Intuitive Interaction with Complex Artefacts

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Dedication

For Dad

Abstract

This thesis examines the role of intuition in the way that people operate unfamiliar devices, and the importance of this for designers. Intuition is a type of cognitive processing that is often non-conscious and utilises stored experiential knowledge. Intuitive interaction involves the use of knowledge gained from other products and/or experiences. Therefore, products that people use intuitively are those with features they have encountered before.

This position has been supported by two initial experimental studies, which revealed that prior exposure to products employing similar features helped participants to complete set tasks more quickly and intuitively, and that familiar features were intuitively used more often than unfamiliar ones. Participants who had a higher level of familiarity with similar technologies were able to use significantly more of the features intuitively the first time they encountered them, and were significantly quicker at doing the tasks. Those who were less familiar with relevant technologies required more assistance.

A third experiment was designed to test four different interface designs on a remote control in order to establish which of two variables – a feature's appearance or its location – was more important in making a design intuitive to use. As with the previous experiments, the findings of Experiment 3 suggested that performance is affected by a person's level of familiarity with similar technologies. Appearance (shape, size and labelling of buttons) seems to be the variable that most affects time spent on a task and intuitive uses. This suggests that the cues that people store in memory about a product's features depend on how the features look, rather than where on the product they are placed.

Three principles of intuitive interaction have been developed. A conceptual tool has also been devised to guide designers in their planning for intuitive interaction. Designers can work with these in order to make interfaces intuitive to use, and thus help users to adapt more easily to new products and product types.

Keywords

Design methods

Ergonomics

Human centred design

Human factors

Industrial design

Interaction design

Interface design

Intuitive interaction

Intuitive use

Observational analysis

Product design

Usability

Talk Aloud Protocol

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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

Alethea Blackler

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Chapter 1

Introduction

1.0 Introduction

Human–artefact interaction is a complex and important topic and has been studied from various viewpoints in recent years. This thesis aims to add a new dimension to the understanding of human–artefact interaction by explaining how and why intuitive interaction occurs and what designers can do to encourage it.

This chapter introduces the research problem and looks at the consequences of the problem and the factors contributing to it. It goes on to formulate a research question which could provide a potential solution for the problem. An overview of the rest of the thesis is provided, limitations of the research are discussed, and a brief synopsis is given of the contribution to knowledge that has been made.

1.1 Research Problem

This research is centred on the observation that products are often difficult to use correctly, especially at first. Members of Western societies may each use thousands, even tens of thousands, of artefacts, and the numbers continue to grow. The consequences of this problem are serious: for manufacturers, there are wasteful costs; for millions of users worldwide, there are frustrations, difficulties and even the threat of life-threatening risk. The problem can be stated in summary as:

Products are often difficult to use correctly, especially at first.

Taylor, Roberts and Hall (1999) suggest that the human context has become the driving force behind product design as new products have fewer constraints on their form imposed by the hardware, and Krippendorff (1995) proposes that smooth and competent interaction with a product could provide intrinsic motivation to use it. As electronic products become more integrated and more intelligent, the proportion of software elements to hardware elements seems to increase (Kwahk and Han, 2002), and increasingly complex technology needs to be usable with decreasing amounts of training (Suchman, 1987). In the information society, knowledge and information become primary resources. There have been exponential increases in system complexity in industry, in various systems from aircraft to power plants. A growing proportion of the workforce is performing information handling tasks, and complex systems are used more and more in the home (Wickens and Seidler, 1995).

A person in a Western society probably uses twenty thousand different objects, each specialised and requiring learning (Norman, 1993); however, people generally do not want to spend time learning how to use a product (Sade, 1999). Bonner (1998) claims that retaining device-dependent knowledge (for example, remembering which button will do what) is becoming more and more difficult for users as products become increasingly abstract and have similar or hidden functionality. Similarly, Giard (1989) states that the world has been inundated with so many manufactured products that the ability of the average user to understand these everyday objects is questionable. For example, in a marketing research project, many consumers could not formulate a mental simulation to describe how some common products worked (Klein, 1998). This suggests that designers should not assume that consumers know how products work (Klein, 1998; Wickens and Seidler, 1995).

Margolin (1994) stresses the need for design discourse to be expanded to include experience. A discourse about experience as it relates to design is a discourse about human interaction with products, he claims. Products are so ubiquitous that even when interacting with another person, people often use a product as a mediator. Humans have an ongoing engagement with products of many types, and each day are in situations with products that result in experiences of varying satisfaction (Margolin, 1994). Each generation faces an array of technologies that demand new skills to operate. However, currently:

> we are living through a period of particularly accelerated technological innovation which is causing a sea change in the way we use products…Thus our experience of products includes a larger component of learning than it has in the past and a successful product must depend on our willingness to master it (Margolin, 1994, p61).

With products that require less knowledge, learning normally occurs by following cues in the interface. After learning to manipulate knobs and dials on radios, most people could manage a TV, but the VCR and remote control devices (referred to here simply as “remotes”) have outstripped the average person’s cultural experience and demand a process of specialised learning, Margolin claims.

The central problem is that users in growing numbers are becoming more and more overloaded with a burgeoning range of products which have an increasing variety of purposes. Many of these products are not easy to use, especially for the first time. Manufacturers are realising that this is a problem they need to overcome more fully if they are to maintain their customer base. Furthermore, the problem could be a major factor in worldwide competition for customers over the coming decades.

1.1.1 Consequences of the Problem

This problem is affecting millions of users worldwide and has a range of consequences. These include risk to the consumer (which could be life-threatening in some situations), negative experiences for the users, and costs for the manufacturers.

Jordan (1998) states that mistakes are more likely to occur because the underlying principles of how a product works are not intuitive or are counter-intuitive. Casey (1998) relates the story of a fighter pilot being confronted in an emergency situation with a cockpit that had been re-designed very differently from the previous model, and was so unfamiliar that he could not get the aircraft off the ground. Ryan (1987, in Benedyk and Minister, 1998), claims that risky behaviour that can lead to accident or injury can be unintentional, precipitated by factors such as poor design.

Wiklund (2004) argues that most medical caregivers prefer devices that are easy to use from the start, especially as they encounter so many of them. Caregivers rarely have time for sufficient training for all the devices they may encounter (Wiklund, 2004), and up-to-date and easily accessible manuals for the equipment are rarely available (ebme.co.uk, 2002). Many first encounters with a device occur at the point of care (patient’s bedside). In these circumstances, users need to understand them

easily and quickly to reduce the chance of error and to prevent harm coming to the patient. This is especially important under the stress of an emergency situation.
All these authors point to the various levels of risks that counter-intuitive products could carry. The risks range from simple mistakes that can be corrected in a couple of seconds, to injury and death. However, even simple and correctible mistakes can have adverse consequences. Nation and Cooney (1982) conducted experiments which suggested that frustration with a system that reacted unexpectedly could lead to aggression. They tested whether aggression was evident when people were subjected to extinction in their set task (i.e. the system no longer responded as previously and as expected). All their experimental groups responded aggressively to extinction. A pressure pad was incorporated in the apparatus, as one of a number of ways of switching off a tone that the device would generate. The researchers found that once participants started to become frustrated, they were more likely to hit the pad (repeatedly and increasingly harder) than use the other available methods of switching off the tone. Frustration with a product leading to negative feelings and even aggression is not an outcome that manufacturers would prefer if they want to maintain their customer base.

Designers should not rely on user perseverance or technical skills to overcome poor interface design, so usable products are critical for attracting and keeping end users (Kwahk and Han, 2002; Margolin, 1994; Smart, Whiting, and DeTienne, 2001; Wickens and Seidler, 1995), especially as technology becomes more and more significant in people’s lives (Asfour, Omachonu, Diaz, and Abdel-Moty, 1991). Dixon and O'Reilly (2002) postulate that although people can learn to do a wide range of difficult tasks if they have to, they would prefer not to and will refrain from using a device if procedures are difficult to figure out. Nielsen (2004) hypothesises that there may be a lack of what he calls “usability culture” in consumer electronics companies. They have had little incentive to emphasise usability as consumers have no chance to try the device until after they have bought it. Those who do make an effort to provide more usable devices are not emphasising the fact in their marketing (Kantrovich, 2001). However, the incentive is growing with the potential profits as consumers become more aware of usability issues (Nielsen, 2004).

Consumer electronics giant Philips claims that the consumer electronics industry is failing with many innovations because they are too difficult to use (van Grinsven and Auchard, 2004). Philips CEO Gerard Kleisterlee has commented that technologies serve the needs of manufacturers and not customers. Thirty percent of all recently introduced home networking products sold were returned because the consumers could not get them to work. Also, 48% of digital camera buyers were delaying their purchase because they perceived the products to be too complicated (van Grinsven and Auchard, 2004). Harker and Eason (1984) also raise the issue of less obvious product failures such as partial use of system potential due to poor design. This is not immediately seen in sales figures, but could affect future purchasing decisions. Meanwhile, Okoye (1998) believes that counter-intuitive interfaces result in increased training costs.

Consequences of the problem are product misuse or under-use, dissatisfaction, frustration and even aggression among consumers faced with products which they find difficult to use, or even injury or death in the case of some medical and safety-critical products. Following from these consequences are costs and liabilities for manufacturers of products and systems; including lost business and increased training and support outlay.

1.1.2 Factors Contributing to the Problem

There is a variety of reasons why products have become problematic. These include overimputation on the part of designers, the division of control, problems with documentation, and the complexity and ubiquity of emerging new technologies. This section will review each of these factors.

Overimputation

Usability problems can arise from the natural human habit of imputing one's own knowledge to others. People impute as a natural way of understanding others because:

> If one has no direct knowledge of what another…does or does not know, and little or no knowledge that would provide the basis for making inferences in this regard, the only thing left to do is to use one's own knowledge as a default assumption as to what the other knows (Nickerson, 1999, p745).

Surprisingly, the assumption that one's own knowledge is representative of what other people know serves well, especially in a statistical sense. However, it can also be the basis for misunderstandings and failures of communication. When one knows something well, it is difficult to put oneself in the position of a person who has none of that knowledge (Nickerson, 1999). Nickerson calls this problem *overimputation*, and says that designers are the worst people to judge the usability of their own products as they cannot put themselves in the position of someone who has none of their knowledge and is seeing the product for the first time.

Designers become so expert in using the artefacts they have designed that they do not believe that anyone else might have difficulties with them, and therefore cannot predict the problems people will have (Crozier, 1994; Norman, 1988; Thimbleby, 1991). The participants in the product development process are often technically orientated, which leads to designs less suitable for non-technical users. The users are therefore required to think in a way that is not natural for them (Sade, 1999). It is dangerous for designers to assume that if they can use something then so can everybody else, since the motivations, specialist knowledge and expectations of the general population of users are unlikely to mimic those of the designer (Harker and Eason, 1984). Harker and Eason describe the distance between the user and the designer as a major problem. They also mention the time distance, as the designer is always trying to predict future user needs and preferences.

There could be two reasons for overimputation: false consensus and illusion of simplicity. The false consensus effect is a tendency to see oneself as more representative of others than one really is, and the illusion of simplicity occurs when one mistakenly judges something to be simple because it is familiar (Nickerson, 1999). This concept is consistent with Berlyne's (1974, in Crozier, 1994) theory on relative simplicity in aesthetics.

Thimbleby (1991) raises the point that designers are often too close to the problem to see users' difficulties. Designers see the development of new models as an accumulation of easily understood increments; users, on the other hand, find themselves facing what seems like a new product with ten or twenty new features, even assuming they have used an older version of the same technology. The application of extra functions to products for marketing purposes or model differentiation can make them unnecessarily complex. Gros (1997) sees such functions as the new ornament: "waste is no longer decoration, but technical bric-a-brac" (p87).

In addition, designers may not feel that consulting users is helpful in the design process. Designers interviewed by Bruseberg and McDonough-Philp (2002) were worried about how their image is perceived. They did not want to be seen to be merely doing what users actually wanted, as that would mean they seem to be following culture rather than shifting or leading it. They were also concerned about how the additional task of carrying out user research might change their roles; they thought they would end up as mediators rather than creators. They worried that they would not be able to design something new, having done research into current perceptions. They also felt that users were insufficiently knowledgeable about new technologies and materials to understand the available possibilities for new products.

Designers also may not access the human factors knowledge base as the sources may not be easily accessible, the data is presented in research reports not easily interpreted by designers, or designers have no training in how to use the information (Harker and Eason, 1984). As a consequence, designers may not be aware of the available research and recommendations for usable products. This is compounded by the fact that they often do not know whether the users will find their products easy to use because they tend to overimpute their own knowledge onto users.

Division of control

The division of labour brought about by the industrial revolution can be seen as separating not only the designer and manufacturer, but also the designer and user; previously they would have been one and the same, or at least in a position to communicate face to face (Kivisto-Rahnasto, 1998). Therefore, the designer has to somehow understand the users and communicate with them through the system image (the product and its interface).

The technological revolution has forced another division, which Blackler, Popovic and Mahar (2002; 2003b) have called the “division of control”. The user no longer has direct manipulation of, or direct feedback from, the controls of many everyday products. This is all done through a digital electronic interface. The term *opaque* has been used to describe a system that does not allow its function to be perceived from its structure (Fischer, 1991), and the terms *lack of visibility* (Norman, 1988, 1993) and *invisibility* (Sade, 1999) have also been coined for this purpose. Functionality used to be obvious because it was controlled by switches or dials on the surface of a product; now it is often buried in the product and reached only by knowing the right way through the menus and prompts (Dumas and Redish, 1993). This is not a bad thing *per se* as it saves users from having to become involved with complex, messy or dangerous parts of products, but it does demand good interface design.

Before the technological revolution, people were able to see how artefacts worked; gears, chains and levers could be moved and users could see the effects. Now there is almost no physical and spatial relationship between the controls, the indicators and the state of the system (Norman, 1993). This situation could be an advantage if the designer uses it to apply strong population stereotypes that would not have been possible in all situations when control was more direct. However, there is a dearth of research into appropriate stereotypes for modern and digital products (Simpson and Chan, 1988).

Norman (1993) divides artefacts into two broad categories according to their visibility: surface and internal artefacts. With surface artefacts, what the user sees is all there is, but with internal artefacts, part of the information is represented internally within the artefact and is invisible to the user. Artefacts with only surface representations do not need a special interface because the surface representation serves as the interface. Internal artefacts need interfaces to transform the information hidden within their internal representations into surface forms that can be accessed by humans. Therefore users depend on the design of the device to make the information visible and usable. Just as the division of labour required designers to empathise with the user, the division of control means that they have to produce an interface with which the user can successfully interact.

Documentation

Cushman and Rosenberg (1991) state that lack of adequate user manuals is a serious problem. Many users avoid reading them whenever possible, and most users of some products completely ignore any manuals or instructions provided (Cushman and Rosenberg, 1991). Rettig (1991) agrees that "no one reads manuals. Well hardly anyone" (p 20). Even well written and well designed documentation is not read by adult readers. Most people will constantly skip ahead and begin to use the system without reading the whole manual (Brockman, 1990, in Rettig, 1991).

It is not that people cannot follow simple steps, it is just that they do not. Many people can only gain understanding through the effectiveness of their actions in the world (Rettig, 1991). The world they are in is more real to them than a series of steps on a page and provides rich context and conventions for everything they do. People try things out, think them through and try to relate what they already know to what is going on (Rettig, 1991). Therefore, most people do not read documentation. They just start using a system, turning to the manuals only when they are stuck or the system does not conform to their expectations. For computer systems, print or online help is seen as a last resort (Rettig, 1991), after repeating steps, rebooting and asking co-workers for help. The only thing not done before looking at the documentation is calling a help desk (Smart et al., 2001).

Documentation is not always available, especially for shared or office equipment and software. For example, a site license does not automatically include manuals; they are an optional extra. Also, training courses may not include a manual. For miniaturised devices, there is a lack of equally portable external support materials to provide user guidance and training (Kaufman, Stewart, Thomas, and Deffner, 1996). In workplaces, users are often trained at roll-out of a new system but users joining the organisation later or changing jobs get only on the job training from co-workers (Rohlfs, 1998).

