older age groups. Some participants demonstrated similar levels of behaviour, but had large differences in age. For example, at least one participant from each age group scored 9% – 10% for the recalled very familiar code. Other researchers in this area have reported similar variances in older adults (O'Brien, 2010). The literature also reports that older adults have a wide range of capabilities (Charness, 2008; Gregor et al., 2002; Hawthorn, 2000; Howell, 1997). While the statistics indicate the overall trends, the individual data shows that some older participants performed equal to, or better than, younger individuals.
Table 7.3 displays the results between the 18–44 age group and the three other age groups for Tukey post hoc tests across all six ANOVAs. Of these 18 relationships, only four did not demonstrate significant differences. Three of these four non-significant relationships occurred within the Retrospective Interview. Of the 14 significant differences, five were significant at a level of $p < .05$. A total of nine of a possible 18 relationships showed significant differences, at a level of $p < .01$. Of the 18 relationships among the three oldest age groups across the six ANOVAs, there were no significant differences. It is very clear that there was a significant difference in familiarity between the youngest age group and the other three age groups. These findings show that familiarity with contemporary products does not decline linearly with age, but drops around the mid-40s.

This suggests that the findings from this study are the result of differences in prior knowledge, rather than any age-related declines in cognition or other abilities, further confirming the validity of the methods used. Age-related declines are seen to affect variables such as time on task, intuitive uses, number of interaction steps, and physical use of inputs (Blackler, Mahar et al., 2010; Docampo Rama et al., 2001; Kang & Yoon, 2008; Langdon et al., 2009; Reddy et al., 2010), while experience affects variables such as interaction strategies, intuitive use, frustration, effort, and variance of performance (Blackler, 2008b; Kang & Yoon, 2008; O'Brien, 2010).

There is some disagreement about what elements of the interaction are affected by experience. Docampo Rama et al. (2001) state that mode errors (errors that are due to the product being in the incorrect state) are a result of differences in prior knowledge. Other research shows significant differences between performance and motor-control errors and age, and not between performance and motor-control errors and prior knowledge (Kang & Yoon, 2008). Lewis et al. (2008) found no significant relationships between prior knowledge and time taken. Reddy et al. (2010), however, found significant negative correlations between prior knowledge and time on task, and Blackler (2008b) and her colleagues (Blackler, Mahar et al., 2010) also found prior knowledge to affect time on task. The measure of time is expected to be rigorous across these studies, as are the statistical methods used. The element that is most likely to vary across the studies is the measurement of prior knowledge. Indeed, Lewis et al (2008) used a different method to measure prior experience to Blackler (2008b), Blackler, Mahar et al. (2010) and Reddy et al. (2010), who used similar methods.

This study did not attempt to measure prior knowledge with products using a subjective, self-reporting questionnaire or test as other studies have (e.g. Blackler, 2008b). Rather, it aimed to measure familiarity and prior knowledge through behaviour. It is argued that this method removes bias that potentially emerges through self-reporting. This study, alongside Field Experiment 1, is the first known study that directly examines product familiarity. The results show that there are very significant differences between older and younger adults, and that there are not significant differences among the three older age groups. While these results may suggest that age is related to familiarity, the findings also suggest that chronological age does not link directly to familiarity.
7.5.2 Methods

Observation is considered to be the closest representation of prior knowledge, as the data is collected from the participant performing the task. The ANOVAs supported this; they show significant differences ($p < .01$) between the youngest age group and the older three age groups for both the observed very familiar and observed not familiar variables (Table 7.3). The variables from the Observation also have significant correlations with the variables from the Primed Task Recall, and the Retrospective Interview, demonstrating consistency across the methods.

The Primed Task Recall and the Retrospective Interview have some different characteristics. The Primed Task Recall appears to give more consistent results than the Retrospective Interview (Table 7.3), yet the retrospective variables have stronger correlations with the Observation than the Primed Task Recall variables. This may be because the Retrospective Interview was reflecting directly on the performed task, and it is likely that participants would discuss this as it occurred for them. The Primed Task Recall, however, was drawing upon what the participant already knew. The similarities in the results between the Primed Task Recall and the Retrospective Interview are surprising, assuming that the recall is based on prior knowledge, and the Retrospective Interview is based on short-term memory. It was thought that the differences in information sources might lead to different results.

The Primed Task Recall (Section 7.2.2) is a method that could potentially be used by designers to identify what participants are familiar with, given a certain task and a certain product. It could be used to extract familiarity with specific parts of a process that a designer may be interested in. The ANOVAs show consistent results (Table 7.3) and the Primed Task Recall uses a method that is thought to reveal knowledge structures, which O’Brien (2010) suggests is more accurate than survey-style tools. The method is fast, and does not require a lot of equipment. It can also be used with non-working prototypes. One potential issue is demonstrating to designers how to identify the knowledge structures that are presented through the verbalisation. The Retrospective Interview is a useful method if an Observation is being conducted. Again, it is a quick, easy method that can reveal additional information about the interaction.

7.6 Summary

This chapter explained the objectives of Experiment 2, and the methods and procedures used to fulfil those objectives. Details of the experiment design were presented. The analysis methods were introduced and then the results of the study were presented. The results have been discussed above.

The results help to answer the two research sub questions posed at the start of this chapter. The questions are:

1. *How familiar are older adults with contemporary products, and how does this differ from the familiarity of younger adults?*

2. *How can designers readily identify what interaction processes older adults are familiar with?*
This study confirmed the findings of Field Experiment 1, that younger adults are significantly more familiar with the products used in this study than older adults, and that the three older age groups have no significant differences, in terms of familiarity, among them. The findings of Experiment 2 in relation to product familiarity built on those from Field Experiment 1, resulting in a deeper understanding of the differences in familiarity between younger and older adults, and answering the first research sub question.

The results confirm that the Observation (with Concurrent Protocol) is a robust method for identifying familiarity in a research context. The Observation and Retrospective Interview are not ideal methods for designers to identify familiarity, due to the more intense nature of the methods. The Primed Task Recall has been identified as a method that may help designers identify familiarity with particular tasks and particular products. It could be developed into a method that would be easy, quick, and highly mobile. These results provide part of an answer to Question 2, although it is suggested that more research may be needed to test the Primed Task Recall tool with designers.

The next chapter provides a discussion of the results of Field Experiment 1 and Experiment 2, in the context of the existing literature. It also highlights the major findings of this research. The outcome of this research is also presented, along with a tool to help design professionals apply the research outcome to the design process.
Chapter 8 – Discussion

8.1 Introduction
This chapter discusses the findings from Field Experiment 1 and Experiment 2 in terms of the literature from relevant areas. The differences between younger and older adults across the two studies are covered, as are the differences between the use of familiar products that participants owned and products that participants did not own. Implications of these findings for design and research are examined. The outcomes of this research are discussed, and an example of a method and tool to determine familiarity that is suitable for use by design professionals is presented.

8.2 Discussion
There are numerous publications that discuss the age-related declines experienced by older adults, ways that these declines may affect their interactions, and ways to combat these interaction issues (e.g., Fisk & Rogers, 1997; Hawthorn, 2000). More specifically, it has been well established that there are age-related declines in capabilities that affect the performance of older adults in the use of contemporary products (Sections 4.3 and 4.4). Other publications aim at raising awareness of the diversity in capabilities of older adults (e.g., Gregor et al., 2002).

The rise of design movements such as inclusive design suggests that there is significant importance placed on understanding how to design for the older individual (Clarkson et al., 2003). However, age does not account for all differences between older and younger adults (Kang & Yoon, 2008; O'Brien, 2010). Thus, there is a need to develop a deeper understanding of the issues surrounding knowledge differences and their effect on interaction, especially among older adults, so that tools, methods and guidelines can be constructed to assist designers.

This research has established a significant difference in familiarity—and, thus, in prior knowledge—between younger and older adults. This is in line with the literature on expertise, which shows a range of benefits of higher levels of knowledge, from an increase in speed, to improvements in perception and more effective search patterns (Section 3.4.1). Blackler (2008b) found that familiarity allows people to interact with products more quickly and more intuitively. O'Brien (2010) supports this, stating that those with higher relevant experience perform better than those without experience. This was observed first hand in this current research over more than 150 observations.

Despite these findings, there is very little in the way of guidelines, methods, tools or approaches to assist designers to overcome the design obstacles encountered in catering for the differences in knowledge between younger and older adults. While Blackler (2008b) does provide a conceptual tool for integrating the principles of intuitive interaction into the design process, it does not target older adults specifically; nor does it provide specific methods with which to identify what individuals know. Furthermore, while Langdon et al. (2007, p. 190) state that one of the implications of their findings is “the use of generic or previously well-learnt and transferable functional features”; there are no suggestions on how to identify such features.

8.2.1 Differences in Familiarity between Younger and Older Adults
Two experiments were conducted for this research, with a focus on developing an understanding of familiarity across a wide range of ages. These are the only known
empirical studies of prior knowledge and familiarity with contemporary products to date that have been conducted in this field. Both experiments demonstrated significant differences in familiarity between younger and older adults. Most other studies only compared disparate age groups, and did not cover a wide range of ages as the studies in this research did.