Because documentation is either not available or not read, human factors professionals tend to believe that a product should be usable without a manual. Even Phillips has conceded that if a product requires a manual it may be too complex (van Grinsven and Auchard, 2004).

Emerging technologies

Product design is undergoing a change from three dimensions to two dimensions as hardware disappears and transforms into interfaces (Gros, 1997). Gros suggests that in the future, multimedia design will probably increasingly concentrate on functional metaphors and clear signs for use, especially where it is part of a product. Interaction, rather than physical products, will need to be designed as products and services become more interactive (Bonner, 1998).

Advances in communication and computing are bringing new devices onto the market rather than the traditional Windows, Icons, Menus and Pointing Device (WIMP) interfaces. These devices are small, mobile and wireless and users will interact with them through tactile, gestural, voice and pen input. These devices bear little resemblance to traditional computers and therefore offer new challenges and opportunities to interface designers (Smith, 1998). More and more novel forms of interaction are appearing that comprise physical objects with embedded computational power, such as electronic ink, interactive toys, smart fridges and networked clothing (Preece, Rogers, and Sharp, 2002). One of the characteristics of these new generation products is that potential users can have difficulty understanding them (Smith, 1998).

Baber and Baumann (2002) discuss embedded, or ubiquitous, computing. An embedded system is any device that includes a programmable computer but is not itself intended to be a general-purpose computer (Baber and Baumann, 2002). Thus, a personal digital assistant (PDA) would count as an example of an embedded system, as would a mobile phone or any domestic products that contain microprocessors. Baber and Baumann (2002) recognise a growing trend towards embedded computer systems that are distributed throughout the environment, and propose that this trend raises significant issues for the usability of these products.

Kaufman et al. (1996) discuss the impact of portable products. Portability requires smaller size, which severely limits the ease and efficiency of user–system interaction. Future devices will provide much more power and functionality than today's desktop computers, but will not even have keyboards. Because of the lack of large displays and supporting materials, the user must depend on memory and mental models to guide navigation. Kaufman et al. (1996) state that the usability of these types of products will depend on their successful integration with human behavioural stereotypes and mental models, and that only human, everyday metaphors can help users benefit from the wealth of information, communication, storage, and processing available through the new generation of tools.

These new types of increasingly powerful, embedded and miniaturised technologies will create further challenges for designers. Not only are they more complex and physically less accessible due to their size, but they will be everywhere. Therefore, people will have less choice about whether or not they want to use certain technologies as it will be very difficult to avoid these types of products in everyday life. Designers will not be able to rely on the technologically inclined enthusiasts propping up the market; a huge range of people will need to be able to interact with them easily.

1.2 Research Question and Aims

Some researchers have long held the view that machines ideally should be self-explanatory, in that their operation should be discoverable, without extensive training, from information provided by the machine itself (Suchman, 1987). Krippendorff and Butter (1984) comment that especially innovative products rely on semantic clues to communicate their use and minimise the need for instructions. Blaich (1986) proposes that every product should speak, communicating its purpose and correct operation without words or numbers.

In general parlance, in advertising and in academic papers such as those of Rutter, Becka and Jenkins (1997), Frank and Cushcieri (1997), Thomas and van Leeuwen (1999) and McMullen (2001), the terms “intuitive to use” or “intuitive use” can be commonly seen and heard. It would appear that making things intuitive to use would address the problem. However, there is a need to de-mystify intuitive use and establish how it can be applied to new products in order to make them easier to use. The research question is therefore:

How can designers utilise users’ intuition in order to make products easier to use?

The aim of this research is to provide designers with principles and tools which they can employ during the design process in order to make their products more intuitive to use. In order to achieve this aim it is necessary to base the research on a theoretical foundation which includes an understanding of the nature of intuition itself and how it relates to product use, and to empirically test that understanding in order to see how it can best be applied to design.

1.3 Overview of Thesis

This section contains an overview of the structure of the thesis, its limitations and the contributions it makes to knowledge.

1.3.1 Contents

Chapters 2 and 3 review the literature on the nature and processes of intuition, finishing with a definition of intuition to be used for the purposes of this study. Chapter 4 reviews the limited work done on intuitive interaction, and Chapter 5 details other relevant work which could contribute to intuitive interaction, ending with a definition of intuitive interaction. Chapter 6 describes the research methodology employed and justifies the methodology according to the needs of the research and the available methods. Chapters 7 and 8 describe the first two experiments carried out on two different products to test the hypothesis that intuitive use of products is based on applying experience gained from other products. Results from these studies are discussed and explained. Chapter 9 covers the redesign process undertaken with a universal remote control. This process allowed a comparison between the re-design of location and appearance of features through a final experiment. The experiment is described and results and conclusions explained. Chapter 10 discusses the implications of all these results, draws conclusions and makes recommendations.

1.3.2 Limitations

Emotion and design (hedonic or affective ergonomics) are possibly related to intuitive interaction in several ways, but their relationships are not examined in this thesis. Emotion as part of the intuitive process is seen as operating on a functional but non-conscious level and encoded as part of a user’s experience. Emotion is not covered in the definition of intuition or intuitive interaction because the focus is on how a user’s experience informs their use, rather than their emotions directly. Emotional state at time of the experiments was a controlled variable in all experiments but was not manipulated.

Due to the limitations of the products used for the experiments, it was not possible to investigate the effects of colour on intuitive interaction. Some conclusions about the way colour could be used can be generalised from the results, but specific investigations focussing on colour are not included.

Individual differences in learning styles and personalities, and how these factors relate to intuition and product use, are not a focus of this research. Reasons for this are discussed in Chapter 3.

1.3.3 Contributions to Knowledge

This research has made a contribution to knowledge by establishing two main principles through experimentation. Firstly, intuitive use is based on past experience and can be transferred between different products or systems. Designers can make products intuitive for target users by employing familiar features in their interfaces. Other researchers have suggested this idea but none have carried out experimentation to empirically test it and apply it to design.

Secondly, the appearance of a feature is more important for intuitive interaction than its location. This suggests that the cues that people store in memory about a product feature depend on how the feature looks rather than where on the product it is placed. From these conclusions three principles and a conceptual tool that designers can directly apply to their designs have been developed.

Further, this research has contributed to new methods in three ways. Firstly, through the detailed use of video observation software, an observer is able to make decisions about the type of cognitive processing a participant is drawing on while using a product. This data, along with more empirical data traditionally collected during in user testing, was used to draw conclusions about whether or not a participant was using the features of the product intuitively.

Secondly, three factors – function, location and appearance – were successfully used to unravel the way in which users experience problems with an interface. These factors have been applied to simple rating scales and used to gain user feedback after a participant has used the product. For simple products where users can easily distinguish the function, location and appearance from each other, these work very successfully. For more complex products where these factors can become more ambiguous, they showed some measure of success but were less clear. For usability testing these factors could be extremely valuable.

Finally, during this work, the researcher has developed a measure of technology familiarity and a method of scoring it. This was used to group participants and was found to be more valuable than the traditional expert, intermediate, novice and naïve groups when investigating intuitive interaction.

1.4 Summary

Chapter 1 has provided an introduction to the thesis, explaining the research problem and its possible solution in the form of the research question. In addition an overview of the contents and contributions is provided. This background will now be built upon in Chapters 2 to 5 as an understanding of intuition and intuitive use is developed.

Chapter 2

Intuition

2.0 Introduction

Research on intuition in psychology and cognitive science has been patchy because intuition is connected with the unconscious, and traditionally was not regarded as accessible to scientific study (Bowers, 1984; Woolhouse and Bayne, 2000). Indeed, Bowers (1984) claims that intuition has been virtually ignored by psychologists. Good overviews of the history of the concept and its intermittent study are provided by Boucouvalas (1997), Bastick (2003) and Fischbein (1987). This chapter firstly reviews definitions of intuition, and then goes on to look in detail at the proposed foundation of intuition: experiential knowledge. Research that has proposed theories of how past experience is used in memory, action and cognitive processing is reviewed as there is very little research into intuition itself. This work also supplies suggestions about the mechanisms by which intuition is informed by past experience.

2.1 Definitions

Intuition has been associated with preconscious processes, mysterious knowledge and subjective certainty of correctness. A variety of terms has been used interchangeably with intuition, such as “right brain thinking”, “gut feeling” and “hunch” (Boucouvalas, 1997). There is no firm and definite agreement on a definition of intuition or exactly how the process works (Bastick, 2003; Fischbein, 1987; Laughlin, 1997), and Hammond, Hamm, Grassia, and Pearson (1987) claim that researchers in cognition almost never explain what they mean by intuition; consequently, it is customary to define it in terms of what it is not. Even philosophers, they argue, fail to say what they mean by intuition. However, this section will demonstrate that many researchers agree on its basic properties.

From the Latin *intueor* (to look at, gaze at, consider or contemplate), the Oxford English Dictionary (1989) defines the term intuitive as “knowledge or mental perception that consists in immediate apprehension without the intervention of any reasoning process.”

Westcott (1961) assumes that intuition is obscure in the inferential process from information to conclusion and that sometimes the relationship between the two may seem to be lacking altogether, and defines an intuitive leap as "…an act in which someone reaches an inductive conclusion from a very limited number of examples or cases" (Westcott, 1961, p267). Jung's (1969, in Bastick, 2003) definition is "a non-judgemental irrational mental activity through which an individual can perceive an internal or external event or object in its entirety." This is not in accord with most other definitions as Jung saw intuition as a personality trait rather than as a form of cognitive processing.

Simonton (1980) defines intuition as "behavioural adaptations to the environment which tend to be unconscious, ineffable, and essentially probabilistic in character" (p6). Eysenck (1995) interprets Simonton's "ineffable" as "impossible to verbalise" (p191), which is generally seen as the operational measure of an unconscious process. Kahneman and Tversky (1982) present intuition as an informal and unstructured mode of reasoning, without use of analytical methods, while Gregory (1987) similarly defines intuition as arriving at decisions or conclusions without explicit or conscious processes of reasoned thinking. Several other researchers agree that intuition is a process by which understanding or knowledge is reached without evidence of a reasoning process (Bastick, 2003; Fischbein, 1987; Noddings and Shore, 1984).

Bowers (1984) defines intuition as the possibility for being tacitly informed by considerations that are not explicitly represented in conscious awareness. He presents it as a distinct information processing mode, in which unconsciously stored information is used to guide decisions and problem solving. Eysenck (1995) defines intuition as a mode of cognitive functioning located at the opposite end of a continuum from logical thinking, characterised by speed and suddenness of reactions, a small number of relevant known facts, feeling of certainty about the conclusion, reliance on unconscious (non-verbalisable) processes, and not following the rule of logic but relying on unusual associations and analogies. The adjective *intuitive* refers to the process of arriving at the solution, not the solution itself. Eysenck claims that intuition is a cognitive process and not a moment or event.

According to Richman, Gobet, Staszewski, and Simon (1996), "intuition is synonymous with the process of recognition (p180). In other words, it is about identifying something that has been seen or experienced before. Cole (1996) equates intuition with pattern recognition. He states that a challenge for the future would be to explore pattern recognition as a key principle for information design. Berry and Broadbent (1988) also state it is likely that some general overall pattern matching process plays a critical role in implicit learning and knowledge use. Klein, who also equates intuition with pattern recognition, has done some of the most important work on intuition in recent years. His definition is; "Intuition depends on the use of experience to recognise key patterns that indicate the dynamics of the situation" (Klein, 1998, p31). Klein's work is discussed in more detail in Section 2.2.4.

These definitions ascribe to intuition the main property of past experience informing the processing. This crucial aspect will be explored first. Other properties identified are processing which a person is not aware of or has not consciously recognised, and the faster speed and efficiency of intuition over other cognitive processes. These and other issues that various researchers have discussed are explored in Chapter 3.

2.2 Intuition and Experiential Knowledge

This thesis is based on the underlying assumption that intuition is based on past experience. Evidence to support this assumption is presented in this section. Much research suggests that intuition relies on experiential knowledge (Agor, 1986; Bastick, 2003; Bowers, Regehr, Balthazard, and Parker, 1990; Cappon, 1994; Dreyfus, Dreyfus, and Athanasiou, 1986; Fischbein, 1987; King and Clark, 2002; Klein, 1998; Laughlin, 1997; Noddings and Shore, 1984). Intuition depends on using experience to recognise patterns that indicate the dynamics of a situation. It relies on implicit memory and "grows out of experience" (Klein, 1998, p34). People draw on memory for large sets of similar incidents, not one specific instance, which may be why people are not aware that intuition is their own experience. Described in this way, intuition does not seem as mysterious as some people may at first assume (Klein, 1998).

Klein believes that usually the experience bank works smoothly, providing structure and interpretation even for unfamiliar tasks. Therefore, a stimulus would not need to be identical to those previously experienced, just similar enough to allow the association (Klein, 1998).

The intuitive process integrates the information that one already has with what is perceived by the senses, and new associations between this information produce insights, answers, recognition or judgements. Shreds of information that before had no meaning become prominent in the light of new conclusions (Bastick, 2003). During intuitive processing some of the premises are contained in the stimulus event and some in the coding system of the perceiver, and intuition can perform rapid extrapolation based on class membership of the event categorised (Eysenck, 1995). Boucouvalas (1997) suggests that intuitive knowing may have different origins, for example the memory, the senses, even the collective unconscious of a society. An optimum intuitive solution will have the maximum redundancy; the most attributes in common between the fewest elements (Klein, 1998) or, in other words, a good match between stored experience and the current perceived situation. So, intuition uses a combination of existing knowledge and the perceived situation to rapidly generate answers.

Bowers et al. (1990) state that “our model of intuition implies the role of memory and experience in judgement and problem solving” (p73). In particular, they propose that clues activate relevant networks in memory, thereby guiding thought to some hypothesis or insight. Bastick (2003) concurs that if something has been experienced before, it will be intuitively recognised. Noddings and Shore (1984) found that intuition does seem to manifest itself in familiar domains, and that people most knowledgeable in an area are those who have the most frequent and the most reliable intuitions. One could interpret their finding as suggesting that this is because those with most knowledge on a topic have a larger store of information for intuition to use. King and Clark (2002) conducted case studies which revealed that their subjects (nurses) attributed intuitive feelings to experience of caring for similar patients. Many of the interview transcripts show that nurses believe that their intuition is based on their experience.

Dreyfus et al. (1986) claim that people use intuition all the time in everyday tasks and that it is not wild guessing or supernatural inspiration. To guess is to reach a conclusion when one does not have sufficient knowledge or experience to do so, whereas "intuition is the product of deep situational involvement and recognition of similarity" (p28). They equate use of intuition with having expectations, which are associated with remembered situations. Intuition, they believe, plays a role in the human ability to make sense of an environment which is potentially infinitely complex.

This dependence of intuition on previous experience is usually not recognised by the general public, and many lay people may assume intuition is instinctive or innate (Cappon, 1994). However, an individual's experience gradually accrues over time. A baby's intuition is composed predominantly of instinctive responses to stimuli which are indeed innate, but people include more and more learned responses in their intuition as they develop (Bastick, 2003). Nardi (1996) states that "all human experience is shaped by the tools and sign systems we use" (p10). This statement strongly supports the central idea that all the tools people use in their everyday lives are adding to the experience bank so that people can access their experience in order to use similar objects.

All those who have seriously researched intuition have agreed that intuition is based on experience rather than on supernatural inspiration or some magical sixth sense. This experience may be stored as an amalgam of previous situations, rather than a specific one or two, and can feed expectations. Tools and artefacts are part of the human experience and contribute to the store of information on which intuition can draw. This section has clearly indicated that intuition is based on experiential knowledge, supporting the underlying assumption of the thesis. The following sections review relevant theories that apply to intuition based on past experience and suggest how intuition may utilise that experience.

2.3 Experientialism and Embodiment

Experientialism sees people's sensorimotor, emotional and social experiences as the main influence on cognitive activity (Benyon and Imaz, 1999; Clark, 1997; Damasio, 1994; Johnson, 1987; Lakoff, 1987; Varela, Thompson, and Rosch, 1991). One of the reasons for this is the way in which the brain develops. Although the neurons are in the brain at birth, the design of brain circuitries that represent the growing body and its interactions with the world depends on the activities in which the person is involved (Damasio, 1994; Greenfield, 2000). The mind exists for and in an integrated organism, and minds would not be the way they are if it were not for the body–brain interplay. Mind and body combined are an indissociable organism, and that organism interacts with the environment as an ensemble (Damasio, 1994). The brain and body are integrated biochemical and neural circuits. This interweaving occurs in biological tissue and uses chemical and electrical signalling. The mind had first to be about the body or it could not have been; the brain evolved to control and respond to the body, so of course it has to be inextricably linked (Damasio, 1994). The biological mind is first and foremost an organ for controlling the biological body. Minds are not disembodied logical reasoning devices, but are organs for rapidly initiating the next move in real world situations (Clark, 1997).

Varela et al. (1991) claim that cognitive science has had virtually nothing to say about what it means to be human in everyday situations. Similarly, Clark (1997) proposes that treating cognition as pure problem-solving invites researchers to abstract away from the very body and the very world in which the brain evolved to guide humans. Cognitive science can no longer afford simplifications that take the real world and the acting organism out of the loop, he says.

Johnson (1987) argues that experience involves everything that makes people human; bodily, social, linguistic, and intellectual experiences combine in complex interactions that make up an understanding of the world. He states that human bodily movement, manipulation of objects, and perceptual interactions involve recurring patterns without which experience would be chaotic and incomprehensible. He calls these patterns "image schemata", and claims that humans could not begin to understand their experience without image-schematic meaning structures. For example, the types of schemata he describes include container, blockage–enablement, path, cycle, part–whole, full–empty, iteration, surface, balance, counterforce, attraction, link, near–far, merging, matching, contact, object, compulsion, restraint removal, centre–periphery, scale, splitting, superimposition, process and collection. All of these can be extended from merely physical actions to metaphors about how people understand the world and language.

Understanding typically involves image–schematic structures of imagination that are extended and figuratively elaborated (Benyon and Imaz, 1999; Johnson, 1987). These give comprehensible structure to experience and connect up different experiential domains to produce coherence and unity in understanding the world. The image schemata are not concrete images or mental pictures; they are more abstract patterns. Johnson (1987) claims that this is how real human beings reason, rather than by some ideal standard of rationality. Therefore, people can understand objects because they have experienced basic image schemata through the working and interaction of their own bodies. People use their experiences as embodied individuals as models or image schemata to understand other parts of the world around them (Balkin, 1998). Similarly, when interacting with the environment, people describe forms in relation to their own body, vision or motion; for example, they allocate front, back, sides, and so on (Krippendorff, 1995).

Varela et al. (1991) mean two main things by the term *embodied*: that cognition depends on the kinds of experience that come from having a body with various sensorimotor capacities; and that the individual sensorimotor capacities are themselves embedded in a more encompassing biological, psychological and cultural context. They emphasise that sensory and motor processes, perception and action are fundamentally inseparable. Damasio (1994) also concurs that the human body, rather than some absolute external reality, is used as the ground reference for the constructions people make of the surrounding world.

Held and Hein (1958, in Varela et al., 1991) conducted animal studies which showed that objects are not seen by the visual extraction of features but by the visual guidance of action with those features. A young animal which develops in the dark but is allowed to move around in a normal way will be able to interact well with its surroundings in the light. However, an animal not allowed to interact with the environment but allowed to see it cannot interact with the environment at all when finally allowed free access to it. Similarly, Campos, Hiatt, Ramsey, Henderson and Svejda (1978, in Clark, 1997) showed that children who can crawl respond to a cliff or drop with fear, whereas those who have not yet experienced independent movement just show curiosity. This suggests that animals and humans learn about the world by performing actions within it, and that perception is action specific.

Tucker and Ellis (1998, 2001, in Borghi, 2004) support this view; they found that eye movement was more accurate in selecting a target that had to be grasped than one that had to be pointed to, and concluded that action intention leads to different ways of focusing on visual properties. Borghi (2004) conducted experiments with objects and the results suggest that objects are conceived of in terms of the potential actions people can perform with them; so the most important parts in an object concept should be the ones affording the more frequent actions performed with it. The cognitive system subserves action by storing information which might be relevant for future actions in different situations (Borghi, 2004).

The notion of scaffolding (the way in which experience with external structures might alter and inform a person's intrinsic modes of processing and understanding) can encompass all kinds of external aids and support provided by others or the environment. A person draws on the resources of mind, body and world in order to accomplish tasks (Clark, 1997). This is similar to Norman's (1988) idea of knowledge in the head and in the world. Norman encourages designers to put all the information they can into interfaces so that users do not have to memorise it.

The research into embodiment and experientialism suggests that intuition utilises experiential knowledge gained through the experience of being in a human body. This is practical knowledge of things like the effects of gravity and the possibilities and constraints of the limbs and fingers. It appears that this sort of knowledge is learned so early and utilised so easily that it is likely never to become conscious for most people, but still guides all their interactions.

2.4 Connectionism

Connectionists describe the mind as consisting of networks of relatively simple processing units connected by links. This idea has also been called “spreading activation” (Holyoak, 1985), “neural networks” and “parallel distributed processing” (Clark, 1997). Connectionist models have changed the way people think about cognitive science. Previously it had seemed unnecessary to have any idea of brain biology in order to have ideas about cognition (Clark, 1997). Clark sees the brain as an associative engine. In the connectionist model, knowledge representation is based on interactions between networks, and if one unit or node is activated, the activation can spread to related items in memory that are linked through the network.

Hebb (1949) proposed a cell assembly theory of cognition that went much further than the prevalent stimulus response work of the time, and laid the foundations for modern theories of connectionism. Hebb’s rule, cited by Damasio (1994) and Varela et al. (1991), states that if two neurons tend to be active together their connection is strengthened, otherwise it is diminished. Therefore, the system's connectivity becomes inseparable from its history. Hebb suggested that the brain contains numerous redundant neural pathways, and proposed that the connections establish autonomous central activities which serve as the basis of further learning (an important link here with use of previous knowledge to tackle new situations). Interest in neural networks declined during the 1970s but was revived by Rumelhart, McClelland and the PDP Research Group (1986), who called it “parallel distributed processing” (PDP). PDP has been more cognitively eclectic than the original connectionist ideas, suggesting that cognitive processes might be constraint satisfaction processes, energy minimisation processes or even pattern recognition processes. It has also been largely defined in relation to a computational theory of cognition, and has been widely applied to artificial intelligence (Clark, 1997).

Connectionist models could provide mechanisms for implementing a parallel, content-addressable memory retrieval system (Holyoak, 1991). Holyoak claims that this type of network can represent the kind of difficult-to-verbalise knowledge associated with expert intuition. Activation and deactivation of associations can be explained through the process of excitatory and inhibitory connections within the neurons, and therefore when a stereotype (Kunda and Thagard, 1996) or mental model (Betsch and Fielder, 1999) is activated, activation spreads to the traits associated with it. Reason and Mycielska (1982) and Greenfield (2000) concur that frequency and recency of a connection will affect its activation level and therefore busy and well used neural pathways are more likely to be used repeatedly; connections commonly made are more likely to be made again in a similar situation.

Varela et al. (1991) claim that the resiliency of the brain to resist damage and its flexibility to adjust to new environments without compromising all of its competence are taken for granted by neurobiologists, but are not seen in the computational paradigm. In the connectionist approach, meaning is not located in particular symbols, it is a function of the global state of the system and is linked to the overall performance in some domain.

Information is carried by a pattern of activation spread across a population of neurons. Distributed encodings present a number of advantages (Clark, 1997). Firstly, the pattern is encoded in such a way that minor variations in the pattern reflect minor differences. Secondly, it is possible to use methods of overlapping storage so each neuron plays a role in encoding many different things. Thirdly, new items or events can be given non-arbitrary codings based on the extent to which a new one resembles an old one. The link Clark makes here between previous knowledge and the approach to new tasks, also emphasised by Holyoak (1985), is important in understanding how intuition functions within this kind of network.

Clark (1997) hypothesises that the knowledge of the system is encoded in the weighted connections between the units, and these weights are adapted during learning. Greenfield (2000) claims that intuition and common sense are dependent on endless configuring and reconfiguring of connections between neurons. Strength of associations between events or things in memory could determine whether they will be linked in certain circumstances (Simonton, 1980). Conditional probability would determine how strong these associations are, and low probability associations would be ignored. Intuition would therefore work by experiential build up of these associations (Simonton, 1980).

The connectionist approach makes perfect sense when seen in the context of neurobiology. It can explain how intuition can access experience from many different domains to suit the current situation, and emphasises how much people base new responses on previous experience. The experientialist account also fits well with these ideas, as the theory that the brain is a physical organ that can grow and change like other parts of the body fits with both positions. Indeed, the connectionist and experientialist approaches tend to be taken together by such researchers as Varela et al. (1991), Clark (1997) and Damasio (1994).

2.5 Dynamic Memory

Schank (1982) founded the theory of dynamic memory. He includes reminding as an important part of memory and human functioning. Processing new situations uses memory structures that contain episodes most closely related to the new one. Thus, reminding occurs when the most appropriate structure in memory that will help in processing a new input has been located. Importantly, people use what they know to help process what they perceive, and they understand in terms of what they have already understood. However, prior to Schank's work, this view of understanding had not been pursued by either psychologists or artificial intelligence workers. This view is shared by those who have worked on experientialism and embodiment (Benyon and Imaz, 1999; Johnson, 1987; Lakoff, 1987) and on intuition (Agor, 1986; Bastick, 2003; Bowers et al., 1990; Cappon, 1994; Dreyfus et al., 1986; Fischbein, 1987; King and Clark, 2002; Klein, 1998; Laughlin, 1997; Noddings and Shore, 1984).

One premise of dynamic memory is that conscious remindings and the remembering that happens unconsciously during understanding are products of the same retrieval process. The natural process of traversing the indexing structure of memory to find the best expectations provides remindings. Such remindings are unintentional and happen as a natural consequence of understanding (Kolodner, 1993). When performing an activity or thinking about an activity they have encountered before, people tend to be reminded of the earlier, similar one. People notice their own remindings when they are surprising; otherwise they may not be consciously available (Kolodner, 1993).

A major claim of the model is that memory is dynamically changing with each new experience. A dynamic memory with indexed general and specific knowledge learns by acquiring new cases, re-indexing the cases it has, creating new generalisations, learning what to pay attention to and learning new ways to index cases. This idea is consistent with the notion of connectionism although it introduces dynamism to the memory model. This seems reasonable if one accepts Clark's (1997) and Greenfield's (2000) contentions that, like a muscle, the brain develops and changes through use, and that hard working parts of the brain grow more connections.

2.5.1 Case-Based Reasoning

Case-based reasoning derives from and is based on dynamic memory. A basic premise of case-based reasoning is that "concrete, specific, operational knowledge in the form of cases is easier and more beneficial to reason with than abstract knowledge" (Kolodner, 1993, p130). Knowledge is in the form of specific events and generalisations of specific events. Knowledge access, or remembering, is a key part of reasoning, as understanding is a process of integrating a new experience with what is already known. People merge and adapt solutions to old problems to solve new ones. Kolodner (1993) assumes that novices begin with incomplete and flawed models of devices and the ways they need to reason to solve problems. With experience they acquire new cases and update the models. As people learn a new domain, they pay attention to the things that previous experience tells them are important (Kolodner, 1993).

Claiming that people find case-based reasoning natural, Kolodner (1993) states that people learning a new skill often refer back to previous problems to refresh their memories. In the natural situations Kolodner observed, use of previous cases was far more important than applying abstract principles or conscious deliberating. Previous cases provided concrete manifestations of the rules that allowed them to be applied easily, although novices can have problems as they do not always access the right cases and they are missing the experience to build up the cases as well as the judgement to decide which parts of a situation are important. This model implies that knowledge can be used within domains or transferred across domains in an unconscious process using the memories already stored about similar situations. This could be equivalent to the process commonly referred to as intuition.

2.6 Expectancies

William James used the term “preperception” for instances in which the stored visual concepts help to recognise insufficiently explicit perceptual patterns. He said that the only things people commonly see are those they preperceive, and the only things they preperceive are those which have been labelled, and the labels stamped into their minds. A person who had lost her/his stock of labels would be lost in the midst of the world (James, in Arnheim, 1969, p93). Arnheim also refers to early experiments by Wundt (year unstated), in which reaction time is shortened or lengthened depending on whether a stimulus, when it appears, is expected or not. The effect of preperception depends not simply on how many times the prototypes have been met in the past (familiarity) but also on what the nature of the given context seems to require (expectedness). What one expects depends on what seems to belong in a particular place (Arnheim, 1969). So the perception of familiar kinds of objects is related to norm images in the observer’s mind.

Wickens, Gordon, and Liu (1998) claim that expectancies based on experience tell the perceptual system what to look for or where. Oxman (2002) claims that visual prototypes guide perceptual identification. This suggests that prototypes made up of past experiences and stored in memory are forming expectations and guiding perception.

Jentzsch and Sommer (2002) found that expected events were processed faster than unexpected ones and fewer errors were made for the more expected event. Participants’ judgement when performing certain tasks is usually influenced by expectation, and what they call intuitive judgement is commonly referred to as subjective probability or expectancy (Jentzsch and Sommer, 2002). The authors suggest that expectancy modulates the relative degree of activation of representations in memory prior to stimulus presentation. If the pre-activated and presented stimuli correspond, there will be an advantage in response speed and accuracy. Pearson and Schaik (2003) found that previous knowledge of display conventions such as colour coding and location of display items can influence effective search of a visual display (website), making it significantly quicker, and that search time will increase if information appears in an unexpected position. Expectancies work is related more to perception than to cognition, but is another demonstration of processing being profoundly affected by the past experiences that have shaped a person's reactions.

2.7 Decision Making and Intuition

There is a growing body of research which demonstrates that intuition is integral to decision making (King and Clark, 2002). Decisions that are quick and relatively automatic are often termed *intuitive decision-making*. Slower and more reasoned or deliberate decisions are called *analytical* (Wickens et al., 1998). Fast (or intuitive) decision making uses various heuristics; for example, the availability heuristic (people will most easily retrieve hypotheses that have been considered recently or frequently) and the representedness heuristic (a tendency to judge an event as likely if it represents the typical features of its category). Usually this is a very effective strategy. The generality of these heuristics has been tested and researchers have found that in the real world, behaviour parallels the results found in laboratories (Wickens et al., 1998).

Intuitive processes inform decision making, and often intuitive awareness leads to analytical thinking to further address a perceived problem (King and Clark, 2002). In other words, people use analytical thought to verify intuition and justify a decision. This often happens in diagnosis, chess and other expert situations (Bastick, 2003; Dreyfus et al., 1986; Klein, 1998; Laughlin, 1997).

2.7.1 The Recognition Primed Decision (RPD) Model

Klein (1993) introduced the Recognition Primed Decision (RPD) model, claiming that it describes how decision making occurs in real world settings. It is a model of naturalistic decision making that describes how experienced people make rapid decisions in real situations. He asserts that the decision is primed by the way the situation is recognised. In his field studies involving fire commanders, he found that for many of them their vast experience had enabled them to merge individual cases and to be able to use a judgement of familiarity or prototypicality that would not be present with the retrieval of an individual case (Klein, 1993).