The results from Field Experiment 1 and Experiment 2 of this current research found that, in terms of familiarity, younger adults were significantly different from the two oldest age groups. In Experiment 2, the youngest age group was also significantly different from the middle-aged group (45 – 59), in terms of familiarity. In both experiments, the three older age groups were not significantly different from one another in terms of familiarity (Figure 8.1) (See Sections 6.4 and 7.4 for detailed reports on the results of each experiment). Across a total of 66 relationships tested for significance with variables related to familiarity over both experiments, only eight relationships failed to hold to the pattern described above. Field Experiment 1 used products that the participants owned, and considered themselves to be familiar with, and Experiment 2 used a common set of four products across all participants.

![Figure 8.1: Significant and Non-significant Relationships in Two Experiments](image)

The consistency of this pattern across methods (triangulation) and across both experiments is important. This is because the analysis of this research focused primarily on identifying familiarity through the application of prior knowledge, rather than through self-reporting methods, which are common in previous research in this area (e.g. Blackler, 2008b; O’Brien, 2010). Triangulation of methods and analysis demonstrates that the patterns shown in Figure 8.1 occur across results for both Field Experiment 1 and Experiment 2.

Previous research has illustrated that familiarity and prior knowledge play an important role in product interaction (e.g. Blackler, 2008b). While the methods used in the previous research in this area have obtained significant and meaningful results, this researcher considers there to be drawbacks in the methods used to identify technology familiarity and prior knowledge, as outlined in Section 5.1.2. The main drawback is considered to be the potential for incorrect reporting by participants. Also, the methods used in previous research investigate experience with a range of products. However, experience does not necessarily translate into knowledge, as shown by research in implicit learning, and older adults also have difficulties with learning implicitly (Howard & Howard, 2001; Howard & Howard, 1997b). The approach that this research has taken is considered to be a more direct reflection of participant knowledge. Spool (2005) and O’Brien (2010) agree that directly accessing
participant knowledge through testing is more accurate than surveys of general technology experience. No other study in this area has conducted direct examination of participant knowledge using multiple methods and compared these over a wide population of users.

The results of the examination of prior knowledge during this research show that younger adults are more familiar with contemporary products than older adults. Field Experiment 1 demonstrated generational effects between the 18–44 age group and the 65–74 and 75+ age groups, and Experiment 2 demonstrated generational effects between the 18–44 age group and all other age groups (Sections 6.4, 6.5, 7.4 and 7.5). The significant differences in familiarity between the 18–44 age group and the 45–59 age group are likely to be the result of learning (Czaja & Sharit, 1998; Docampo Rama, 2001), and this will be discussed in Section 8.2.2. A generational effect on different groups is likely to be the result of each group being exposed to a different interaction paradigm for the first 25 years of life (Docampo Rama, 2001; Lim, 2010). This would suggest that the 18–44 age group have higher levels of relevant prior knowledge of the products they were using, because they were exposed to the relevant interaction paradigms as they were growing up. Older adults may have less relevant prior knowledge, as they were exposed to different interaction paradigms during their formative years. (For more on generational theory and generational effects, see Section 4.6.)

It is possible that age-related declines in sensory, physical and cognitive capabilities might have played a part in the performance of older adults. The effects of this were minimised in this research in several ways. Firstly, time on task was not used as a performance measure, as age has been linked to increases in time on task (Docampo Rama et al., 2001). Older adults are often slower in terms of motor skills (Vercruyssen, 1997) and experience declines in cognitive abilities (Gregor et al., 2002). This suggests that older adults would perform more slowly than younger adults. Secondly, the differences demonstrated between younger and older adults are characterised as a step up or down, rather than as a linear relationship. A nonlinear relationship between age and performance is the result of differences in prior knowledge, rather than age-related declines (Docampo Rama, 2001). Age-related declines manifest as linear relationships between age and performance (Docampo Rama, 2001). Almost all results displayed a clear nonlinear pattern. Thirdly, variables that have been shown by other research to be related to age have been purposefully avoided in the methodology and heuristics used to identify familiarity. For example, ‘number of steps to complete task’ has been shown to have a significant relationship with age (Hurtienne et al., 2010; Kang & Yoon, 2008), so this research used percentages of total steps, rather than a tally of the variable coded. Another example was the use of relative speed as a heuristic. Because older adults often experience decreases in motor skills (Vercruyssen, 1997), this heuristic looked at the average interaction speed, and then used deviations from the average speed as an indicator of higher or lower levels of familiarity, rather than ‘faster’ or ‘slower’ interaction. This removed general interaction speed as a heuristic used to identify familiarity, which would favour younger adults over older adults.

The results could possibly be explained by differences in technology usage and technology adoption rates between younger and older adults. Research has demonstrated that older adults use technology to a lesser extent than their younger
counterparts (Fox, 2004), and this in turn will likely result in lower levels of relevant prior knowledge and familiarity. Self-efficacy also plays a role in interactions between older adults and contemporary products. Using products that participants owned, and deemed that they were familiar with, as well as products that were not owned, helped to mitigate these effects. Field Experiment 1 was conducted with products participants owned, doing a task they were familiar with, in their own homes. This experiment was designed to enable the researcher to examine the differences in the levels of familiarity demonstrated within a context that was comfortable and familiar for participants. The results from Field Experiment 1 are consistent with the results from Experiment 2 that used uniform products across all participants, even though a set of non-familiar products was used. The differences between Field Experiment 1 and Experiment 2 are discussed below.

The high level of significant differences among age groups in terms of familiarity could be explained by Type I errors. A Type I error is also known as a false positive, which, in this case, could be where the statistical tests show significant differences between two age groups, where significant differences are not actually present (Keppel & Wickens, 2004). Measures were taken to ensure the reliability of data analysis. These can be reviewed in Sections 6.3 and 7.3. Triangulation of methods was also used in both Field Experiment 1 and Experiment 2 to ensure methodological validity.

The differences in performance between younger and older adults are considered to be the product of differing levels of prior knowledge. The majority of the differences are thought to be the result of exposure to technology during the formative years (Docampo Rama, 2001; Weymann & Sackmann, 1993). Docampo Rama et al. (2001) identified a nonlinear relationship between mode errors and age with a three layered interface (a simulated mobile phone interface). They found significant differences in mode errors between the youngest age group and the three oldest age groups, and no significant differences in mode errors among the three oldest age groups. This is consistent with the results of Experiment 2, which also used products that participants did not own. Docampo Rama et al. (2001) attribute the nonlinear differences in performance to differences in knowledge as a result of growing up with products that have a different interaction paradigm.

More recent research by Lim (2010) also demonstrates similar results. In an interview-based study, content analysis revealed that adults over the age of 45 from the Electro-mechanical generation had more difficulties using contemporary products than younger adults from the Software generation (Section 4.6). Lim (2010) reports that older adults were more affected by low levels of familiarity and a lack of relevant prior knowledge. A second study was conducted using an observational methodology. Lim’s second study identified significant differences in task completion rates with contemporary products between those below the age of 56 and those 56 and older. Lim’s (2010) findings demonstrate relationships that are very similar to the relationships seen in Experiment 2, where a consistent set of products was also used. Lim attributes these results to a difference in technology generations, resulting in different prior knowledge. The results from both Docampo Rama’s (2001) and Lim’s (2010) research support the results of this research, and strengthen the argument that the findings are the result of differences in prior knowledge, primarily as a result of participants being part of different technology generations.
The differences in significance among age groups in terms of familiarity across the two experiments may suggest that middle-aged adults benefit from using technology over a period of time. The 45 – 59 age group were born in the Electro-mechanical technology generation. However, they seem to be able to transfer experience with products from the newer style of interface into usable knowledge that, in turn, increases performance. It is interesting to note that the 60 – 74 age group and 75+ age group, who were also born in the Electro-mechanical technology generation (Docampo Rama, 2001), did not appear to demonstrate an improvement in interaction with extended periods of usage. It appears that the 45 – 59 age group benefited more from having owned the product for a period of time, than the two older groups. This finding may suggest that older adults have more difficulty with knowledge transfer.

Research demonstrates that older people often struggle with elements of learning. Howard and Howard (2001) have shown that older adults have difficulty learning patterns when they are actively trying to do so. Older people also learn less than younger people when trying to identify patterns, and learn less complex information (Howard & Howard, 1997b). Older adults also have difficulties learning relationships between items (Naveh-Benjamin, 2000; Ostreicher et al., 2010). This could be particularly important in the use of contemporary devices, as interaction concepts often relate to interface features. Kang and Yoon (2008) describe older adults as being more rigid, and lacking cognitive flexibility. They suggest that older adults do not utilise prior knowledge as well as younger adults do when using new products. Research on knowledge transfer supports this, showing older adults do not transfer knowledge as effectively as younger adults (Dahlin, Nyberg, Bäckman, & Neely, 2008). O’Brien (2010) also states that knowledge may be less accessible for older adults than younger adults in relation to product interaction.