Experience allows a person to understand a situation in terms of plausible goals, relevant cues, expectancies and typical actions (Klein, 1993). Fire commanders' experience let them see even a non-routine situation as a prototype, so that they knew the typical course of action. Their experience let them identify a reasonable reaction as the first one considered, so they did not need to think of others and processing was faster (Klein, 1998). Because the RPD model is based on decision makers using their existing experience, Klein (1998) sees it as a model of intuition. In the RPD model, proficient people detect patterns and typicality. They can size up a situation at a glance and realise that they have seen it or variants of it dozens or hundreds of times before, even though each situation has something unique about it. Their experience buys them the ability to recognise when a situation is a typical case, or when a pattern is broken or an expectancy violated.

Recognitional decision making is most likely when the decision maker is experienced, time pressure is great and the condition is not stable, but Klein (1993) found that professional engineers still relied heavily on recognitional decision making for difficult cases even when not under time pressure. Analytical strategies were often used by decision makers with less experience, and sometimes both recognitional and analytical decision making processes were applied within the same task (Klein, 1993). This accords with the Skill, Rule, Knowledge model (Section 3.3).

After developing this model over many years of field studies, Klein (1998) presents its main applications as improving training and designing better systems. Klein's work provides the strongest and most recent evidence that intuition is based on prior experience. He developed his model based on observations and interviews of hundreds of people in fields from fire-fighting and engineering to search and rescue and the military and his work is highly respected.

2.8 Metaphor and Analogy

One way in which many researchers have suggested that experiential knowledge can be tapped is by using metaphor and/or analogy. Metaphors can provide immediate awareness of some aspects of the world (Dent-Read, Klein, and Eggleston, 1994), which is a claim also made for intuition. Metaphor and analogy are not synonymous. An analogue is an event or example drawn from the same or a related domain while analogies consist of parallels in relations; kittens are to cats as puppies are to dogs (Dent-Read et al., 1994). A metaphor comes from a different domain (Klein, 1998). The definition of metaphor is a point of controversy in philosophy, cognitive psychology and human computer interaction (Dent-Read et al., 1994). Metaphor, in the experiential sense, is a process by which people understand and structure one domain of experience in terms of another domain of a different kind. The most basic type of projection is metaphorically extending a schema from the physical to the non-physical. Metaphor operates at the level of projections and elaborations of image schemata, and people may not consciously experience these projections (Johnson, 1987). People use analogues and metaphors for understanding situations, generating predictions, solving problems, anticipating events, designing equipment, and making plans (Klein, 1998).

The human conceptual system is fundamentally metaphorical according to Lakoff and Johnson (1981). Lakoff (1987) claims that metaphor is natural and motivated by the structure of human experience. Greenfield (2000) presents metaphor and analogy and the ability to draw them as a major evolutionary step in the development of mankind, and Holyoak (1991) claims that analogical thinking is particularly powerful, saying that it is one of the central mechanisms for transfer of knowledge across domains.

Barker and Schaik (2000) and Norman (1993) agree. All the applicable factors belonging to the metaphorical vehicle are implied through the vehicle itself, so its use may be more economical and therefore more effective than the long list of factors that it represents (Gregory, 1987). The power of metaphorical models stems from their ability to shape and hence limit understanding, and without metaphorical models understanding may be difficult or impossible (Balkin, 1998).

Metaphor involves retrieval of useful analogies from memory and mapping of the elements of a known situation, the source, and a new situation, the target (Holyoak, 1991; Lakoff, 1987). Once the relevance of the source is considered and an initial partial mapping has been established, the analogical model of the target can be developed by extending the mapping. Ideally, the goals, objects and constraints of the resulting target model will be as similar as possible to those of the source (Holyoak, 1985).

Process and function, as well as shape, can be the basis of a metaphor. Some of the properties of the vehicle objects must be present in the depiction of the topic objects in order for the depiction to be metaphorical (Dent-Read et al., 1994). A functional metaphor or analogy relates the function and operation of one object to those of some other object, for example a typewriter as a metaphor for a word processor. A non-functional metaphor does not relate to function or operation but to some other aspects, for example a sports car as a metaphor for a word processor (Janlert and Stolterman, 1997). Often, abstract concepts are defined metaphorically in terms of concepts that are more concrete and more clearly structured (Lakoff and Johnson, 1981).

However, "a metaphor can serve as a vehicle for understanding a concept only by virtue of its experiential basis…no metaphor can be comprehended, or even adequately represented, independently of its experiential basis" (Lakoff and Johnson, 1981, p202). Therefore, metaphors are grounded in experience and understood only in relation to experience. Each experience or vicarious experience can serve as a metaphor or analogue (Klein, 1998). Rasmussen (1986) mentions intuition as being enabled by this sort of transfer. Using metaphor, a problem is transferred "…to a level where immediate intuition from experience is available" (Rasmussen, 1986, p123).

A connectionist style network can use the similarities that link the components of the source and target problems. Therefore, the more properties a problem in memory shares with the target problem, the more likely that problem is to be selected as the source.

Analogy and/or metaphor in thinking seems to help most when people know something about a situation but not enough for a satisfactory analysis (Klein, 1998). Metaphor can be seen as a process which may allow people to transfer knowledge between domains. When a person has relevant experience in a different domain, metaphors could be used to relate that knowledge to a new situation. Therefore, intuition could make use of this sort of reference in order to apply related knowledge to a new situation.

2.9 Schemata

Scripts and schemata are examples of one general class of representation that can be called schemata (Brewer, 1987; Rutherford and Wilson, 1991). A schema is a cognitive structure that is used as a representation – primarily to store and organise experience. Schemata are built up in the course of interaction with the environment and are available at increasing levels of generality and abstraction to guide subsequent perception and experience (Mandler, 1985). Scripts put actions and events into a context and can be used to explain and plan events (Neisser, 1987). A script defines actors, actions and objects likely to be present in a given situation. They are flexible, non-proscriptive (Fivush, 1987) representations of familiar, stereotyped events (Mandler, 1984; Medin and Smith, 1984). Scripts are the basic unit considered by Schank (1982) in the dynamic memory model.

The everyday world is classified as types of situations, and assigned to each situation is a body of specialised knowledge (Suchman, 1987). Schemata relate familiar events, scenes and stories to new ones, they tell people what to expect, when in the sequence, what objects might be there, and so on. They guide expectations based on stored, typical experiences (Mandler, 1984).

Activation of parts of a schema implies the activation of the whole, as prior co-occurrence determines mutual activation of features in the schema. Schemata operate interactively, input from the world is coded relevant to the schema currently operating and also prompts new schemata to run as appropriate (Brewer, 1987; Mandler, 1985). Whenever some event occurs, the activation process proceeds automatically to related schemata, and the activation of some schemata will mean the inhibition of others. Because schemata are linked by features, the more they are activated and elaborated, the more they will be remembered and used again (Mandler, 1985). This view accords with the connectionist theories that well used pathways and connections will be strengthened and used further.

Rumelhart and Norman (1981) propose that complex new procedures can be readily created by modelling them on existing schemata and modifying them slightly. This process of modelling they call “learning by analogy”. Carrying over existing features of the existing schema will allow people to make inferences about the new situation without explicit knowledge of it. It therefore allows them to learn a good deal very quickly provided that an appropriate analogy is used. Schemata provide a suggestion of how experiential knowledge could be stored and accessed during intuitive processing.

2.10 Mental Models

People are able to understand things they have never encountered before and Brewer (1987) claims that this anomaly can be explained by mental models. Norman (1988) maintains that there are three cognitive models of every object: the conceptual model (how the designer conceptualises the object), the user's model (which the user develops to explain the operation of the object) and the system image (the physical realisation of the conceptual model; the appearance and operation of the object, accompanied by any manuals that go with it). Thus, the only way the designer communicates with the user is through the system, which is critical as it is only through the system image that the user can develop an appropriate mental model.

One of the main purposes of the Users Conceptual Model is to explain how the user utilises the device in unfamiliar tasks, and how much of this behaviour is guided not by rational analysis but by a feeling that that is the way one uses this device (Young, 1983). This feeling could be interpreted as the result of intuition. Rohlfs (1998) hypothesises that if there is a good match between the system and the user's model, then the system is intuitive and users will be able to complete a task on the first attempt with little help. Therefore, he recommends that the user's model of the current system should be preserved as much as possible in a new system. However, "most user models are hazy and incomplete, and are constructed through interaction with the machine" (Crozier, 1994, p139). Despite this, because of the general prevalence of the application of mental models in the human factors and design communities, and their link with past experience and therefore possible link with intuitive interaction, it is necessary to look at them in more depth.

2.10.1 Definitions of Mental Models

Johnson-Laird (1981), the originator of mental models theory, states that

> A model *represents* a state of affairs and accordingly its structure…plays a direct representational or analogical role. Its structure mirrors the relevant aspects of the corresponding state of affairs in the world (Johnson-Laird, 1981, p174).

Other definitions include:

> A user's model of a complex system is a cognitive construct that describes a user's understanding of a particular content domain in the world (Fischer, 1991, p21).

> The purpose of a mental model is to allow the person to understand and to anticipate the behaviour of a physical system. This means that the model must have predictive power, either by applying rules of inference or by procedural derivation…in other

> words, it should be possible for people to "run" their models mentally (Norman, 1983, p12).

Rutherford and Wilson (1991) concur with the latter definition.

Mental models theory sees reasoning as a semantic process based on the construction and manipulation of representations in working memory (Barrouillet and Lecas, 1999). Mental models are formed through the experiences and prior knowledge of users (Innocent, 1991); past experience, expectations, and what users perceive of the system (Rutherford and Wilson, 1991); observation, instruction or inference (Norman, 1983); experience, self-exploration, training, instruction, observation, and accidental encounters (Fischer, 1991). Mental models generate expectancies about how a system will behave (Wickens et al., 1998), but can be unstable, incomplete, difficult to run, lacking in firm boundaries, and unscientific and parsimonious (Norman, 1983).

2.10.2 Relationships with other Representations

The terms *mental model* and *internal representation* are often used synonymously. However, internal representation is a catch-all term used to refer to some activity or state within any organism or machine that represents some other entity. Mental models are a sub-category of internal representations (Rutherford and Wilson, 1991). A propositional representation is the result of a superficial understanding. A more profound understanding leads to construction of a mental model, which is based on the propositional representation but can also rely on general knowledge and other relevant representations in order to go beyond what is explicitly clear (Johnson-Laird, 1981). Therefore, mental models can be constructed or elaborated from propositional representations (Brewer, 1987).

However, "…we have now reached the point where there is considerable confusion about the nature and function of these different forms of representation" (Brewer, 1987, p187). There is also much inconclusive debate about where imagery fits into the various representations (Johnson-Laird, 1981). There is still no clear definition of how mental models, scripts, schemata and other proposed types of representations fit together.

2.10.3 Application to Systems Design

Psychologists generally regard mental models as a tool for understanding the mind and behaviour. However, despite the lack of consensus on what mental models are and how they work, human factors and human-computer interaction (HCI) professionals have applied them to systems design (Rutherford and Wilson, 1991). Many of them believe that a user's conceptual model should be able to explain aspects of performance, learning and reasoning, and be a basis for design guidelines (Norman, 1983; Young, 1983), and that a system should allow the user to predict system performance; in other words, the system should act like a mental model (Barker and Schaik, 2000).

Fischer (1991) concurs that mental models should enable users to understand a system, but suggests that constructing models for general purpose systems and differing users can be very difficult. Therefore, in a complex system, he suggests one should not try to construct a perfect model, because it does not exist. The user's model of the system contains concepts which do not belong to the system, and there are system parts of which the user is unaware. Similarly, Norman (1983) claims that most mental models that users have are "messy, sloppy, indistinct and incomplete" (p13). Another problem with applying mental models theory to design is that the need for different mental models for different brands greatly increases memory load for users (Wickens et al., 1998).

Users do not need an accurate model of how a product itself works. They learn tricks common to many products (Norman, 1988). They do not need a model of how the details work to be able to fix common and simple problems, and they are not expected to fix malfunctions. Richards and Compton (1998) present systems that allow the user to decide how to use them as better than systems that try to anticipate what the user wants to do, such as those that employ user models. Therefore, in domains where an operator is interacting with a complex and dangerous system such as a nuclear power station, an accurate model of the whole system is essential in case of a breakdown (Patrick, Halliday, James, and Vaudrey, 1999; Vicente, 1997). When the operator is replaced by a user or consumer, a different approach would seem to be more sensible; for example, the internal structure of a calculator is complicated enough that a user does not have (and should not need) a detailed picture of what happens inside (Young, 1983). Norman (1988, 1993) concurs. This makes sense because many aspects of the internal workings of equipment are irrelevant to most user tasks (Fischer, 1991), and an accurate rendition of the system's inner workings will not necessarily provide the best resource from which to build a clear picture of its central abstractions (Fischer, 1991).

Okoye (1998) claims to have predicted a shared mental model in order to facilitate intuitive use but is not completely convincing. Mental models are nebulous and hard to define, and it is very difficult to assess if a person or group of people share a whole model or not. This makes it difficult to apply them successfully to systems or product design. Marchionini (1995) claims that each individual user possesses unique mental models, and some psychologists have suggested that mental models are not suitable to apply to systems design (Rutherford and Wilson, 1991). For these reasons, this research is not based on a mental models approach.

2.11 Summary

This chapter has addressed the definitions of intuition and established that it is based on experiential knowledge. Many theories depend upon the fact that when people encounter a new situation, they base their actions on their previous experience. Seen from a neurobiological standpoint like connectionism or embodiment, or from the point of view of a hypothesised model, script or schema, previous experience is the key to the sort of fast and efficient cognitive processing and decision making that all people do every day. Intuition – a process thought to be non-conscious, fast and efficient, and to provide answers sometimes seemingly from nowhere – has to be based on past experience.

People can use intuitive processing in a particular situation only if they have had previous experience to draw on. Many theorists believe that the experiences gained simply through being in a human body in the world inform all of a person's interactions, while experiences with the thousands of artefacts people interact with every day are also relevant. Intuition accesses past experiences in memory, probably through spreading activation of similar connections. Intuition can also work through metaphor, using a cue similar to something seen previously to solve a new problem, or it could possibly access and run mental models of the way things work. The evidence also suggests that it is past experience that allows intuition to inform decision making in many cases.

Now that the foundation of intuition has been established as past experience, Chapter 3 will address other properties and aspects of intuition such as speed, correctness, unconscious processing and emotion, and relate them to current, relevant models of cognitive processing. How intuition contributes to problem solving and expertise will also be examined.

Chapter 3

Intuition and Cognitive Processes

3.0 Introduction

Chapter 2 established that intuition is based on past experience. This chapter covers other important aspects and properties of intuition. Various definitions ascribe to intuition the properties of non-conscious or non-verbalisable processing, correctness and speed. All of these properties will be discussed, along with how intuition may fit into current cognitive processing models. Also explored are how intuition is linked to insight and the debate about individual and task related differences in the use of intuition.

The actual possible mechanisms of intuition are also discussed through psychology and neuroscience research. Researchers have begun to link intuition with emotion or somatic markers which guide the unconscious processing. This important idea is explored and related to the theory already covered, to provide an overall picture of the workings and properties of intuition. Finally, a definition of intuition for the purposes of this study, based on the work reviewed in Chapters 2 and 3, is provided.

3.1 Intuition and Consciousness

Most modern authors see intuition as part of a continuum of processing which ranges from very controlled and conscious at one extreme to completely automatic and requiring no conscious thought at the other. Some lay people seem to believe intuition to be instinctive or innate knowledge, which may be because the process is non-conscious and therefore seems mysterious (Bastick, 2003). It has been argued that the reasoning process is not in evidence when intuition is used as the cognitive processing takes place outside the conscious mind so that the steps in processing are not known. Many researchers agree that the understanding or knowledge required during the intuitive process is retrieved from memory during non-conscious processing (Agor, 1986; Bastick, 2003; Bowers et al., 1990; Cappon, 1994; Dreyfus et al., 1986; Fischbein, 1987; King and Clark, 2002; Laughlin, 1997; Noddings and Shore, 1984). People processing intuitively would often be unable to explain how they made a decision because it was based on stored memory associations (i.e. tacit knowledge) rather than reasoning *per se* (Wickens et al., 1998). Bastick (2003) claims that the intuitive process could be preconscious except for some of the gross sensations or guiding feelings of which the person must become consciously aware, and which are sometimes called an “intuition.”

Despite the fact that many mental processes are undoubtedly unconscious or subconscious (Vera and Simon, 1993), the notion that information processing can occur outside consciousness has a long and controversial history. Many people throughout history have proposed that more goes on unconsciously than most people believe (Baars, 1988), and it cannot be denied that at least some neural processing occurs outside consciousness, but different assumptions have been made about the extent to which cognition and consciousness co-occur. These issues continue to be the object of lively debate (Atkinson, Thomas, and Cleeremans, 2000). For many years, the notion that unconscious mental processes played a role in cognition was viewed sceptically by researchers and theorists (Baars, 1988; Dorfman, Shames, and Kihlstrom, 1996).

In cognitive psychology, due to the behaviouralists’ position that there were no non-conscious processes, the consciousness debate was deferred for decades. The debate has been avoided by use of terms such as attention, perception, exposure to stimulus, verbal report and strategic control, which can disguise the real questions (Baars, 1988). More recently, however, the idea that mental structures, processes and states can influence experience, thought and action outside of awareness and voluntary control has been more widely accepted (Baars, 1988; Dorfman et al., 1996). The existence of unconscious processes is no longer questioned, although there is no uniform agreement about how sophisticated these processes are (Eysenck, 1995). Freud’s version of the unconscious is full of emotion and negativity; actually, unconscious processing is less strange and more useful than he believed (Eysenck, 1995).

The processing in the nervous system that produces the world that people experience takes place within a network of millions of cells and interactions which are heavily influenced in their patterning by culture and personal development. Most of the knowing that goes on in this welter of processing is unconscious. Human brains are constantly testing expectations against perception, and most of this process of anticipation, recognition and cognition is intuitive (Laughlin, 1997). There is evidence that unattended streams of information in experiments are processed and represented whether they are conscious or not; perceptual events are processed for some time before they become conscious, if they ever do (Baars, 1988). This evidence emerges from a variety of paradigms including dichotic listening tasks, impressions of other persons, interpretation of ambiguous pictures, implicit memory in neurological patients and normal participants and patients exhibiting "blindsight" (Bowden, 1997). Some of this work is discussed below.

Jacoby and Witherspoon (1982) report experiments which showed that people had enhanced perception of words they had previously been presented with without being aware that they had been presented with the words. Therefore, they conclude that:

> although deliberate remembering obviously does occur, many functions of memory may operate without intention or awareness. Memory for a prior event may influence the interpretation and encoding of a later event without a person being aware of remembering the prior event (p300).

Remembering without awareness may operate in an early passive phase of processing that is involved in a variety of tasks, and Jacoby and Witherspoon (1982) claim that the judgement or processing that one remembers comes after the passive form of remembering, and suggest that effects of this sort may be important in both simple and complex tasks. Eysenck (1995) suggests that people are “unaware of their unawareness” (p183) and imagine that consciousness covers a much larger ground than it actually does. He emphasises that the results and not the processes of thinking appear in consciousness, and sees intuition as a function of unconscious processes. Hammond (1993) also claims that low conscious awareness is characteristic of intuitive processes.

Implicit learning is a process whereby knowledge of a complex environment is acquired and used largely independently of awareness of either the process of acquisition or the nature of the knowledge acquired (Reber, 1992). Reber presents intuition as the end product of an implicit learning experience. Implicit (or experiential or unintended or unnoticed) learning forms implicit or tacit knowledge, which allows processes based on experiential knowledge, like intuition, to operate. Reber, Walkenfield and Hernstadt (1991) claim that tacit knowledge is practical, informal, and usually acquired indirectly or implicitly. It does not lend itself to being directly taught and is the type of knowledge used for success in most real-world settings.

Berry and Broadbent (1988) investigated implicit learning using various computer-based tasks. They found that given a non-salient relationship between decision and action, subjects learn about control characteristics of these systems in an implicit way. They experience great difficulty in verbalising their knowledge of the system. Berry and Broadbent's (1988) experiment showed that significant transfer of learning occurred when subjects were presented with the same or a conceptually similar task. There was no transfer when the second task was conceptually or perceptually dissimilar from the first. Participants also showed no transfer if they were presented with two similar tasks but were told of the critical relationship between them. The authors claim that such a finding fits in with the idea that these tasks are performed in an implicit manner with participants not being verbally aware of the basis on which they are responding.

Bowers' (1984) view of intuition is as a distinct information processing mode, in which unconsciously stored information is used to guide decisions and problem solving. Bowers claims that perception and consciousness of stimuli are different, and that it is selective attention that transforms a perception into consciousness of what is perceived. For this case he uses the term *noticed*. Information can be perceived without being noticed, but not vice versa. The threshold for noticing a stimulus is higher than the threshold for perceiving it, so whether or not something is noticed can depend on involvement in alternative activities. Bowers (1984) argues that there are two generic modes of non-conscious influences: those that go unnoticed, and those that are unappreciated as influences. The distinction between perceiving and noticing allows these two modes. Information perceived but not noticed is not likely to be processed into long term memory so is not available for later recall. However, information need not be conscious in order to be influential and information perceived need not be noticed in order to have a demonstrable impact on behaviour (Bowers, 1984). Bowers (1984) suggests that cues that trigger intuitive processing could be the things that go unappreciated.

Baars' (1988) Global Workspace theory describes the brain as a collection of specialised processors, with consciousness associated with a global workspace in the brain that can distribute to and recruit from many specialised, unconscious networks. Both conscious and unconscious stimuli are apparently analysed quite completely by automatic systems, but unattended stimuli are not broadcast throughout the nervous system and conscious ones are. In this way the nervous system can cope with novel information, but the most proficient systems are generally the least conscious. Intuition is one of these proficient, non-conscious processes. Baars (1988) claims that this makes sense as the mechanisms associated with conscious experience are remarkably small in capacity, when compared with the enormous size and sophistication of the unconscious parts of the nervous system. This theory relies on the connectionist paradigm and has similarities to Bowers' (1984) ideas about a noticing threshold – the things which are noticed are those that are broadcast, but things that go unnoticed may never be broadcast and hence never become conscious. Whether the noticing threshold or the global workspace are appropriate metaphors or not, it is clear that intuition, along with other cognitive processes, can operate unconsciously.

Ideas such as remembering without awareness, implicit knowledge, the noticing threshold and global workspace theory demonstrate how unconscious retrieval of information in long term memory for intuitive processing could happen without people being aware of the retrieval or even the storing of the information, giving intuition its strange reputation. Because these processes are non-conscious or at best semi-conscious, intuition can seem to work like magic, because not only is accessing the experience non-conscious, storing it could be also (according to the implicit learning work), meaning that people may believe that they have never been in a similar situation before. The fact that some people believe that intuition is used when there is little information available (e.g., Westcott, 1961) is also explained by this – the information is not obvious in the perceived situation but it is available in memory and accessed non-consciously.

Klein (1998) claims that people have trouble observing themselves use their own experience and therefore find it hard to explain the basis of their judgements. Patterns can be subtle and people often cannot describe what they noticed or how they judged a situation as typical, and therefore intuition has a strange reputation. Klein's interview and case study participants were not aware they were using their own experience in their everyday decisions; one even thought that extrasensory perception (ESP) was providing the solutions. In this case, rather than giving the participant specific facts and memories of particular events, his experience affected the way he saw the situation, allowing him to recognise things without knowing how (Klein, 1998).

3.1.1 Speed of Intuition

Intuition also yields quick results, as it allows people to grasp meaning or significance without relying upon slower, analytical processes (Bastick, 2003; Salk, 1983). As Agor put it:

> …intuition, fully developed, is a highly efficient way of knowing. It is fast and accurate. Our system will process a wide array of information on many levels and give us an instantaneous cue, how to act. We have the answer even though we do not understand all the steps or know fully all the information our system processed to give us this cue (Agor, 1986, p6).

Clark (1997) claims that the speed of non-conscious processes is based on parallelism. There is a delay of up to half a second between the time the brain receives a stimulus and the time a person is conscious of it (Greenfield, 2000). Therefore, just from timing when reactions occur during skilled behaviour, researchers can conclude that such behaviour must be non-conscious. In automatic behaviour the brain has reacted and initialised a response before the person is conscious of stimulus or response. Conscious reaction time is 100 times slower than the fastest potential firing rate of a neuron. Consequently, non-conscious processing is much faster than conscious processing, and the time needed to scan memory for previous experiences on which to base a response is much less than conscious reaction time (Baars, 1988).

Although intuitive processing is not as efficient as automatic processing, the fact that a person's most proficient systems are the least conscious helps to explain why intuition is generally non-conscious. Because intuition is non-conscious, it is fast, and/or because intuition is fast, it is non-conscious.

3.2 Intuition and Emotion

Love (2003) stresses that current emotion-based approaches in design are problematic and that design research needs to take the sort of approach suggested by Damasio's (1994) work (reviewed below). He states that theory-making about human aspects of designing (including theory-making in the area of interaction with designed systems, services and organisations) has been grounded in philosophically based speculations about internal process related to emotion and feeling, without relation to the physicality of these processes.

Damasio claims it is not sensible to leave emotion out of any concept of mind, but this is what traditional accounts of cognition do. Arbib and Fellous (2004) agree that there is no easy separation between emotion and cognition and believe that there is rich interaction of cognitive and emotional processing in the mammalian brain. Damasio (1994) sees feelings as having a privileged status because they are represented at many neural levels, and they are tied inextricably to the body. Because of these ties they come first in development and retain a primacy over people's mental lives.

Dorfman et al. (1996) present the product or outcome of intuition as an informative feeling, which tells the person about processes that are happening unconsciously. Others also hypothesise that feelings may be the outlet through which the result of the intuitive process is communicated to the conscious mind. King and Clark (2002) investigated intuition in nurses and reported that intuition was often felt as an emotion; for example, a nurse may feel uneasiness or foreboding about a patient's condition.

Bastick (2003) and Klein (1998) regard emotion as not just the product but the very mechanism of intuition. Bastick (2003) details his theory of intuitive thought, which involves emotional "sets" driving the intuitive process. The emotional sets comprise associations of response tendencies and emotional states; in other words, prior experiences and the emotion attached to them are encoded together. Large amounts of information can be coded by associating the information with an emotional set so that being in that set recalls the information. Experiences of two situations producing similar emotional states enable one to consider these situations as intuitively analogous if similar emotional states (feelings) are associated with each. In this way, Bastick (2003) presents emotions as the internal contexts of information used in the intuitive process.

3.2.1 The Somatic Marker Hypothesis

Damasio (1994) stresses that the processes of emotion and feeling are an intrinsic part of the neural machinery for biological regulation, whose core is constituted by homeostatic controls, drives and instincts. Damasio (1994) defines emotion as a set of changes in body states caused by interaction with the environment, and feeling as the separate internal representation of that emotion. Feelings are neural representations of the emotional states. The neural representation seems to be equivalent to Bastick's (2003) emotional set, and the current body state is the emotion itself.

An emotion may be induced through non-conscious engagement with the environment. Damasio (1994) discusses the possibility that people are wired to respond to certain stimuli or combination of stimuli with a pre-defined emotion; for example size, sounds and movements related to threats from natural predators, or certain body states like severe pain. One need not recognise the threat or know what is causing the pain in order to respond in a preset way. These are innate processes called primary emotions. Secondary emotions occur once people begin experiencing feelings and forming systematic connections between experienced situations and primary emotions.

Both chemical and electrical (neural) signals get to the brain in the event of an emotion (Damasio, 1994). Networks in the prefrontal cortex respond to images that are formed through either sensory input or thoughts and memories. The prefrontal response comes from dispositional representations that embody knowledge pertaining to how certain types of situations usually have been paired with certain emotional responses in each person's individual experience.

The prefrontal, acquired dispositional representations needed for secondary emotions are separate from the innate ones needed for primary emotions. Damasio himself puts the whole idea very clearly:

> In conclusion, emotion is the combination of a *mental evaluative process*, simple or complex, with *dispositional responses to that process*, mostly *toward the body proper*, resulting in an emotional body state, but also *toward the brain itself* (neurotransmitter nuclei in brain stem), resulting in additional mental changes. Note that, for the moment, I leave out of emotion the perception of all the changes that constitute the emotional response…I reserve the term *feeling* for the experience of those changes. (Damasio, 1994, p139)

Damasio (1994) formulated the somatic marker hypothesis (SMH) to explain how emotion can influence behaviour and cognition. As he explains:

> In short, *somatic markers are a special instance of feelings generated from secondary emotions*. Those emotions and feelings *have been connected, by learning, to predicted future outcomes of certain scenarios.* When a negative somatic marker is juxtaposed to a particular future outcome the combination functions as an alarm bell. When a positive somatic marker is juxtaposed instead, it becomes a beacon of incentive. This is the essence of the somatic marker hypothesis (Damasio, 1994, p174).

People are born with the neural machinery required to generate somatic states in response to certain classes of stimuli – the machinery of primary emotions. However, most somatic markers used for decision making are probably created in the brain during the process of education and socialisation by connecting specific classes of stimuli with specific classes of somatic state. In other words, they are based on secondary emotions, which are based on experience (Damasio, 1994). In order to select a response, a person needs neither conscious knowledge nor a conscious reasoning strategy. The requisite knowledge was once conscious; that is, when it was learned. However, experience with similar scenarios made the brain pair the provoking stimulus with the most advantageous response (Damasio, 1994). Damasio hypothesises that the critical and formative set of stimuli to somatic pairings is formed in childhood and adolescence. Somatically marked stimuli continue to accrue throughout life, but the formative ones are there from early stages.

Associations with various markers will be different for each person based on his/her experience. However, Damasio (1994) states that the experience many people have had with basic things such as door handles or broomsticks is likely to be similar, whereas experience based more on social interactions will vary more between people. This augurs well for the idea of making interfaces that will be intuitive for large numbers of people, although it could be foreseen that this could change if human-machine interaction becomes more socially based.

Somatic markers do not need to be perceived consciously. Triggering of activity from neurotransmitter nuclei (part of the emotional response) can bias cognitive processes in a covert manner and thus influence conscious reasoning and decision making (Damasio, 1994). Damasio goes on to relate somatic markers to intuition. He states that the explicit imagery related to a negative outcome would be generated, but instead of producing a perceptible body-state change, it could inhibit the regulatory neural circuits located in the brain core, which mediate aversive and approach behaviours. A negative option might be avoided altogether and a positive one made more likely by this covert mechanism, which Damasio suggests may be the source of intuition.

Damasio and his colleagues have conducted experiments with risk taking according to implicit rules with normals and brain damaged patients (Bechara and Damasio, 1997). They devised the Iowa gambling task to test the SMH. The task is based on participants choosing cards from two packs, one of which has high risk but high rewards (the "bad" pack), and the other of which has lower rewards but lower risks (the "good" pack). These experiments have revealed evidence for a complex process of non-conscious signals which are based on previous experiences that have been stored with an appropriate emotional state that attends them. Both normal and frontally damaged people generated skin conductance responses (SCRs) as each reward or punishment occurred after turning a card.

In normal subjects, within a number of card turns into the game, SCRs would be generated when considering a card from a "bad" pack. Normal participants began to trigger anticipatory SCRs when they pondered risky decisions before they verbalised their knowledge. The process of pondering is conscious whether the knowledge used is conscious or not. The process leading to anticipatory SCRs is mostly non-conscious, although it may become conscious in the form of a feeling. The magnitude of these SCRs increased as the game progressed and the knowledge became more conscious. The brains of normals were signalling the "badness" of the deck as they learned to predict a bad outcome. These responses were not there at the start of the game, showing that these things were learned from experience. Frontally damaged patients showed no anticipatory response, and normals were less likely to choose risky options than brain damaged patients.