Czaja and Sharit (1998) found significant differences in performance among three different age groups on the first day of a three day data input study. On the second and third day of the study, significant differences were found only between the old
group and the young group, and between the old group and the middle-aged group. There were no significant differences between the middle-aged group and the young group. Seemingly, practice allowed the middle-aged group to improve their performance to a point where they were no longer significantly different from the younger age group. Furthermore, the young and middle-aged groups showed significant performance improvements across each of the three days, while older adults showed no significant improvements until the final day (Czaja & Sharit, 1998).

Czaja and Sharit’s (1998) research also suggests that older adults may struggle to integrate what they learn from day to day use of a product into improving their performance with that product. This is why a distinction between prior experience and prior knowledge is particularly relevant (Section 3.2.3). Experience may not necessarily be converted into knowledge that can then be applied to future interactions. The difficulties that older adults have with converting experience to knowledge have important implications for designing products for this age group. Using existing knowledge may prove to be much more important for those over the age of 60. Those between the ages of 45 and 59 seem to be better able to integrate knowledge gathered from interactions into use, resulting in greater improvements in performance over time. However, these age ranges are likely to be non-discrete, due to the high levels of variation in the capabilities of older adults (Hawthorn, 2000).

The differences in learning ability between younger and older adults are important to note when considering methods for measuring familiarity. The findings of this research and the literature in general suggest that younger adults often learn more effectively than older adults (Howard & Howard, 2001; Howard & Howard, 1997a; Naveh-Benjamin, 2000; Ostreicher et al., 2010). Thus, equivalent experience with a product is likely to result in a younger adult learning more than an older adult. This would suggest that comparing experience between younger and older adults based on reported depth and frequency of use, as has been frequently done in this research area (e.g. Blackler, 2008b), does not necessarily accurately reflect prior knowledge.

This current research suggests that middle-aged adults (45 – 59) learn more from ownership of a product than the older age groups. While they did not perform significantly differently to younger adults with owned products, they did perform significantly differently with contemporary products they did not own. Older adults have been shown to have deficits in implicit learning (Howard & Howard, 1997b), and in encoding relational information (Ostreicher et al., 2010) (For more on age-related cognitive declines, see Section 4.3). This finding suggests that the middle-aged group are likely to be able to learn new interaction methods or techniques that they have not previously come across, while it may be more effective for older adults to use interface features that they are already familiar with. Older adults could still learn the new methods, but it is likely to take a longer period of time. Designers may need to take these findings into consideration when targeting specific age groups.

8.2.3 Identifying Familiarity
It is clear that there is a significant lack of provision of ways to identify user familiarity, both in the literature and in available design tools and methodologies. Integrating an understanding of what older users are familiar with and a comprehension of the effects of cognitive decline into the design process should lead to products that are much more suitable for older adults. However, no methods have
yet been found which explicitly allow designers to access user familiarity and/or prior knowledge, without relying on self-reporting methods. Some of the existing methods and resources around this area are introduced and discussed.

Blackler (2008b) developed the Technology Familiarity (TF) Questionnaire. The TF Questionnaire was developed as a research tool rather than a tool suitable for industry use. It has been adopted in subsequent research by O’Brien (2010) and her colleagues (O’Brien et al., 2010) and is similar to methods used by Kang and Yoon (2008) and Langdon et al. (2009). The TF Questionnaire relies heavily on self-reporting. Blackler (2008b) found significant correlations between the scores from the TF Questionnaire and time on task, intuitive first uses, intuitive uses overall and level of assistance required. This shows that the TF Questionnaire is a useful approximation of prior knowledge and product familiarity; however, it does not identify specifics about what a participant is familiar with, and thus is not suitable for an industry context. A simplified variant of the TF Questionnaire was used in Field Experiment 1, but was abandoned for Experiment 2, as it did not provide relevant data in this context. As discussed above, comparing characteristics of product usage may not accurately reflect prior knowledge, due to differences in learning ability between younger and older adults.

Researchers at the School of Engineering Design at Cambridge University developed another resource for use in this area. As a result of extensive research on inclusive design (See Clarkson et al., 2003; Keates & Clarkson, 2003b; Langdon, Clarkson, & Robinson, 2008, 2010), they published the Inclusive Design Toolkit (i~design, 2010b). The toolkit website provides knowledge and tools with regard to understanding the functional capabilities of older adults, including their cognitive, sensory and motor abilities. While prior knowledge and familiarity are mentioned briefly in a section on Long Term Memory, no tools or methods are provided to identify familiarity or prior knowledge, or to integrate this knowledge into the design process (i~design, 2010a).

Thus, there is a need for methods that can identify users’ domain specific and task specific prior knowledge of products. Such methods could be used to identify what target users know, and what they are familiar with. This knowledge could then be integrated into the design process, resulting in more intuitive products (Blackler, 2008b). This current research has identified such a method and this method will be discussed in Section 8.3.

This researcher believes that by examining how individuals apply knowledge, a realistic understanding of prior knowledge can be gained, without directly surveying them about their past experiences with products or how often they use them. In a scenario where participants are required to use the knowledge they have, it is suggested that participant behaviour can reflect prior knowledge. A classic example is an observation. For example, participants are required to do a particular task with a particular product. To execute that task, they will utilise their prior knowledge. The amount of prior knowledge the participants have in this area (including little to none) is likely be reflected by the participants’ behaviour, such as hesitation and predictive action. While studies in the area currently use observations, there tends to be a focus on measures such as time on task and errors, rather than on participant behaviour. The work of Blackler (2008b) and her colleagues (Blackler, Mahar et al., 2010) is the
exception. The methods that have been used in Field Experiment 1 and Experiment 2 are discussed in terms of their suitability for use in an industry setting.

Observation and Concurrent Protocol

Observation in combination with Concurrent Protocol, as used in this research (Section 6.2.2), is considered by this author to be the most rigorous method for identifying prior knowledge. The main reason for this is that there are multiple layers of behaviour that can be used to identify familiarity. For example, the Concurrent Protocol provides verbal data that can be used to identify familiarity. The Observation provides other layers, such as speed, motor skill and proceduralisation of actions—all of which help to identify familiarity. Observation and Concurrent Protocol can be used with familiar or unfamiliar products, and can be used to identify more general product knowledge or specific task or feature knowledge, depending on the activities set by the researcher. While this is considered to be an effective method, there are some drawbacks to using Observation. Observation requires the use of a product or system; this can make Observation more difficult with products in development. The equipment required to capture Observation—the products themselves, and at least one video camera and tripod—makes it more difficult and less mobile than other methods. As experienced by this researcher, timeframes for Observation are difficult to assess; some people may take two minutes, and some may take twenty minutes to do the same task. This can increase demands on the designer’s time, and also increase costs.

Observational data can be difficult to analyse. Specialist video analysis software makes the analysis process easier, but it is still time and resource intensive. The analysis of video data also requires a more elaborate understanding of participant behaviour than the other methods that presented here, and training is necessary to help researchers identify the various aspects involved in identifying familiarity from video data. The coding heuristics used in this research (Section 5.6.2) could be used as a starting point for this training. For Observation to be time and cost effective for designers, while at the same time maintaining rigour, further development of the observational process and the analysis methods is required.

Task Recall

The Task Recall method used in Field Experiment 1 (Section 6.2.2) produced significant results when compared across age groups. The participant was required to describe how to do the selected task. The verbalisation was recorded and the steps were coded based on the way the participant described them. Grouped steps (describing multiple actions in one phrase or action) were significantly correlated with procedures (Section 6.3.4), which were sections of highly effective, familiar interactions during task performance. This suggests that groupings from the Task Recall can be used to identify familiarity with specific actions.

On the surface, the method seems to be an effective way to elicit familiarity; however, a closer examination found significant differences among age groups in the number of grouped steps from the Task Recall that were executed as procedures in the Observation. This suggests that while it may be an effective method for younger adults, it is not an effective method for identifying familiarity in older adults. The results suggest that although older adults demonstrate familiarity through verbalisation, it is not an accurate representation of the familiarity they displayed during task execution. For younger adults, verbalised familiarity corresponded closely to familiarity displayed during task execution. One other limitation of this method is
that the participant owns the product used; this reduces the scope of possible products, and also requires the researcher to go into the field to perform this method. Finally, low levels of verbalisation can show high levels of familiarity, or low levels of familiarity. If verbalisation alone is being used to identify familiarity, it could be very difficult to tell if the participant is showing high or low familiarity.

**Semi-structured Interview**

The Semi-structured Interview yielded a score that displayed similar patterns to other variables measuring familiarity, including: percentage of total steps in procedure, percentage of total steps grouped, and percentage of total time in procedure. It is suggested, therefore, that using the Semi-structured Interview is one way of discovering familiarity. The most important aspect of the interview is the way the questions are structured. The questions should target the application of knowledge, rather than being directed at experience. Given the responses, a scale can be determined that can be used to create a score (Appendix B).

This method has both benefits and limitations. One limitation is that familiarity is only examined on a product level, and not on specific task levels. Also, to date, this method has only been tested with products that participants have owned. Another problem is creating questions that ensure the application of knowledge in context. Questions that do not do this are likely to face the same problems as the self-reporting methods used by earlier research in this area (e.g. Kang & Yoon, 2008; Langdon et al., 2007). However, the benefits of this method include: speed, flexibility, minimal set up costs in time and resources, easy data capture, easy analysis, and high mobility.