Damasio (1994) suggests that before and beneath the conscious hunch there is a non-conscious process gradually telling the normal player, with increasing insistence, that punishment or reward is about to strike if a certain action is carried out. He believes the prefrontal networks would hone in on the ratio of "bad" versus "good" outcomes for each deck, on the frequency of bad or good somatic states experienced after punishment or reward. The player would be guided into a theory about the game by this automated sorting out. Damasio (1994) doubts that this is a fully conscious or fully non-conscious process. This suggests that intuition is at work, as the process that operates between automatic, skilled processing and conscious, knowledge-based reasoning. Damasio (1994) claims that gambling is analogous to life, where much of the knowledge by which people live and by which they construct their adaptive future is doled out bit by bit, as experience accrues, and uncertainty reigns. Real knowledge, like the player's in the gambling task, is shaped by both the world with which people interact and by the biases inherent in the human organism; for example, preference for gain over loss and reward over punishment. These findings are analogous to the reports from King and Clark's (2002) subjects that the product of intuition can be a sense of foreboding or something being wrong, and clearly link emotional responses to past experience.

Maia and McClelland (2005) claim to have repeated the experiment and use their results to refute Bechara and Damasio (1997) about when knowledge of the implicit rules of the game becomes conscious. However, they did not include the skin conductance measurements, which were a key component of the original experiment. Bechara, Damasio, Tranel and Damasio (2005) claim that Maia and McClelland's study undermines the traditional methods for identifying implicit knowledge (unprompted protocol) by using a probing technique. They do not accept that Maia and McClelland's results undermine the SMH. Maia and McClelland (2005) also concede that the SMH has not been disproven and they do not entirely agree that their findings are incompatible with it.

Encoding or processing specificity assumes that for an item to be recalled from long-term memory using a cue, the cue must have been encoded into memory with the original item (Brooks, 1987). Tulving and Thomson (1973) state that information that is stored is determined by what is perceived and how it is encoded, and what is stored determines what retrieval cues are effective in providing access to stored information. Tulving and Thomson's (1973) research supports the encoding specificity principle as they found that strong extra-experimental associates of list items, when presented to the subject as recall aids, increase the probability of correct responses. This idea sits well alongside the somatic marker hypothesis (SMH) and Bastick's (1982, 2003) theory of intuitive thought as it postulates a way in which the emotion can be stored with the experiential memory and can be used as part of the retrieval process.

This work on emotion suggests that somatic markers could be coded when an experience is stored in memory and used as part of the search and retrieval process when people are looking unconsciously for matches for a particular perceived situation. Bechara and Damasio (1997) suggest that intuition works through experientialism with emotional reminders in long term memory as triggers. From this viewpoint, emotion is stored as part of the experience and it functions as part of the process of intuition but is not necessarily consciously felt as an emotion. Positive or negative somatic markers attached to records of experiences in memory guide intuition. Positive markers could be associated with the endorphin rush that is hypothesised to accompany an insight or “Aha!” experience, which could be equated to Bowers’ (1984) threshold of awareness. This work is important as it reveals a mechanism that could be responsible for the storage and later retrieval of information for use during the intuitive process, based on the idea that intuition utilises past experience.

3.3 The Skill-Rule-Knowledge Model

Rasmussen (1993) developed the Skill-Rule-Knowledge (SRK) model of task performance. This model is important as it explains clearly how the various cognitive processes work and interact. It relates the ideas considered so far in this chapter to each other and helps to explain how intuition plays a role in cognition. According to the model, people operate on one of the levels, depending on the nature of the task and their degree of experience with the situation. Highly experienced people will process at the skill-based level. This is non-conscious, automatic processing. Those familiar with tasks but lacking extensive experience will be processing at the rule-based level. The cues are recognised as meaning certain things, termed *signs* (Rasmussen, 1990). These signs then trigger rules accumulated from past experience, and previous successful solutions or decisions (Schunn, Reder, Nhouyvanisvong, Richards, and Stroffolino, 1997; Wickens et al., 1998). The rules are if–then associations between cue sets and the appropriate actions. When the situation is novel, decision makers will have no rules stored from previous experience to call on. They will therefore have to operate at the knowledge-based level, which is analytical processing using conceptual information.

According to the SRK model, in a real world context, a person might operate at the knowledge-, rule- or skill-based level and will switch between them depending on task familiarity. A novice can work only at the analytical knowledge-based level. At an intermediate point, people will have a knowledge base and some rules from training and experience. They work predominantly at the rule-based level but must move to knowledge-based processing when the situation is a new one. The expert has a larger knowledge base, a greatly expanded rule base and a skill base, so can work at the skill-based level, but lack of familiarity with something will revert the expert to knowledge-based processing. The SRK model is consistent with accepted and empirically supported models of information processing, which generally include perception, decision and action in a similar format to the SRK model (e.g. Wickens et al., 1998).

Wickens et al. (1998) have expanded the SRK model into an information processing model that accommodates many of the processes postulated by others. Here they equate rule-based with intuitive processing, which separates intuitive from automatic processing. During intuitive rule-based processing there is more active cognitive processing than for automatic skill-based processing, as the person must consider a variety of cues. The cues trigger a retrieval of appropriate cue–action rules from memory, and these specify the desired goal and action sequence that is to be executed. Which of these processing strategies people are most likely to use depends on the specific domain or job, level of expertise, amount of time and amount of uncertainty. A system and its displays will affect the type of decision strategies selected by operators (Wickens et al., 1998).

It is important that Rasmussen (1993) and Wickens et al. (1998) split rule-based or intuitive processing from automatic processing. They claim that intuitive rule-based processing is founded on rules and procedures learnt through prior experience, but it is not a completely automatic sequence. When people use a new product, they cannot do everything automatically, but if the product is intuitive to use, they can call on previous experience to complete tasks easily. Intuitive processing is sometimes more conscious than automatic processing (Rasmussen, 1993; Wickens et al., 1998), but is consistently unappreciated (so, according to Bowers' (1984) theory, intuition is not unnoticed but it is also not appreciated as an influence). This helps to explain why intuition seems so mysterious.

Signals, signs and symbols are the information observed from the environment that can be equated with the skill, rule and knowledge categories (Rasmussen, 1990).

Signals are sensory data that can be processed as continuous variables (skill-based). Symbols can be formally processed (knowledge-based). At the rule-based level, information is typically perceived as signs. Information perceived is defined as a sign when it serves to activate or modify existing actions. Signs refer to situations by convention or prior experience and can dictate stereotype acts (if–then rules). They can serve to activate stored patterns of behaviour, and operating from signs may be the normal way for humans to be efficient (Rasmussen, 1990). This is important as signs operate on the rule-based level, which Wickens et al. (1998) have called intuitive; so intuitively processing signs in the environment may be the normal way in which people operate efficiently. A feature of the environment can mean different things to different people and so could be a sign to one person and a symbol to another. The distinction between signals, signs and symbols is independent of the form in which information is presented. It depends, rather, on the context in which it is perceived; in other words upon the intentions and expectations of the perceiver. This can be based only on their experience.

Consciousness is not needed in highly skilled and routine actions. Knowledge can fade from consciousness with practice, but then return when a task becomes more difficult. However, even though something may becomes less conscious with practice, it is still used in the task (Baars, 1988). This is reflected in the Skill-Rule-Knowledge model as people can process on any or all of the levels depending on their experience with a particular task.

Importantly, the SRK model accords with the idea that intuitive processing is based on experience, and that different features of the environment can be processed differently depending on the perceiver’s experience. It suggests a three-strand model of cognition, with intuition somewhere in the middle and analysis and automatic processing at each end.

Based on these ideas, it appears that automatic processes (the skill-based level) are even less consciously available than intuition, and maybe faster and more accurate, whereas conscious reasoning sits at the other extreme. Therefore, one can conclude that intuition allows efficient processing of situations similar to those previously experienced, but does not require the extensive overlearning needed for a person to process automatically. In order to make the relationship between automatic and intuitive process clearer, the important field of automatic processing will be reviewed in the following section.

3.3.1 Automatic Processing

Research on automaticity (sometimes called bottom-up or data-driven processing) goes back to the 1890s (Bargh, 1989; Logan, 1989). Human performance has been hypothesised to be the result of two processes, referred to as *automatic* and *controlled* (Schneider, Dumais, and Shiffrin, 1984; Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977). However, processing need not be cut and dried, and could involve a mixture of automatic and attentive processing (Schneider et al., 1984), or there could be a continuum along which the processes lie (Isen and Diamond, 1989; Logan, 1985). Schneider and Shiffrin (1977) and Shiffrin and Schneider (1977), in their seminal work on automaticity, disagree with the continuum idea. However, the SRK model introduced by Rasmussen (1993) and further developed by Wickens et al. (1998) suggests that there are various points along a continuum between automatic and controlled, one of which is intuitive. People may not even always process the same stimuli automatically, but could change their processing method depending on other circumstances and their goals (Isen and Diamond, 1989).

An operator’s loss of consciousness about a predictable event is a signal that the event has been learned completely (Baars, 1988). Automatic processing is fast, parallel, effortless and not limited by working memory capacity. It is not under direct control, and is how people perform well-developed skilled tasks. In a laboratory situation, automatic processing can develop when subjects process stimuli consistently over many trials. Controlled, or attentive, processing is slow, generally serial, effortful, capacity-limited and regulated. It must be used to deal with novel or inconsistent information (Schneider et al., 1984; Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977).

Controlled processing modifies memory and leads to the development of automatic processing (Schneider et al., 1984; Schneider and Shiffrin, 1977; Shiffrin and

Schneider, 1977), and automaticity is considered the result of overlearning or repeated exposure (Isen and Diamond, 1989; Lewicki, 1986; Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977; Simonton, 1980). Often, processes that are now automatic were once consciously learned; for example grammar, or the journey to work (Isen and Diamond, 1989; Logan, 1985; Schneider and Shiffrin, 1977; Shiffrin and Schneider, 1977). Therefore, controlled processes are instrumental in the development of new automatic processes, and automatic and controlled processes working together allow a limited capacity processor to perform very complex tasks (Schneider et al., 1984). Indeed, (Logan, 1985) suggests that automaticity is a necessary component of skill as there is not enough attentional capacity to develop higher level skills until lower level ones have become automatised. He claims that most skills have automatic components.

Schneider and Shiffrin (1977) and Shiffrin and Schneider (1977) take an attentional approach to their research, whereas Logan (1989) defines automaticity in terms of underlying memory processes; he calls this the instance theory of automaticity. The theory assumes that automaticity is a memory phenomenon and automatic processing is based on single-step, direct-access retrieval from memory. Humans acquire a domain-specific database that provides the right information without much computation but by direct-access retrieval (Logan, 1989). The information provided by automatic processing seems to come unbidden; people can look at a familiar situation, recognise it and know what to do.

Norman (1981) introduced the Activation-Trigger-Schema system (ATS) to explain this phenomenon. The ATS model assumes that action sequences are controlled by sensorimotor schemata, and that skilled actions need only be specified at the highest levels of their memory representations. Once the highest-level schema is activated, the lower-level components of that action sequence complete the action, to a large extent autonomously, without the further need for intervention except at critical choice points. Schemata are triggered by satisfaction of their conditions by previous actions, by the environment, or by perceptions. For example, during driving, schemata for braking or steering are triggered by appropriate conditions (Norman, 1981). Reason and Mycielska (1982) concur that familiar objects will trigger automatic actions:

“...familiar objects possess what we call an *immediate controlling region*. Once in touch with them, our actions conform to the structural needs of the object” (p224).

Therefore, attention is not necessary when the same cognitive process has been executed many times (Ericsson and Simon, 1984). Greenfield (2000) suggests that automaticity works by the skilled learning changing the way brain cells fire and permanently altering them. They subsequently need less input from other brain cells in order to fire the habitual response. However, just as predictability promotes automaticity, violations of predictability may re-create consciousness again. Informal demonstrations suggest that many automatised skills can become conscious again when users encounter some unpredictable obstacle (Baars, 1988).

Intuition is not an automatic process, and the use of a new product cannot be automatised until a user has had extensive experience with it. The SRK model explains where intuitive and automatic processing sit in relation to each other. Automaticity is a process which is even more efficient than intuition but relies on more experience. For certain tasks, intuitive processing may develop into automatic processing if the task is overlearned. How the relation between intuition, consciousness and automaticity is seen in these and other theories is discussed in more depth in Section 5.4.

3.4 Individual and Task Differences

Much current thinking supports the idea that intuition is available to all people and will be used depending on the circumstances (Bastick, 2003; Bowers et al., 1990; Klein, 1998). Eysenck (1995) suggests that there is a continuum and that intuitive and analytical minds are extremes of the continuum with most people somewhere in the middle using both intuition and analysis. The Myers Briggs Type Indicator (MBTI), based on Jung’s work on personality, differentiates intuitive and analytical as distinct “types”. It is an inappropriate instrument, according to Bastick (2003). Jung based his classifications on his own observations, and did no experiments on the theory. Jung himself declared that the typology was just a scheme of orientation and that the classification of individuals meant nothing (Carroll, 2003). Further, although the

MBTI has been widely applied, it was developed by amateurs and it, too, had no basis on experimental work (Carroll, 2003).

Westcott (1961) looked at individual differences in intuitive thinking. He conducted experiments to study the distribution of people who were both willing to make inferences based on little information and tended to be correct in their conclusions. His experiments therefore involved confidence ratings for each solution participants reached. He also calculated an efficiency score for each participant's performance. The confidence that participants showed in their conclusions was positively related to their actual success, so they generally knew when they were right although no feedback was given. He found that participants who make intuitive leaps are the most predictably confident. However, he did not separate the problems he gave participants into insight and analytical problems, as is standard in insight research, and Woolhouse and Bayne (2000) doubt that Westcott was measuring intuition since there was no measure of awareness. Even so, this work would not disprove the thesis that intuition is based on experience as the people who were more successful at making intuitive leaps may have had more relevant experience on which to base those leaps. The feelings of confidence measured by Westcott could be similar to the feelings discussed in Section 3.2, which are the mechanism by which the conscious mind becomes aware of a solution.

Woolhouse and Bayne (2000) also conducted experiments in this field and claim that their research supports the position that there are individual differences in the use of intuition. However, there are some problems with their research. The re-coding system they used to classify interview responses has room for error and is not well justified. Their experiment also depended on the use of the Myers Briggs Type Indicator, which other researchers such as Bastick (2003) and Carroll (2003) have discredited. They claim to have found that "feeling types" were more successful than "thinking types" at using intuition. However, the difference between feeling and thinking types (in use of intuition) that they present is not significant (although they ignore this fact). Also, they admit that many of the participants used explicit knowledge rather than intuition to perform the task (according to self-report) and so their intuitive capacity remains unmeasured.

Woolhouse and Bayne (2000) did, however, find that there were no significant relationships between use of intuition and gender. Boucouvalas (1997) suggests that the issue of gender differences in use of intuition is semantic, with men preferring to use terms like “hunch” and “gut feeling” rather than intuition.

Such work on individual differences in intuition has been superseded to some extent by task-induced mode research. Wickens et al. (1998) and Rasmussen (1990) suggest that different types of tasks will induce different strategies in different people depending on their level of experience with the relevant task (Section 3.3). Klein (1998) seems to agree that different conditions will mean different strategies, arguing that recognition primed decision-making (Section 2.2.4) is more likely to be used under time pressure, with a higher experience level, in dynamic conditions and with ill-defined goals. These ideas accord with the thesis on past experience and intuition, suggesting that people use intuition if they have experience to draw on, but use more analytical processes otherwise.

Hammond, Hamm, Grassia and Pearson (1987) developed a cognitive continuum to classify intuitive and analytic tasks. They propose that the position of a task on the continuum determines the type of information processing triggered. Task conditions may also include some properties from each end of the continuum, and therefore some of the properties of both modes of cognition could be induced. Tasks with both intuitive and analytical properties may induce a compromise between intuition and analysis. After a set of experiments designed to get participants to think in the different ways on a set of tasks classified from analytical to intuitive, Hammond et al. (1987) conclude that participants performed better when cognitive properties corresponded to task properties.

In the context of the present study, the most important conclusion to come from their work was that intuitive cognition can perform as well as and even out-perform analytical cognition by the same person. Hammond (1993) went on to further investigate how task conditions can be located on a continuum that ranges from those that are highly intuition-inducing to those that are highly analysis-inducing. He lists task characteristics that he claims are intuition-inducing, such as large number, perceptual measurement, continuous and variable distribution and simultaneous display of cues, high redundancy among cues, low degree of certainty in task, organising principle of task unavailable and brief time period to complete it. However, these characteristics are not developed enough to be applied to the design of products or systems. Hammond claims he used a quantitative method to order the tasks on the cognitive continuum, but still does not fully explain how he defines intuition and how he came up with this list of its properties.

Wright, Fields and Harrison (2000) explain that problems requiring internal representation in the mind, like the Tower of Hannoi task or the 8 puzzle, make greater demands on problem solvers than problems in which rules are implicit in the structure and/or apparatus. Therefore, they claim that information in external representations can be accessed by the perceptual system alone, whereas internal representations have to be retrieved from memory. They recommend that information perceivable from an information display should exactly match information required for the task. If the display does not obey this mapping principle then the task cannot be achieved unless the user has other information internally represented (Wright et al., 2000). The authors claim that their experiments with the 8 puzzle provide strong evidence that the design of external resources is an important factor in determining interaction strategy (Wright et al., 2000, p35).

Cockayne, Wright and Fields (1999) agree that the way in which a problem is represented can affect the ease with which a solution can be found, and state that this is well known in problem solving research. These authors devised a new interface for the “8 puzzle” which was direct but also reduced moves needed (the roundabout interface). This roundabout strategy could also be used with the standard direct manipulation interface, but participants did not adopt it unless they had had prior exposure to the roundabout interface. This suggests that while the perceptual features of the roundabout interface support the development of the strategy, once learned it can be used in the absence of the external cues. This supports the idea that intuition is based on past experience, but also raises the issue that a good interface design can induce a better way of thinking about tasks. An internal representation of a problem in the mind of course requires past experience to construct, so some people may still be able to perform this type of task intuitively if they have relevant past experience.

However, making an interface intuitive for people with very little past experience could depend on using the kinds of methods investigated here.

The work on individual and task difference suggests that all people have access to intuition as a cognitive process This is important, as designing for intuitive use must rely on users being able to utilise intuition if it is to have any impact. Most evidence suggests that tasks affect processing mode depending on whether or not they, or features of them, are familiar to the solver, which lends further support to the conclusion that intuition is based on experience. The SRK model also accords with this idea as it allows for use of different levels of processing, depending on experience.

3.5 Correctness of Intuition

Intuition is defined by some writers as necessarily correct (some researchers have even operationalised intuition as a correct answer), whereas most say it is only a useful guide that rarely misleads (Bastick, 2003). Bastick suggests that intuition is always considered to be subjectively correct but where there is an accepted correct answer for comparison, intuition may not always completely agree. Intuition is correct in that it harmonises all the subjective information currently available, and intuitive perceptions are experienced as true in the same way that sensory data is experienced as true (Bastick, 2003). However, often it seems that wrong intuitions are forgotten whereas correct ones are remembered selectively, contributing to the supposition that intuitions are mostly correct (Bastick, 2003).

Klein (1998) and Eysenck (1995) agree that intuition is not infallible. One’s experience will sometimes mislead. For example, one can learn the wrong lessons from experience and therefore apply them wrongly (Klein, 1998). Hammond (1993) argues that analysis produces fewer errors than intuition but when errors in analysis do occur they are more catastrophic than errors in intuition.

As intuition is based on experience, one could conclude that the more relevant experience people have, the more likely they are to be able to use intuition correctly.

Expert intuition therefore tends to be very reliable (Richman et al., 1996), whereas intuition based on only a few relevant past instances, or on similar experiences that are not directly related to the current situation, could be less reliable.

3.6 Intuition and Problem Solving Research

The “Aha!” experience (sometime called insight restructuring) is an instinctive affective response involving suddenness (Bowden, 1997). Solvers are unable to report the processing. Insight involves a mental restructuring that leads to a sudden gain of explicit knowledge (Wagner, Gais, Haider, Verleger, and Born, 2004). Whether an individual will experience a given problem as an insight problem is a function of both the individual's personal knowledge and experience, and the features of the problem itself (Bowden, 1997). Solvers easily recognise the correct approach with non-insight problems although they may have difficulty successfully executing the necessary steps. In contrast, solvers may have difficulty recognising the correct approach for solving insight problems, but once the approach is recognised the solution is immediately obvious.

Bowers et al. (1990) view intuition as having two stages: guiding and integrative. The guiding stage involves an implicit perception of coherence that guides thought unconsciously towards a more explicit understanding. The integrative stage involves integrating into consciousness a plausible representation of that coherence, and occurs when sufficient activation has accumulated to cross a threshold of awareness. Transition between the two stages could be experienced as an insight or immediate perception. During a discovery-type experience the pre-analytic, intuitive stage of the inquiry generates hypotheses, which seems to involve relatively automatic activation of networks by clue-words (Bowers et al., 1990). Eventually the build up of information crosses the noticing threshold (Bowers, 1984), seeming sometimes like insight. However, a continuous task can give the impression of a sudden solution because of the use of these non-conscious cognitive processes. At some point the solution becomes conscious and this can seem like a miracle or sudden inspiration, like a Eureka or Aha! experience.

Bowden's (1997) experiments tested the hypothesis that the Aha! experience associated with insight solutions is related to unreportable processing. In particular, it was hypothesised that unreportable memory activation and retrieval processes can make the solution available to the solver, but leave the solver unaware of the solution's source. Solvers may be most likely to experience the Aha! of insight when they solve a problem but are unaware of the source of the solution. Several factors influence the ability of solvers to retrieve solution-relevant information. The information in memory and the problem must share similar surface features, similar goals, or similar structural relations. Of these characteristics, similarity of surface features appears to exert the greatest influence over what information is initially retrieved (Bowden, 1997). This finding is in accordance with those who suggest that metaphors which relate to surface features are the most successful (Klein, 1998).

Bowden's experiments showed that unreportable hints lead to insight-like solutions, which provides converging evidence that unreportable processing can produce the Aha! experience of insight solutions. One could conclude from this that intuition may be the unreportable, unconscious process that leads to insight. The environment and the stored knowledge combined provide the clues needed for a successful solution (Bowden, 1997), just as intuition combines information in the situation and in memory to come up with solutions (Bastick, 2003).

The Aha! experience can be seen as the affective product of the unconscious processing that goes on during the solving process. It seems likely that people use intuition when solving these kinds of problems, and also possible that they experience something similar to an Aha! response when processing intuitively on other types of problems.

3.7 Intuition and Expertise

Expert behaviour involves the ability to recognise key features of situations and to access information that is relevant to them in memory (Richman et al., 1996). These authors argue that experts use intuition. Often, in well studied areas of expertise such as chess or diagnosis, an answer is identified immediately without the expert being aware of how; but experts will then verify the answer to check whether it is correct. Intuition is reliable enough to permit the expert to proceed with the task much more rapidly and reliably than the novice, who must employ more tedious step-by-step search processes (Richman et al., 1996). This idea accords with the Skill-Rule-Knowledge model, suggesting that experts are processing at the rule- and/or skill-based level while novices are using knowledge-based processing.

Salthouse (1991) suggests that knowledge of many different types is the thing that allows experts to perform better than novices. The knowledge of the expert includes an extensive store of representations that can be used in solving problems (Richman et al., 1996). This sort of knowledge is in long term memory and is often evoked when necessary. What appears to be held in working memory is a pointer to each chunk of information in long term memory, so that the contents of memory can be rehearsed by accessing the image of each chunk (Richman et al., 1996). Therefore, Richman et al. (1996) suggest that an expert has the ability to recognise familiar cues and gain access to the relevant knowledge associated with them. Posner (1988) also stresses that it is knowledge use and storage that is at the root of understanding expertise, and Klein (1998) concurs.

Experts use intuition to detect typicality and to notice events that did not happen and other anomalies that violate the pattern (Klein, 1998), which suggests that much of expertise is intuition. In support of this idea, Kahneman and Tversky (1982) found that what is intuitive for the expert is often non-intuitive for the novice. Reber (1992) argues that tacit knowledge is coded abstractly within the brain, linked to the relevant stimuli, and Richman et al. (1996) also suggest that this is how expert knowledge is encoded. This concurrence, as well as evidence from protocol analysis that the detail of expert knowledge is often not accessible to the experts (Ericsson and Simon, 1984), suggests that much expert knowledge may be accessed through intuition.

Experts can store and access virtually unlimited amounts of information in long term memory with the speed and reliability normally seen with working memory (Ericsson and Simon, 1984). Ericsson and Polson (1988) assert that expert improvement beyond normal short term memory capacity is due to more efficient use of long term memory. Experimental subjects generate long term memory codings of information using their existing knowledge. At the time of encoding, retrieval cues are incorporated into the memory trace and allow retrieval of the information (Ericsson and Polson, 1988). This is an example of encoding specificity at work, which again suggests that intuition may be the process used by experts to retrieve and utilise their vast store of knowledge when appropriate.

3.8 Summary

This chapter has reviewed the research relating to the nature and workings of intuition. Intuition is generally non-conscious and so is not verbalisable or recallable, and can influence people's actions without their conscious knowledge. Information can be perceived without being noticed, and can be processed and responded to without being stored in long term memory (Bowers, 1984).

Rasmussen (1993) and Wickens et al. (1998) distinguished intuitive, or rule-based, processing from automatic processing. Intuitive processing is not completely automatic, but is consistently unappreciated (Bowers, 1984). It is likely that intuition is not a cut and dried process but instead operates as part of a continuum between highly controlled and completely automatic processes (Isen and Diamond, 1989; Logan, 1985). People making a decision at the intuitive level on the SRK-based scale (Wickens et al., 1998) would often not be able to explain how they made the decision because it was based on stored memory associations rather than conscious reasoning. Because people processing intuitively cannot verbalise their thinking process in detail, intuition can seem mysterious or magical whereas it is in fact simply very efficient.

Because it is efficient, intuition is also generally faster than conscious forms of cognitive processing, and researchers agree that it is often correct but not infallible. It also seems likely that everybody is able to use intuitive processing although the type of task and how familiar they are with it will influence the type of processing they use.

Intuition very likely uses somatic markers or emotional states which mark experiences when they are encoded and therefore allow them to be retrieved at an appropriate time. Intuitive processes may be utilised by experts in their advanced processing as well as during insight problem solving and other tasks such as product use.

From the understanding developed through Chapters 2 and 3, a definition of intuition has been formulated for the purposes of this study:

> Intuition is a type of cognitive processing that utilises knowledge gained through prior experience (stored experiential knowledge). It is a process that is often fast and is non-conscious, or at least not recallable or verbalisable.

Chapter 4 will address the previous work on intuitive interaction with products and systems in the realms of product design and human–computer interaction as progress is made towards relating this understanding of intuition to product use.

Chapter 4

Intuitive Interaction

4.0 Introduction

The term “intuitive” as used in the design profession has not been clearly defined. No author has thoroughly addressed the issue or fulfilled the objectives of the present study. However, intuitive use of products has been mentioned (although not fully addressed) by a variety of authors in diverse literature.

The Principles of Universal Design, developed at the North Carolina State University Centre for Universal Design, include Principle Three: Simple and Intuitive Use. A product should “be consistent with user expectations and intuition” (NCSU, 1997). Contact was made with the Centre, and one of the authors of the Principles stated that “we have not done any deep research in this area” and “the concept makes so much sense to me I never questioned it” (Story, 18/12/2000, personal communication)

Davis (1996) mentions the desirability of encouraging users to perform tasks in an “…intuitive manner,” (p118) but gives no further details about precisely what this means, or how it should be done. Taylor, Roberts and Hall (1999) state that “products should communicate their purpose and means of use in ways which allow intuitive use…” (p218). They do not define or expand on the concept of intuitive use. Parks (1998) claims that some domestic appliances are designed for intuitive use, although she does not cite any research into intuitive use, or any case studies on how it was designed into these appliances. IBM (2005) include "products should be natural and intuitive to use" as one of their ten user rights, but do not explain what they mean by it.

Birkle and Jacob (1988) claim that they developed an intuitive interface for sound system software but do not describe the meaning of the word intuitive and do not explain what principles they applied to their interface to make it intuitive. Rosson and Carroll (2002) have produced a textbook to help student interface designers make usable interfaces. They make liberal use of the word intuitive without explaining exactly what they mean by it. Richards and Compton (1998) claim that flexible and intuitive systems are needed. They equate intuitive interaction with user friendliness and present intuitive interaction as a good match between the things the user sees and does and what they feel to be appropriate, but do not explain further.

None of these authors have identified intuitive use well enough to make it possible to draw firm conclusions from their work. The more in-depth work relative to intuitive interaction applied to design is reviewed in Sections 4.1 and 4.2. This review includes work where the meaning of intuitive use and/or interaction is defined, or the assumed meaning comes across clearly. It is separated into the product design and Human Computer Interaction (HCI) realms, as the depth of understanding of intuitive interaction differs slightly between these fields. This difference will be demonstrated in the following pages.

4.1 Relevant Work in the Products Realm

Rutter, Becka and Jenkins (1997) discuss the design of the Rapport ergonomic chair. The design team wrote into the brief that the adjustment of the settings for a wide variety of users should be “intuitive in terms of the logic of their operation” (p29). As an example, they mention that the design language of the lumbar support panel was borrowed from a cushion. It was felt that an intuitive reaction to any discomfort would be to adjust the panel as though it were a cushion behind the lower back. This relates intuitive use of a new product to previous experience with an existing one, but no research or justification for this is cited by the authors.

Frank and Cushcieri (1997) present a case study about the design of an “intuitive” mechanical surgical grasper for minimum access (keyhole) surgery, where movement of the fingers was replicated by the movement of the grasper jaws. Many existing graspers are counter-intuitive in that the movement of the jaws does not correspond to the movement of the handles (Frank and Cushcieri, 1997; Roderick, 2001). The new grasper was developed in close collaboration between surgeon and designer, and it is possible to infer that this grasper was intuitive because it transferred its movement system from the actions surgeons would use to grasp an organ in their hand in traditional surgery. However, no reference is made to how the designers knew that this was intuitive.

Wiklund (2004) argues in support of intuitive interfaces for medical equipment. He defines intuitiveness as initial ease of use, based on instructions in the device and existing knowledge and skills. Wiklund (2004) recommends standardising interfaces between brands so that they are the same in each ward, and comments that nurses become frustrated when things contradict their expectations. He asserts that standardisation of controls and symbols will make experience with them transferable, again revealing an understanding of intuitive use as based on past experience with similar devices.

Murakami (1995) developed a physical input device that allowed deformation of a foam cube which was translated into deformation of a CAD drawing on a screen. He calls this “direct and intuitive” throughout the paper. It is easy to see that interaction is direct; in direct manipulation everything is done graphically instead of in an abstract medium like a programming language (Hutchins, Hollan, and Norman, 1986). This is beneficial as direct manipulation interfaces allow the interface to disappear so that users feel directly engaged with the task (Hutchins et al., 1986). Hutchins et al. (1986) argue that direct manipulation interfaces amplify a user’s knowledge of a domain and allow them to think in the familiar terms, so that even novices can perform a task if they are familiar with the task domain and appropriate icons are used to depict that domain. This goes some way to linking direct and intuitive manipulation, but this link is not explained by either Murakami (1995) or Hutchins et al. (1986).