Further development would strengthen this method. Future research should specifically examine if the method uncovers high levels of familiarity among older adults, with products that older adults are likely to be very familiar with. This research used contemporary products, and older adults generally did not score highly. Another area for development could be testing the method using product categories such as microwaves, rather than specific products such as the participant’s mobile phone.

**Primed Task Recall**

The Primed Task Recall was a method used in Experiment 2 (Section 7.2.2). The data collected by this method showed significant results, which followed patterns shown by both the Observation and the Retrospective Interview in Experiment 2 (Table 7.2). While this method is similar to the Task Recall, it does have some differences. The primary difference is that any product can be used for a Primed Task Recall, not just products that participants own, and participants describe what they think they need to do to execute a particular task. The method can also be used to examine a very particular aspect of an interaction, by carefully selecting the task.

The Task Recall, used in Field Experiment 1, was not effective at identifying older adults’ familiarity; yet, the same effect was not seen in the Prime Task Recall. This may be explained by the increase in the effects of semantic priming with age. Laver and Burke (1993) conducted a meta-analysis of 15 studies, all showing priming effects are greater for older adults than younger adults. This may balance out differences in memory often seen between younger and older adults (Hawthorn, 2007). Triangulation of methods was also used to ensure research rigour.
As with the Task Recall, the Primed Task Recall relies on verbalisation to identify familiarity. Since it uses verbalisation, the Primed Task Recall also comes up against the problem of low levels of verbalisation suggesting either high or low levels of familiarity. However, the method does have benefits, including: low cost, fast execution, easy data capture, easy analysis, high mobility, and application to all physical products. Further research could investigate if this method is effective when using images of products. This images-only method could be tested with products that already exist in the market, and those that are currently going through the design process. One potential issue with the use of this method is facilitating the coding of the verbal data in a way that leads to robust identification of familiarity.

8.2.4 Discussion Summary
This research sought to answer two research sub questions. The first of those was:

1. *How familiar are older adults with contemporary products, and how does this differ from the familiarity of younger adults?*

In response to this question, the research found that, in terms of familiarity, younger adults are significantly more familiar with contemporary products than older adults. This research has also demonstrated that there were no significant differences in familiarity among the three oldest age groups. Furthermore, the research suggests that younger and middle aged adults integrate more knowledge as a result of ownership of a product than older adults do. The second sub question posed was:

2. *How can designers readily identify what interaction processes older adults are familiar with?*

In addressing this question, this research identified a method—the Primed Task Recall—that could be used in the design industry to identify familiarity. The method has shown to be robust, and is considered to be suitable for industry as it is low cost, fast, allows for easier data capture, is highly mobile, and allows for easy data analysis. The application of this method is explained below.

8.3 Research Outcome
The Primed Task Recall has been identified as a method that can be used to identify prior knowledge and familiarity. Subsequently, a tool—The Familiarity Identification Tool (FIT)—has been designed in order to help design professionals apply the Primed Task Recall method and to code verbalised data from the method. This section discusses: the Primed Task Recall method, the design and trial of FIT which is designed to help with its application, the integration of FIT into the design process, and the way in which knowledge should be utilised in order to support and facilitate intuitive interaction.

8.3.1 Primed Task Recall
The Primed Task Recall is a viable investigational method to identify specific areas of participant familiarity. It has been broken down into three sections: preparation, execution and analysis. The process of applying the Primed Task Recall is simple. Before applying the method, the appropriate preparations need to be made. First, the design team needs to identify an interaction to be investigated. The next step is to find products (prototypes and images of products could be used) that have similar functionality or that are used to perform similar tasks to those performed by the product or service being designed. Tasks that could reveal suitable interaction
strategies that are related to the product in development should be identified. A sample of users from the target demographic then needs to be enlisted to conduct the Primed Task Recall. Once the designer has completed this preparation stage, the method itself can be used.

The steps for using the Primed Task Recall are as follows:

1. Participant reads through the task sheet.
2. Participant is shown the selected product for three seconds.
3. Participant describes how to perform the task with the selected product.

The final step is to apply the analysis technique to identify which interaction processes are very familiar, and which are not. Very familiar processes are likely to be several consecutive steps that have been coded as ‘very familiar’. Once familiar processes have been identified, they can be applied to a particular design task.

8.4 The Familiarity Identification Tool

The Familiarity Identification Tool (FIT) was designed and prototyped as an iPad application, with the intention of bringing the Primed Task Recall method into the hands of the designer. The application was required to not only provide video and audio analysis functionality, but also to inform the designer as to what the method involves, why it works, and how to identify familiarity through verbalisation. A trial was needed to test the validity of the tool for an industry context. The tool prototype can be found on a CD in Appendix I. In this section, the term ‘designers’ refers to the industrial designers who used the tool in the trial, while the term ‘users’ refers to the individuals describing the task that the designers analysed.

The purpose of the method is to identify what a particular user group is familiar with in relation to a particular project. Familiarity is likely to vary across age groups and user segments for a variety of reason. Thus it is difficult to say ‘older adults are familiar with A’, or ‘interaction style B works for all users’. The point of the FIT tool is to provide designers with a way to identify familiarity so that they can discover what user already know in relation to a particular interaction. By integrating this knowledge in to the design process, designers are more likely to produce interfaces that are easy for their target user group to interact with.

8.4.1 The Tool

The tool consists of two main areas. The first area is training. This is focused on introducing the method and explaining how to identify familiarity through a set of heuristics. The ‘Introduction’, ‘Identifying Familiarity’ and ‘Demo’ sections of the prototype cover these areas (Figure 8.2).
The ‘Introduction’ section introduces the premises upon which the method is based. Intuitive interaction and the familiarity framework are introduced briefly, followed by an explanation of the skill acquisition process and the effect of this on how users think about, and verbalise interactions. It also introduces the method used to identify familiarity. Some parts of this section flow automatically, as a video would, while the designers control others parts (Figure 8.3).

The ‘Identifying Familiarity’ section introduces a set of heuristics built upon the heuristics (identified in Section 5.4) from the Familiarity Framework (Section 3.1.6) and from Field Experiment 1 and Experiment 2. The heuristics are divided between the three levels of familiarity, and designers can examine all the heuristics for one level before moving on to the next (Figure 8.4).
The ‘Demo’ section demonstrates how to use the tool. There are demonstrations of how to set up projects, to add users, to analyse data, and to interpret the data output. This section has videos with a voiceover that demonstrate the use of the tool and its various aspects.

The second area the tool addresses is ‘Projects’. ‘Projects’ refers to applications of the Primed Task Recall (the Primed Task Recall is referred to as the Familiarity Identification Method within the tool). This section allows the designer to set up new projects, edit existing projects, add users to existing projects, and analyse projects (Figure 8.5).
When adding a project, the designer must first name the project. Products that are being used in the trial are then added. Each product must have at least one task associated with it. When adding a task, the steps required to perform the task are entered. These steps are later used in the analysis. Finally, the designer specifies what information about the participant is to be captured, and also how that data is to be captured (Figure 8.6).

A user can then be added to the project. The user is named, and the information specified in the project set up is entered. Next, a media file must be added to the user. This can either be an audio file or a video file. The media files can be added from the existing libraries on the iPad, or can be recorded in the moment using the iPad’s inbuilt camera and microphone. Once this has been completed, the participant can be analysed. Both the project set up process, and the process of adding users can be viewed in the ‘Demo’ section of the digital prototype (Appendix I).

A user can then be added to the project. The user is named, and the information specified in the project set up is entered. Next, a media file must be added to the user. This can either be an audio file or a video file. The media files can be added from the existing libraries on the iPad, or can be recorded in the moment using the iPad’s inbuilt camera and microphone. Once this has been completed, the participant can be analysed. Both the project set up process, and the process of adding users can be viewed in the ‘Demo’ section of the digital prototype (Appendix I).

The Analysis section is where the designers analyse the user describing the task. The task steps specified in the project set up appear in a list on the left, and the media window is on the right. Each step can be tapped, and then analysed based on the characteristics demonstrated by the user (Figure 8.7). Once all steps have been analysed, tapping on the ‘Complete’ button finishes the analysis. This process can be seen in the ‘Description Analysis’ video in the ‘Demo’ section of the tool (Appendix I).
The final section is the Data Output section. This section is not included in the prototype version of the application due to software limitations. This section would interpret the analysis, and compare it with the data entered about the users. The application would then present the designer with the most familiar and least familiar tasks for each of the aspects of the participant entered. For example, if age was specified in age groups, the data would output the most familiar and least familiar tasks for each age group. The data would also be presented to the designer graphically, to allow for evaluation and interpretation.

8.4.2 The Trial
A trial was conducted to test some aspects of the tool, and to compare the results the designers got from analysing the videos using FIT with the results this researcher got from analysing the same videos. The trial was conducted with five practising Industrial Designers whose industry experience ranged from 1 year to 11 years. In order to carry out the trial, a prototype application was developed.

8.4.3 The Prototype
A partial prototype of FIT was developed using a multi-fidelity approach (Coyette, Kieffer, & Vanderdonckt, 2007). The prototype was designed using a hyperlinked slideshow made with Keynote, with embedded video files. Demo videos were created using specially designed hyperlinked slideshows, with voiceover instructions captured as a screencast using Screenflow. These were converted to an appropriate video format and embedded within the slideshow. The prototype was exported from Keynote as a QuickTime file; this allowed for the hyperlinking to remain, thus simulating the functionality of a working application.

The prototype did not function as the application was designed to, due to limitations in the software used. Due to these limitations, the prototype was created for use with a touch screen connected to a PC. Limitations also meant that some functionality—such
as on-the-fly analysis as the video played, precise video playback controls, and an integrated heuristics library on the analysis screen—could not be integrated. The QuickTime file had a few additional bugs which participants were warned about, and were assisted with as necessary.

8.4.4 Procedure
Each designer was presented with the same scenario (Appendix J) and worked through the introductory material within the application. The introductory material included a brief explanation of intuitive interaction, and of why the method works and what it involves. Two demo videos explained the processes involved in setting up a project, in adding users, and in the analysis. A set of criteria for the three levels of familiarity was provided. The criteria used are shown in Table 8.1, and also which of the heuristics each criteria related to (Section 5.4.1).

Table 8.1: FIT criteria and heuristics.

<table>
<thead>
<tr>
<th>Familiarity Level</th>
<th>Criteria</th>
<th>Related Heuristic(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Familiar</td>
<td>Grouping</td>
<td>Domain knowledge</td>
</tr>
<tr>
<td></td>
<td>Redundancy</td>
<td>Domain knowledge, awareness and perception</td>
</tr>
<tr>
<td></td>
<td>Non-verbalisation</td>
<td>Domain knowledge</td>
</tr>
<tr>
<td></td>
<td>Certainty and speed</td>
<td>Domain knowledge, relative speed, and awareness and perception.</td>
</tr>
<tr>
<td></td>
<td>Product Response</td>
<td>Domain knowledge, forward planning and anticipation</td>
</tr>
<tr>
<td>Familiar</td>
<td>Uncertainty</td>
<td>Domain knowledge, forward planning and anticipation, and relative speed</td>
</tr>
<tr>
<td></td>
<td>Vagueness</td>
<td>Domain knowledge, and awareness and perception</td>
</tr>
<tr>
<td>Not Familiar</td>
<td>Base knowledge</td>
<td>Domain knowledge, and awareness and perception</td>
</tr>
<tr>
<td></td>
<td>‘I don’t know’</td>
<td>Domain knowledge, and forward planning and anticipation</td>
</tr>
<tr>
<td></td>
<td>Non-verbalisation</td>
<td>Domain knowledge</td>
</tr>
</tbody>
</table>

The designers were then required to analyse three users using the familiarity framework presented in Chapter 3. A project had already been set up, and the users had also been added. The product, task and all video files were taken from Experiment 2. Before the designers analysed the videos, they were required to familiarise themselves with the product and the task the users were describing. They were given the task sheet and the product, and asked to perform the task in their own time. The designers were then giving analysis sheets (Appendix K), which allowed them to analyse the video on paper, as the functionality of the prototype did not allow for the analysis to occur within the application (Figure 8.8).
The three videos were of the same product and the same task, and were chosen as they each demonstrated a different level of familiarity. Each designer was required to analyse each step, and no assistance or guidance was given about what level of familiarity was being demonstrated. After the designers had finished coding the final user, a short interview was conducted; this focussed on the process and whether it would be useful in industry.

8.4.5 Analysis

It is important to note that none of the designers had encountered this material, this method, or this tool before; nor had they been exposed to any of the training material or analysis heuristics before the trial. Each designer had approximately 15 minutes with the training material before beginning to analyse data. All training was inbuilt into the application, and no training was given directly to the designers by the researcher. All designers commented that, given more practice, they felt they would be much more confident in their decisions.

The analysis of the three chosen user videos from Experiment 2 was exported from Noldus Observer and imported into SPSS. The data from the five designers was entered into SPSS alongside the data from Experiment 2. Each designer made six decisions on familiarity per video, resulting in a total of 18 decisions. The Kappa coefficient was used to compare the result from each designer with the results from Experiment 2. The Kappa coefficient was used as it was used to compare the two raters in Experiment 2. In addition to the Kappa coefficient, ‘Agreement’ is reported as a percentage of total decisions, and ‘Absolute Disagreement’ is reported as a percentage. ‘Absolute Disagreement’ is where the researcher coded a step as Very Familiar, or Not Familiar, and the designer coded it as the opposite. The value is given as a percentage of all Very Familiar and Not Familiar codes. Table 8.2 shows all data.
Table 8.2 Data from Familiarity Identification Tool (FIT) Trial

<table>
<thead>
<tr>
<th>Designer</th>
<th>Years’ Experience</th>
<th>Kappa (ϰ)</th>
<th>Agreement</th>
<th>Absolute Disagreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>0.155</td>
<td>44%</td>
<td>10%</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>0.642</td>
<td>78%</td>
<td>10%</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>0.304</td>
<td>56%</td>
<td>10%</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>0.455</td>
<td>67%</td>
<td>0%</td>
</tr>
<tr>
<td>5</td>
<td>&lt;1</td>
<td>-0.013</td>
<td>28%</td>
<td>40%</td>
</tr>
</tbody>
</table>

Landis and Koch (1977) report a set of arbitrary benchmarks that are useful for describing the relative strength of agreement associated to the Kappa coefficient. Table 8.3 shows the ranges and their corresponding labels.

Table 8.3 Kappa Statistic Ranges and Labels (Landis & Koch, 1977)

<table>
<thead>
<tr>
<th>Kappa Statistic</th>
<th>Strength of Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;0.00</td>
<td>Poor</td>
</tr>
<tr>
<td>0.00 – 0.20</td>
<td>Slight</td>
</tr>
<tr>
<td>0.21 – 0.40</td>
<td>Fair</td>
</tr>
<tr>
<td>0.41 – 0.60</td>
<td>Moderate</td>
</tr>
<tr>
<td>0.61 – 0.8</td>
<td>Substantial</td>
</tr>
<tr>
<td>0.81 – 1.00</td>
<td>Almost Perfect</td>
</tr>
</tbody>
</table>

8.4.6 Results

The results from the Kappa coefficient show that there is variance across the level of agreement between this researcher and the designers, from poor agreement to substantial. The least experienced designer had the lowest agreement of all the designers, and had a high level of absolute disagreement, while the most experienced had the highest agreement. These results show promise, considering that the version of the tool used was a partial prototype, and was in its first iteration. Designers also only had a short period of time to familiarise themselves with the material before beginning analysis. More in-depth training is likely to result in improvements in agreement. The low level of absolute disagreement is also promising (with the exception of the least experienced designer), showing that designers understood the heuristics identifying the differences between high and low levels of familiarity.

The interview revealed that all designers considered that they would improve their reliability and consistency with the heuristics with more practice and exposure to the tool. All designers also considered the tool to be valuable to industry, with one designing stating it would have been useful for a recently completed project, and another commenting that such a tool would be crucial to the success of an up-coming project.

A number of improvements could be made in the next iteration of the tool, which should increase the kappa score. The first is to provide examples of each of the heuristics demonstrating where it could be applied. The second is to provide example videos that can be coded and then compared against the correct coding. The third is to give access to the heuristics while video is being coded. These three improvements would likely raise the kappa score, improving the reliability of the tool.
The results from the trial suggest that designers can identify familiarity using a tool (FIT) based on the Primed Task Recall, albeit with varying levels of success. Furthermore, the feedback provided by the designers suggests that FIT would be a useful tool for designers working in industry. It is suggested that FIT should be developed further, with a focus on prototype functionality and the introductory and training material. More extensive trials would also need to be conducted once FIT has been fully developed.

8.5 Summary
This research has shown that familiarity with contemporary products is significantly different between younger and older adults. It has also recommended a suitable method—the Primed Task Recall—to identify familiarity in the design industry. However, it is necessary to provide some framework within which the method can be applied within the design process, and that has been achieved with the aid of FIT. The use of FIT during the design process will give design professionals the ability to access user knowledge easily and effectively. Applying this knowledge during the design process is likely to result in products and systems that are easier to use.
Chapter 9 – Conclusion

9.1 Introduction
This chapter concludes this thesis by presenting key aspects of this research. The implications of the findings are presented, along with the limitations of this research. The novel contributions to knowledge are identified and explained. Next, possible future directions of this research are discussed. Finally, the conclusions of this research are presented.

9.2 Implications
The findings presented in Section 8.2.1 show that younger adults have different prior knowledge to older adults, and that in terms of familiarity, older adults do not differ significantly from one another when using contemporary products. The literature with similar findings suggests that the differences in performance are the result of growing up with products that use a different interaction paradigm (Docampo Rama, 2001; Lim, 2010; Weymann & Sackmann, 1993), which results in different prior knowledge. This has implications for both research and the design industry.

When conducting research exploring product usage amongst older adults, particular attention should be paid to the concept of different technology generations. Age groups should be factored around technology generations, to ensure that generational effects do not skew data. Docampo Rama et al. (2001) used before and after 1960 as the divide in their experiment. An alternative method is to use more, smaller age groups in order to isolate the generational effect more easily. An example of such an approach can be seen in Lim (2010). When designing a product for older adults in industry, it is suggested that utilising the interaction paradigm that they experienced in their formative years will result in products that are more usable, as they utilise prior knowledge. A failure to integrate the prior knowledge of older adults into products is likely to continue to result in products that older adults find difficult to use.

The findings presented in Section 8.2.2 have implications for both research and the design industry. As older adults may not learn as much from product use as younger adults do (Czaja & Sharit, 1998; Howard & Howard, 1997b; Naveh-Benjamin, 2000), research methods that examine elements of product usage behaviour—such as how often a product is used, or how long a product has been owned—are unlikely to provide accurate reflections of user knowledge. This author considers that methods that target the application of participant knowledge in context are more likely to show relevant prior knowledge. This is also supported by O’Brien et al. (2010) and Spool (2005). The findings of the current research suggest that different age groups could potentially benefit from different approaches to interfaces. Older adults are likely to have more difficulties learning new ways of interacting with products. If older adults are the target market, it would be beneficial to understand what older adults already know, and to integrate this knowledge when designing interaction processes. Adults under the age of 60 also may find an interface based on existing prior knowledge easy to use, but can also learn new interaction styles.

A tool was designed and prototyped around one of these methods, the Prime Task Recall, and a trial was conducted, showing that designers, who had never used the method before, could analyse data and have some level of success at identifying
familiarity on the first use of the tool (Section 8.4). All designers who participated in the trial mentioned the need for easy access to tools that would help them conduct user research easier, faster, and better. Two of the five designers expressed direct interest in the tool for use in industry. If the tool were to be developed further and introduced to market, designers would have access to a tool that enables them to conduct robust research faster, more easily, more effectively, which is likely to result in more intuitive products, and more rewarding user experiences.

Section 8.2.3 presented additional methods used in this research that have potential for use in industry. There are implications for these methods for research also, as other researchers can use the methods presented to investigate familiarity and prior knowledge in future studies. These methods could also be developed and tested further in both academia and industry to complement the Familiarity Identification Tool and help identify familiarity and prior knowledge in different ways.

9.3 Limitations
One limitation of this research was the lack of cognitive testing alongside the examination of familiarity. Both Field Experiment 1 and Experiment 2 were mobile experiments, and were designed to place as little burden on participants as possible; cognitive testing would have increased the length of the experiment, and also the load on participants. While cognitive testing may have provided an interesting contrast, the analysis methods used avoided elements that have previously been related to cognitive decline (for reasons earlier explained).

A second limitation was the sample size used for each of the experiments. The sample sizes were constrained by the timeframes of the research project, and also by difficulties with recruiting suitable participants, based on age, gender and education balancing. Nevertheless, the sample sizes used in both Field Experiment 1 and Experiment 2 produced significant results.

A third limitation was the products used in Experiment 2. The products were relatively common products, but may not be an accurate reflection of all contemporary products. A range of products was selected that had different interaction styles, and different levels of complexity, in order to get a broad cross section of possible interactions. Also, the aim was not to see if individuals were familiar with the latest, high tech products, but with product types that they were likely to have used.

A fourth limitation was cultural. Both experiments were conducted in South East Queensland, Australia, and it is unknown if the results would be replicated in other western cultures or in eastern cultures. However, the methods used focused on how to identify knowledge, rather than on identifying a particular type of knowledge, or knowledge that is based in a specific culture. Furthermore, it is thought that the same findings would evolve regardless of the cultural setting, given the importance of the difference in technology generation in the sample population.

9.4 Contributions to Knowledge
This research has made four significant contributions to knowledge. The first contribution is that younger adults demonstrate significantly higher levels of familiarity with contemporary products than older adults. This suggests that younger
adults know considerably more about contemporary products, and have a much richer and more complex understanding of how contemporary products work. This knowledge and understanding enables younger adults to use contemporary products more effectively as they have more relevant prior knowledge to apply to their use than older adults do. Also, older adults of varying ages do not display significant differences in familiarity. This finding demonstrates that age alone does not explain differences in familiarity. This is the first known study in this area that has investigated familiarity across a sample with a broad age range. This has implications for those designing products targeting older adults. When designing products that older adults will use, care needs to be taken to use interaction strategies with which older adults are already familiar.

The second significant contribution to knowledge is that middled-aged adults (45 – 60) demonstrate higher levels of familiarity with products they own than with products they do not own. The two oldest age groups do not experience this increase in familiarity. This suggests that middle-aged adults may be able to more readily access knowledge gained from prior experience with a product. Therefore, middle-aged adults may be more likely to be able to learn new interaction methods, while older adults will likely benefit more from designs utilising interaction methods they have already experienced. No other research has been found that has compared familiar and non-familiar products. Care should be taken when choosing interaction strategies in products that older adults will use, as they are likely to have more challenges to face when learning new interaction processes. It may be more effective to identify and utilise existing knowledge and familiar processes to integrate into the interface being developed.

The third contribution to knowledge is a contribution to methods. A new research methodology has been developed that can be used to identify familiarity. This set of methods, unlike most existing methods used in this area of research, does not rely on self-reporting. Instead, user knowledge is examined in context, allowing for more precise identification of familiarity and knowledge. A Familiarity Framework (Section 3.1.6) has also been developed, which can be used by researchers to examine familiarity. The framework has three levels, which correspond to identifiable behaviours and levels of knowledge. This framework is supported by a set of heuristics that has also been developed to help identify levels of familiarity through observation (Section 5.4.1). These heuristics allow for a more comprehensive understanding of what elements of interactions are linked to cognitive declines, and which areas are affected by prior knowledge.

A fourth contribution to knowledge was the development of a new method, the Primed Task Recall (Section 7.2.2). This method allows researchers to identify participant familiarity faster and easier than any other known method. It utilises context based knowledge, rather than relying on self-reporting surveys of experience and usage, which may be subject to bias (Section 4.1.2). The method has been transferred into a tool that can be used to identify familiarity by researchers and design professionals.
9.5 Future Directions for this Research

There are several future directions this research could take. One area is to examine the components of prior knowledge beyond the distinctions made between image schemas and acquired knowledge in this research. Investigating the role that the separate components of prior knowledge have in intuitive interaction would be beneficial, providing an even greater understanding of how knowledge and cognitive decline contribute to interaction. Methods to identify the different types of knowledge would need to be developed in order to conduct this research. This work would be likely to examine systems knowledge and domain knowledge and how each of these contributes to successful user product interactions.

More research could be conducted on the differences between middle-aged adults (45 – 59) and older adults (60+). The results of this research suggest differences in the effect of prior use on familiarity across these two age groups. It will be helpful to further understand this relationship, so designers can integrate this knowledge when designing for these age groups. This could be investigated by utilising a longitudinal study to examine the change in product knowledge with an unfamiliar product over time.

The Familiarity Identification Tool (Section 8.3) should be developed further, and then tested with industry based researchers and designers. Initial trial results show promise, and elements of the tool and the prototype can be improved. These areas include increases in functionality, through the use of appropriate development software, improvement in usability as a result of observing designers interacting with the application, further development of training material, and completion of the analysis and data output modules. Additional testing should be carried out on a larger scale than the initial trial, and with more videos for analysis. This would provide more data to compare between designers and researchers.

Additional research could be conducted with the Semi-structured Interview. While results from the interview were found to be significantly correlated to variables related to familiarity, it is not suitable for use by designers in its current form. Further development of the semi-structured interview could involve establishing criteria for setting questions that target user familiarity. This may involve: testing a range of questions; using self-reporting questions and questions that require the application of knowledge; and establishing what style of question best uncovers product familiarity. Additional testing could also look at the application of the semi-structured interview to products that users do not own, as this method has currently only been explored with products and product types that users have owned.

Also, a study that examines product familiarity amongst older adults with a device that they are likely to be familiar with from their own technology generation—such as a record player—could be conducted. An interesting aspect here would be to also include younger adults in the study and investigate how they respond to older products.

9.6 Conclusion

Familiarity plays an important role in user interaction with products. To date, no known research has examined product familiarity of younger and older adults, with a focus on identifying familiarity through participant behaviour. Many believe that
young people are more familiar with products than older people, or that they know more about products than older people. While this has often been said, it has not been empirically examined. This research used empirical methods to collect data that demonstrates differences in familiarity between younger and older adults.

It is clear that the consideration of the relevant prior knowledge of potential users should be incorporated into the development process of products and services. Not only do older adults have significantly different levels of familiarity than younger adults, some face more challenges in learning as they age beyond 60. The use of existing knowledge—in the form of image schemas and acquired knowledge—is suggested as a way to make products easier for people to use.

It is acknowledged that integrating relevant prior knowledge will not solve all problems that older adults face with contemporary products. Other research has clearly identified that age-related cognitive decline also plays a role in the difficulties that many older adults face. Guidelines already exist to help designers develop products that take the cognitive abilities of older adults into consideration.

If designers can combine the consideration of cognitive abilities of older adults with an understanding of the relevant prior knowledge of the target user group, the result should be products that are satisfying for users. It is likely that such products will not only be easier for older adults to use, but also for younger adults.

This research has clearly identified significant differences in familiarity between younger and older adults. A tool has then been proposed that can be used to identify user familiarity. This tool, with further development, will allow designers to easily access users’ prior knowledge. By integrating this knowledge into the design process, designers should be able to develop products that are easier and more intuitive to use. This work has established a firm basis for the study of user familiarity, and has built on previous work. Researchers continuing the study of the role of familiarity and prior knowledge in product–user interaction can use this work as a point of departure in the many possible research directions suggested above.
References


Hanson, V. L. (2010). Influencing Technology Adoption by Older Adults. *Interacting with Computers, In Press, Accepted Manuscript.*


Appendices
Appendix A

Field Experiment 1 - Example Questionnaire
<table>
<thead>
<tr>
<th>Device</th>
<th>Frequency</th>
<th>Ownership</th>
<th>Importance</th>
<th>Notes: (Participant Name)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lounge Stereo</td>
<td>W</td>
<td>10y</td>
<td>D</td>
<td>CD, Tape, Records</td>
</tr>
<tr>
<td>TV</td>
<td>D</td>
<td>1y</td>
<td>Y</td>
<td>News, Comedy, Movies</td>
</tr>
<tr>
<td>DVD</td>
<td>W</td>
<td>10y</td>
<td>Y</td>
<td>Mystery shows</td>
</tr>
<tr>
<td>General Phone</td>
<td>D</td>
<td>&lt;M</td>
<td>&lt;M</td>
<td>Cabled</td>
</tr>
<tr>
<td>Computer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microwave</td>
<td>W</td>
<td>6.5y</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Dishwasher</td>
<td>X</td>
<td>15y</td>
<td>&lt;M</td>
<td></td>
</tr>
<tr>
<td>Oven</td>
<td>X</td>
<td>6y</td>
<td>&lt;M</td>
<td></td>
</tr>
<tr>
<td>Washing machine</td>
<td>X</td>
<td>3y</td>
<td>&lt;M</td>
<td></td>
</tr>
<tr>
<td>Personal Use</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Microwave</td>
<td>X</td>
<td>6.5y</td>
<td>X</td>
<td>Portable music player</td>
</tr>
<tr>
<td>Oven</td>
<td>X</td>
<td>3y</td>
<td>X</td>
<td>Mobile phone</td>
</tr>
<tr>
<td>Camera</td>
<td>X</td>
<td>15y</td>
<td>X</td>
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</tr>
<tr>
<td>Out and About</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATM</td>
<td>&lt;M</td>
<td>5y</td>
<td>&lt;M</td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood pressure</td>
<td>&lt;M</td>
<td>2y</td>
<td>&lt;M</td>
<td></td>
</tr>
<tr>
<td>Pedometer</td>
<td></td>
<td>3y</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Electric thermom</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heart rate monitor</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Body mass index</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Body fat metre</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date: 3/12/09</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B

Semi-structured Interview questions from Field Experiment 1, with example. interview score, and explanation.
Semi-structured Interview - Question Set for Selected Product

(Questions in italics were not used to construct the Semi-structured Interview score)

1. What are some of the things you use this product for?

2. What do you like about it?

3. What do you not like about it?

4. Are there any things that you have find difficult doing?

5. Do any of the features or buttons remind you of other products?

6. What else would you like the technology to be able to assist you with?

7. What is the best experience you have had with this product?

Score Formula and Explanation

Score is given in **bold** text, answer is in normal text

<table>
<thead>
<tr>
<th>Activities (Q. 1)</th>
<th>Difficulties (Q. 4)</th>
<th>Remind (Q. 5)</th>
<th>Assist with (Q. 6)</th>
<th>Experience (Q. 7)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1 = 1 activity</strong></td>
<td><strong>1 = Yes - 2</strong></td>
<td><strong>1 = No</strong></td>
<td><strong>0 = No</strong></td>
<td><strong>1 = No recall</strong></td>
</tr>
<tr>
<td><strong>2 = 2-3 activities</strong></td>
<td><strong>2 = Yes - 1</strong></td>
<td><strong>2 = Product category</strong></td>
<td></td>
<td><strong>2 = Generalised</strong></td>
</tr>
<tr>
<td><strong>3 = 4-5 activities</strong></td>
<td><strong>3 = Yes - General</strong></td>
<td><strong>3 = Brand</strong></td>
<td></td>
<td><strong>3 = Specific event</strong></td>
</tr>
<tr>
<td><strong>4 = 6+ activities</strong></td>
<td><strong>4 = No</strong></td>
<td><strong>4 = Specific Product</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The answers given to Question 4, relating to difficulty, were divided into three categories: no difficulties, specific difficulty or general difficulty. If the participant stated that s/he did not find any aspects of the product difficult to use, then it was categorised as ‘no difficulties’. If a participant mentioned difficulties with a specific feature or tasks, then it was classified as ‘specific difficulty’. For example, one participant stated (in reference to his DVD player): “There is some difficulty in using the remote to try and channel the internal application”. When participants discussed difficulties that were broad, and did not mention a specific function or task, it was categorised as ‘general difficulty’. For example, one participant said: “Just all the buttons, um, how to operate it”. These answers were collated and comparisons between age groups were made.

Participants responded in four different ways to Question 5, asking if the product reminded them of any other products they used. The answers included: specific products, a brand, one or two product categories, or no products. The results were compared. Participants were asked how else the technology could assist them. Participants mentioned improvements such as: “being able to read my mobile phone without glasses” and, in reference to a microwave, “clean itself would be nice”. The number of improvements was tallied across age groups and compared.
Participants were asked about the best experience they had had with the product. The experiences were specified as: a specific event, a generalisation, or not recalled. A specific event was either a single event such as sending a photo to a loved one from a phone, or a specific activity, such as being able to make custard quickly in the microwave. A generalisation was a comment that was in some way based around the general functionality of the product. For example, one participant stated: “A good experience is when you push a button, put the CD in, and it comes up on screen”. Some participants could not recall any particular event, and did not make a generalisation. These were specified as ‘no recall’.
Semi-structured Interview Example

Name: (Participant Name)
Product: Mobile Phone (Blackberry)

1. What are some of the things you use this product for?
   *Calls, SMS, Email, Communication with Family/Business, Camera, Video, Calendar, Contacts, Browser*

2. What do you like about it?
   *It means that I’m always in contact. Easy. Convenient*

3. What do you not like about it?
   *

4. Are there any things that you have found difficult doing?
   *Using it to its maximum capability*

5. Do any of the features or buttons remind you of other products?
   *

6. What would you like technology to be able to assist you with?
   *GPS Navigation*

7. Can you think of the best experience you have had with this product?
   *I was able to take a video when I was overseas, and email it directly to my kids.*
Appendix C

Field Experiment 1 - Participant Information Sheet, Consent Form
Participant Information

Name

_______________________________________________

Date of Birth

_______________________________________________

Contact details
Telephone: __________________________
Email: __________________________

Level of Education

_______________________________________________

Occupation / Previous Occupation

_______________________________________________
PARTICIPANT INFORMATION for QUT RESEARCH PROJECT

Utilising Familiarity to Facilitate Intuitive Interaction for Older Adults

Research Team Contacts

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact Information</th>
</tr>
</thead>
</table>
| Simon Lawry, PhD Candidate | 07 3138 9183  
|                       | s.lawry@qut.edu.au                      |
| Prof. Vesna Popovic, Principal Supervisor | 07 3138 2669  
|                       | v.popovic@qut.edu.au                    |

Description

This project is being undertaken as part of a PhD by Simon Lawry. 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 what older adults are familiar with, and to develop investigational methods that can be used to discover this. These investigational methods can then be utilised by designers to investigate user familiarity and prior experience among older adults, and thus design products that are more intuitive to use.

The research team requests your assistance because your participation will help us to develop possible investigational methods for designers to use to understand what older adults are familiar with. This will allow them to design products that utilise what users already know, and are therefore more intuitive to use.

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 an interview, which will be conducted in your place of residence. The interview is expected to last between 30 minutes and one hour. The aim of the interview is to find what products you feel you are familiar with, and why. The interview will be recorded with a digital audio recorder, and a digital camera may be used to document any examples of products discussed in the interview.

Expected benefits

It is expected that this project will not directly benefit you. However, it may benefit you in the future, as the tools developed from this research project begin to be adopted by designers, resulting in more intuitive products.

Risks

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

Confidentiality

Only the research team will have access to any information you provide, and the data that you help create. Your anonymity and confidentiality will be safeguarded in any and all publications resulting from this research.

Although you will be recorded in both video and audio recordings, which others may listen to or watch on occasion, your personal information will never be displayed. Only members of the research team will be able to connect the data you help create with your personal information.

All Audio/Video (AV) data will be stored in a secure location, which is accessible only to members of the research team. The data will not be destroyed, but stored as backups in a secure location. The data will only be used by members of this research project, for this project, and for no other purpose. Participation in the project is not possible without being recorded in either video or audio.

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.
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
• agree to participate in the project
• understand that the project will include audio and/or video recording
• consent to having video footage or stills of myself that are taken during the tests published or displayed for the purpose of explaining the results*

Name  ..........................................................................................................................

Signature .................................................................

Date  /  /  

*Please delete this paragraph if you do not consent to having images of yourself used to explain the results of the tests.
Appendix D

Additional graphs from Field Experiment 1 results
Figure 1: Frequency of use compared to product importance

Figure 2: Product ownership across age groups (mean)

Figure 3: Mean number of activities with selected products across age groups
Appendix E

Task Sheets for all 5 products used in Experiment 2 (including test product). Each set task sheet was on a separate A5 sheet of paper
Calculator

Turn the calculator on.

Add 5 and 7 together.

Multiply the result by 6.

Clear the answer.

35mm Camera

Put the film into the camera.

Turn the camera on and turn the flash off.

Zoom into the target on the wall and take a photo.

Turn camera off.
Digital Camera

Insert SD Card

Turn the camera on and turn the flash off.

Zoom into the target on the wall and take a photo.

Turn camera off.

Analogue Alarm Clock

Set the time to 9:25.

Set the alarm for 6:35.

Turn the alarm on.
Digital Alarm Clock

Set the time to 9:25.
Set the alarm to 6:25.
Turn the alarm on.
Appendix F

Experiment 2 - Participant Information sheet, Consent Form
Participant Information

Full Name

_______________________________________________

Date of Birth

_______________________________________________

Age

_______________________________________________

Contact details

Telephone: _______________________________________

Email: __________________________________________

Level of Education

School

Undergraduate

Postgraduate
Utilising Familiarity to Facilitate Intuitive Interaction for Older Adults

Research Team Contacts

<table>
<thead>
<tr>
<th>Name</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simon Lawry, PhD Candidate</td>
<td>School of Design 07 3138 9183 <a href="mailto:s.lawry@qut.edu.au">s.lawry@qut.edu.au</a></td>
</tr>
<tr>
<td>Prof. Vesna Popovic, Principal Supervisor</td>
<td>School of Design 07 3138 2669 <a href="mailto:v.popovic@qut.edu.au">v.popovic@qut.edu.au</a></td>
</tr>
</tbody>
</table>

Description

This project is being undertaken as part of a PhD by Simon Lawry. 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 what older adults are familiar with, and to develop investigational methods that can be used to discover this. These investigational methods can then be utilised by designers to investigate user familiarity and prior experience among older adults, and thus design products that are more intuitive to use.

The research team requests your assistance because your participation will help us to develop possible investigational methods for designers to use to understand what older adults are familiar with. This will allow them to design products that utilise what users already know, and are therefore more intuitive to use.

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 an observation of the day-to-day use of common electronic household products and appliances. You will be asked to perform simple tasks with the products, which will be recorded on video. A short retrospective interview will be conducted after the observation. The observation and retrospective interview will be recorded with digital video cameras. Participation will take no longer than an hour of your time.

Expected benefits

It is expected that this project will not directly benefit you. However, it may benefit you in the future, as the tools developed from this research project begin to be adopted by designers, resulting in more intuitive products.

Risks

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

Confidentiality

Only the research team will have access to any information you provide, and the data that you help create. Your anonymity and confidentiality will be safeguarded in any and all publications resulting from this research.

Although you will be recorded in both video and audio recordings, which others may listen to or watch on occasion, your personal information will never be displayed. Only members of the research team will be able to connect the data you help create with your personal information. Due to the nature of this research you will not be provided with an opportunity to verify comments and responses apart from the opportunity provided during the retrospective interview.

All Audio/Video (AV) data will be stored in a secure location, which is accessible only to members of the research team. The data will not be destroyed, but stored as backups in a secure location. The data will only be used by members of this research project. Participation in the project is not possible without being recorded in both video and audio.

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 research 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 5123 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

Utilising Familiarity to Facilitate Intuitive Interaction for Older Adults

Research Team Contacts

<table>
<thead>
<tr>
<th>Simon Lawry, PhD Candidate</th>
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</tr>
</tbody>
</table>

Statement of consent

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- have had any questions answered to your satisfaction
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- agree to participate in the project
- understand that the project will include audio and/or video recording
- consent to having video footage or stills of myself that are taken during the experiment published or displayed for the purpose of explaining the results

☐ I consent to having video footage or stills of myself that are taken during the experiment published or displayed for the purpose of explaining the results

☐ I do not consent to having video footage or stills of myself that are taken during the experiment published or displayed for the purpose of explaining the results

Name: ........................................................................................................................................

Signature: ..................................................................................................................................

Date: ........... / ........... / ...........
Appendix G

List of actions performed with products in Experiment 2
### Table G.1 List of actions for products used in Experiment 2

<table>
<thead>
<tr>
<th>Product</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Camera</td>
<td>Open card compartment</td>
</tr>
<tr>
<td></td>
<td>Insert SD card</td>
</tr>
<tr>
<td></td>
<td>Close card compartment</td>
</tr>
<tr>
<td></td>
<td>Turn camera on</td>
</tr>
<tr>
<td></td>
<td>Turn flash off</td>
</tr>
<tr>
<td></td>
<td>Zoom in</td>
</tr>
<tr>
<td></td>
<td>Take photo</td>
</tr>
<tr>
<td></td>
<td>Turn camera off</td>
</tr>
<tr>
<td>Digital Alarm Clock</td>
<td>Set time</td>
</tr>
<tr>
<td></td>
<td>Set alarm</td>
</tr>
<tr>
<td></td>
<td>Turn alarm on</td>
</tr>
<tr>
<td>35mm Camera</td>
<td>Open card compartment</td>
</tr>
<tr>
<td></td>
<td>Insert SD card</td>
</tr>
<tr>
<td></td>
<td>Close card compartment</td>
</tr>
<tr>
<td></td>
<td>Turn camera on</td>
</tr>
<tr>
<td></td>
<td>Turn flash off</td>
</tr>
<tr>
<td></td>
<td>Zoom in</td>
</tr>
<tr>
<td></td>
<td>Take photo</td>
</tr>
<tr>
<td></td>
<td>Turn camera off</td>
</tr>
<tr>
<td>Analogue Alarm Clock</td>
<td>Set time</td>
</tr>
<tr>
<td></td>
<td>Set alarm</td>
</tr>
<tr>
<td></td>
<td>Turn alarm on</td>
</tr>
</tbody>
</table>
Appendix H

Experiment 2 – $T$ test for Gender

Table showing $t$ test for gender. No significant differences are demonstrated across 7 variables.
### Levene's Test for Equality of Variances

<table>
<thead>
<tr>
<th></th>
<th>F</th>
<th>Sig</th>
<th>df</th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>95% Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>recalled very familiar</td>
<td>5.596</td>
<td>0.025</td>
<td>30</td>
<td>0.223</td>
<td>8.06423</td>
<td>6.92274 - 9.20770</td>
</tr>
<tr>
<td>observed very familiar</td>
<td>1.054</td>
<td>0.313</td>
<td>30</td>
<td>0.298</td>
<td>7.59312</td>
<td>7.17327 - 7.05665</td>
</tr>
<tr>
<td>retrospective very familiar</td>
<td>0.569</td>
<td>0.457</td>
<td>30</td>
<td>0.192</td>
<td>11.97917</td>
<td>8.97588 - 3.52020</td>
</tr>
<tr>
<td>Baseline</td>
<td>3.018</td>
<td>0.093</td>
<td>30</td>
<td>0.926</td>
<td>-0.68412</td>
<td>-15.53092 - 14.16269</td>
</tr>
<tr>
<td>observed not familiar</td>
<td>0.006</td>
<td>0.939</td>
<td>30</td>
<td>0.714</td>
<td>-2.86304</td>
<td>-18.63912 - 12.91302</td>
</tr>
<tr>
<td>retrospective not familiar</td>
<td>1.219</td>
<td>0.278</td>
<td>30</td>
<td>0.136</td>
<td>-13.54167</td>
<td>-31.60551 - 4.52217</td>
</tr>
<tr>
<td>Totaltime</td>
<td>0.139</td>
<td>0.712</td>
<td>30</td>
<td>0.955</td>
<td>-8.32437</td>
<td>-30.1883 - 290.53959</td>
</tr>
</tbody>
</table>
Appendix I

A CD with the FIT prototype used in the trial is attached to the inside of the back cover. Please read the readme.txt file before opening the QuickTime file.
Appendix J

FIT Trial, context
CONTEXT

You have just started a new job with a design consultancy. The consultancy has assigned you to a project working with Canon to develop the next model in the G series, the G–13. You have been given an iPad with the Familiar Identification Tool (FIT) app on it, and have been asked to analyse the three users in the Canon project after going through the training material, and familiarising yourself with the app.

The goal of this is to identify interaction process that users of other types of cameras are familiar with. Once the processes have been identified, they can be integrated into the interaction processes of the G–13, thus making it easier to use.

CAUTION

Please be aware that this is a digital prototype, and in some instances may take longer than expected to react.

SECOND WARNING, BEFORE ANALYSIS

Again, I’d like to remind you this is a prototype. To activate the videos, press the play button, wait slightly, and then tap the video again.

Due to limitations with the software you can only restart the video by tapping the progress bar under the video.
Appendix K

FIT Trial – Analysis Sheet