Vroubel, Markopoulos and Bekker (2001) developed a prototype of a home messaging appliance. The driving design principles were simplicity of the application and intutiveness of interaction. They wished to let people maintain current habits, and thought users should be able to use it without directions or explanation. User trials showed that even those without computer expertise found it easy to transfer their knowledge of pen, paper and calendars to this application. All participants were comfortable using the system within five minutes. These authors also provide no definition of intuitiveness but the information reported implies that easy transfer of existing knowledge is the key.

Thomas and van-Leeuwen (1999) present a case study describing the design of two mobile phones. One objective was that the phones should allow simple calls to be made intuitively. The concepts that were developed used conventional dialling behaviour and allowed users to apply their existing experience. Usability test results suggested that users would learn how to operate the interface quickly, and the phones were acclaimed in the press for their unprecedented usability. Thomas and van-Leeuwen (1999) imply that inexperienced users are the ones who need tasks to be intuitive, and they applied users' existing experience to make a task intuitive, so presumably they also believed that experience contributes to intuitive use. However, they do not define exactly what they mean by intuitive.

Ardey (1998) designed an automated cockpit system for light aircraft according to what he calls the "principles of intuitive use" (p14-1). He does not define exactly what he means by this but he presents intuition as being the only processing mechanism available when attentional resources are limited. Therefore, he designed the cockpit to be easy and simple to use even when the pilot has his/her attention focused elsewhere. This system, for example, enables pilots to undertake trouble shooting on any system of the aircraft; in the past only extremely experienced pilots could do this and only under low workload conditions. One of the criteria followed was intuitive perception, which is not explained at all, but Ardey also mentions tradition as another criterion, giving a hint that he may be linking intuition with past experience. Ardey claims that the revised shape and arrangement of input devices support "processes of intuitive acting…" (p14-7) but does not explain what these processes or actions may be.

Dixon and O'Reilly (2002) conducted a research project into intuitive use. They argue that prior experience leads to intuitive interaction, and declare that adults almost never learn completely new procedures. Instead they adapt some old, previously learned one. Where there is no previously learned relevant procedure, people generally perform very poorly, even if a task is equivalent in difficultly to other tasks. For example, Global Positioning Systems are totally new products with very little reference to anything else whereas a new phone or printer requires the use of procedures and features that have been previously learned, so tasks of equivalent difficulty are completed more easily with phones or printers. Dixon and O'Reilly (2002) make the assumption that most new procedures are successful because they are similar to old ones, and that most procedural learning is therefore critically dependent on prior knowledge of similar tasks.

Dixon and O'Reilly’s (2002) work started from a solid foundation, by basing intuitive use on past experience. However, their classification scheme of procedures relied on plans, which have been largely superseded (Suchman, 1987). Clark (1997) explains that the work on classical planning assumed that complex sets of actions are determined by an internalised version of some set of instructions. However, looking closely at the real world behaviours of planning agents (humans, robots or simulations), it has become clear that there is a rather more complex interplay between plans and the supporting environment that is way beyond simple feedback. The problem solving methods of biological brains do not really follow the plan-as program model (Clark, 1997). Instead, individuals deploy general strategies which incorporate operations upon the world as an intrinsic part of the problem-solving activity. Therefore, basing their classification scheme on plans was a poor decision for Dixon and O'Reilly.

Dixon and O'Reilly divided interface similarity into three types: functional similarity, procedures that involve the same sequence of sub-goals; procedural similarity, situations where the same steps are used to achieve a given sub-goal; and interface similarity, where the same motor control schema is used for a given step. Their experiments involved people learning precisely controlled artificial tasks in a laboratory and then attempting to transfer this learning onto a new interface. However, this approach does not control or even take into account other previous experience or stereotypes that participants may have, so it is not ecologically valid.

They found minimal or non-existent effects of functional similarity, and state that this may be because of prior experience that subjects had with other devices (which again exposes the weakness of their experiment design). They include appearance of button labels in procedural similarity. They found a lot of difference between performance on training and transfer interfaces for this type of similarity (benefits from having previously learned the steps in the same order) and their interpretation of this is that this effect is not at the level of sub-goals or internal states of the device and does not involve reasoning about the device and how it works. They tested interface similarity by such manipulations as varying positions of buttons. The results showed some benefit from familiar layout but the performance measure (“transfer”) is their own logarithmic scale and is not explained. From the graphs published it seems unlikely that this difference is significant. However, it was found that the same effect of button layout was observed whether the labels on the buttons were the same or different. Layout is likely to make a difference in this context as there is only one task previously learned from one interface rather than many tasks from many products as in the real world. Also, it was learned immediately prior to the transfer task so is easier to remember. Dixon and O'Reilly have not yet reported the rest of their work on interface similarity. Obviously there is more to interface design than location and this researcher would argue that appearance is part of interface design, not part of procedure.

Dixon and O'Reilly (2002) claim that there is little effect in manipulating the graphics, fonts and logos. However, they do not report how they have done this, or with what rationale. They claim that having the same button name helps very little if the steps are performed in a different order. This may apply if the task is a unique one only just learned (as in this case) but not necessarily with real tasks and button names and/or icons that are truly familiar. The main problems with this work are the lack of ecological validity (which is a serious confound), the absence of statistical analysis and the failure to explain the logarithm used for the measurement of success. Their reliance on outdated plans and subgoal work, and the way in which they have classified the different types of similarity, are also points of weakness.

Although many of these authors do not spell out what they mean by intuition or intuitive interaction, and despite that fact that the term intuitive has been over-used and under-explained in the literature, it can be inferred that most of them assume it is related to past experience and can be applied to products by using familiar features that users have seen before. The success of this approach has been demonstrated by Vroubel et al. (2001), Thomas and van-Leeuwen (1999) and Frank and Cushcieri (1997), who all induced what could be called intuitive interaction by including familiar features in their designs. It seems that intuitive interaction has been applied but not necessarily categorised in the product design arena.

4.2 Relevant Work in Human–Computer Interaction (HCI)

Allen and Buie (2002) review various words used by usability specialists, one of which is “intuitive”. They argue that a rich and evocative word like intuitive is wasted if it sits in a “fog of uncertain associations” (p18). Their definition is: “an intuitive interface asks no more of a user than what he already knows or can immediately deduce from previous life experience” (p18), which clearly relates intuitive interaction with past experience.

Raskin (1994) also discusses possible meanings of intuitive as it is commonly used to describe interfaces and concludes that intuitive equals familiar. He states that “it is clear that a user interface feature is ‘intuitive’ insofar as it resembles or is identical to something the user has already learned” (p18), and “Intuitive = uses readily transferred, existing skills” (p18). He also comments that “…something cannot become intuitive over time, it is either intuitive or it is not” (p17). In this last quote he contradicts himself as this is an instance where the word familiar cannot be substituted for intuitive – things can become familiar over time. Raskin himself claims to avoid using the term intuitive, believing it to be associated with the paranormal, and preferring to use familiar instead. None of the intuition literature associates intuition with the paranormal although this may be an association made in popular culture in some places. The use of familiar to mean intuitive can also be misleading as intuition is a cognitive process, and intuitive use of a product or interface involves a cognitive process. Familiarity is not a cognitive process, so it is not an adequate term to describe what is happening. It can be used to describe interfaces or features of them that have been part of a person’s past experience (to a greater or lesser extent) and that is the context in which the term familiar is used in this thesis.

There has been, possibly due to Raskin’s (1994) easily accessible paper, more of a general understanding of a meaning of intuitive (as related to familiarity) in the HCI field than the design field. This is reflected in the larger body of research that has been generated in HCI which addresses or mentions the issue. However, there are still no authors who have investigated the issue thoroughly and most have not defined what they mean by intuitive use.

In relating what he sees as the desirable qualities of a friendly system, Galitz (1989) relates several terms to intuitive use: natural (operations should mimic the worker's behaviour patterns, thought processes and vocabulary); predictable (system actions should be expected within the context of the other actions that are performed); and self-explanatory (steps to complete a process should be obvious). All of these qualities depend on prior knowledge of similar things.

Bielenberg (1992) claims that "intuitive" is not an ideal way to describe an interface and that any interface must be learned at some level and thus is not intuitive. However, he also claims that the nipple is the only intuitive interface, which reveals that he may have been confusing intuitive with innate. He cites no intuition research or definitions but has made his own assumptions about the nature of intuition, assuming that it relates not to past experience, but to instinct. He goes on to advocate the mental model approach to interface design, claiming that there will always be an underlying task structure that fits naturally. This approach assumes that every user has the same mental model, whereas Marchionini (1995) claims that each individual user possesses unique mental models, experiences, abilities and preferences. Bielenberg does, however, mention that a familiar metaphor turns something unfamiliar into something familiar, which can tap into a previously established mental model, so some understanding of the role of previous experience in intuition is evident.

Spool (2005) argues that it is very hard to make an interface seem intuitive. It is a word he hears frequently from participants in user tests. He talks about the knowledge gap between the current knowledge point and the target knowledge point, very clearly relating intuitive use to prior experience, although not quite defining intuitive. The knowledge gap is where design happens: design is not needed prior to the current knowledge point or after the target knowledge point. He stresses that designers need to design in this gap to make target and current knowledge coincide. They can do this in two ways: train the user or reduce the knowledge necessary by making the interface easier to use. Spool (2005) argues that most good design (at least in software) does both. He has discovered in the course of his work with users that there are two conditions where users will tell a designer when an interface seems intuitive: when both current knowledge point and target knowledge point are identical (the user knows everything s/he needs already); or the points are separate but the user is unaware of this as the design is bridging the gap (the user is being trained in a way that seems natural). Spool's short paper is written for practitioners and firmly relates intuitive use to past experience, with some strong arguments from user testing and field studies. However, no rigorous research is cited.

Barker and Schaik (2000) define the intuitiveness of an icon as "the ease with which a user can deduce its meaning without having had any previous experience of it (within a computer interface)" (p162), and Wright, Fields and Harrison (2000) state that novice users' choice of menu names is informed by their knowledge of everyday meanings of the labels used. These workers seem to agree that intuitive use of features is based on past experience with similar things that can be transferred to new interfaces.

McMullen (2001) reports on a project aimed at developing an intuitive library website for a university. She found that students did not possess enough information literacy to fulfil their research needs with the current site as the site was not intuitive for those who had no previous research experience. Those unfamiliar with research and research resources would need instruction and explanation in a manner that was clearly understandable from the initial screen. This suggests that McMullen has linked intuition with existing knowledge or experience, but she does not articulate this and intuitive is not defined.

Knopfle and Voss (2000) designed a software-based design review tool for the car industry that would allow changes to be made to Virtual Reality (VR) CAD representations rather than physical models. They used a familiar scenario (the design review meeting) and electronic versions of familiar tools that would normally be used for the same task (e.g. rulers) to make their intuitive interface. They also borrowed metaphors from other familiar products (such as jog dials from video cassette recorders) to make the VR environment more familiar to users. No testing is reported, and the authors have not defined the concept of intuitive use, although they do convey the idea that familiar features will make an interface intuitive.

Raisamo and Raiha (2000) designed an alignment stick for use with CAD applications. They employed user's existing drawing habits by adopting metaphors as close to the real world as possible (the metaphor they used was a ruler). They also tested their design using physical rulers and shapes before they even began to write the programme, making sure that they had a good idea of what happened in the real world before creating a metaphor from it. They conducted an experiment to compare time on task and subjective preferences, with participants using the alignment stick, a palette or a pull-down menu. The stick was significantly faster for the simpler tasks but significantly slower for the more complex one. Subjective ratings of naturalness showed no significant differences between the three methods and there was also no significant difference in accuracy between the methods. However, the authors felt that the stick was intuitive because users who had no previous experience of drawing programs could draw on other experiences in order to use the stick, and they state that intuitive interfaces are based on previous experience.

Lehikoinen and Roykkee (2001) designed an interaction system for wearable computers (N-fingers). They wanted the technique to be efficient and natural as they envisaged that such computers would be used while the wearers were also performing other tasks. They claim that the design is intuitive and easy to learn. The interface works by sensing the thumb touching the first two fingers. After an iterative design and testing process the researchers developed a glove that utilised a layout based on the curser keys of a keyboard. This proved to be successful when compared with the same task using a keyboard during testing, and was as fast as a standard keyboard. Users judged it to be logical and easy to use, and the authors conclude that it is an intuitive technique. They argue that the intuitiveness of N-fingers would allow it to be operated even with external sources of distraction if users were doing other tasks. These authors applied users' previous experience with cursor keys to an entirely new product and users found it natural to use; this is more evidence for the thesis that applying familiar features to a new product can make it intuitive.

Hummels, Smets and Overbeeke (1998) conducted two experiments to explore how designers use gestures to demonstrate a three dimensional shape. Hummels et al. (1998) define intuitive interfaces as "…interfaces that can be used without learning…" (p198). They conclude that a totally intuitive gestural interface would be possible. Dorfmuller-Ulhaas and Schmalstieg (2001) and O'Hagan, Zelinsky and Rougeaux (2002) are also working on this type of technology and agree that gestural interfaces would be more intuitive than traditional VR approaches. Kang (1998) designed a system of hands-free VR navigation and claims it is "simple, intuitive and unobtrusive" (p247). This was done using facial pose tracking which the design team present as a step towards the development of human-centric computer interfaces that allow humans to interact with computers using natural speech and gestures.

These gestural studies suggest that intuitive use could be induced by using more "natural" gestures or movements than traditional interfaces allow. These types of gestures (those which people learn from childhood in order to interact with others) are possibly based on formative sets of stimuli to somatic pairings formed in childhood and adolescence (Damasio, 1994). According to the connectionist theories, the connections required for these responses or gestures are reinforced by constant use and so would be very strongly preferred. This could be what makes them seem so natural even though they need to be transferred into a different context. In addition, people tend to interact with computer technologies as though they were communicating with other people (Janlert and Stolterman, 1997), which could be another advantage for gestural and other interfaces based closely on existing human interaction habits.

Okoye (1998) produced a thesis detailing her study on intuitive graphical user interfaces (GUIs). She does not discuss in the literature review what intuition or intuitive use is, providing no definitive meaning of intuition. She defines an intuitive interface as one that allows novice users of computer applications to be productive with little or no training, and which allows ease of learning and recall, and subjective satisfaction. Okoye (1998) stresses that "the element of familiarity is the most crucial cognitive factor in making an interface intuitive…" (p40), stating that intuition can be added to an interface by adding familiarity and citing Raskin (1994). However, she does not explain the theoretical foundation for this definition.

The aim of her project was to use a metaphor-based mental model as the foundation for the intuitive design. Okoye's goal of applying metaphor to interfaces was to evoke a certain mental model already built by the user; the metaphor acting as a catalyst or trigger. Therefore, the target user community must be familiar with the metaphor, which must have a definitive meaning or structure so that when it is invoked, everyone knows what to expect. Okoye (1998) first conducted tests in which people were asked to link various icons with their meanings. The icons were designed in three groups: intuitive (based on familiar things), Windows-style and random. She claims that this research suggested groups of users could share a mental model. The testing she did revealed that users had a shared understanding about what familiar icons meant, which does support the idea that intuitive interaction is based on familiarity and experience. However, an icon is not a model. A mental model of a whole product or system is implied by the use of the term mental model.

Okoye (1998) then designed and tested her Intuitive Metaphor Mental Model based interface, comparing it again with a Windows-based and a random interface. She used time on task as an index of ease of use, and a subjective survey instrument to measure user interaction satisfaction. The intuitive interface performed better and she contends that the users had the support and guidance of a model in long-term memory which enabled them to use the interface intuitively. Again, this research supports the idea of experience enabling intuitive use, but the use of the mental model approach does not appear to be justified. Some psychologists have suggested that mental models are supposed to describe cognition and are not suitable to apply to systems design (Rutherford and Wilson, 1991).

It is unclear whether or not there is any reliable way to predict what a mental model might be and how to trigger it. Okoye (1998) claims to have done this but is not completely convincing. Okoye cites studies which show that people do form mental models; however, she also details failed attempts by other researchers to apply them to interfaces. She saw hers as the first successful attempt but it is difficult to see how her work really relates to mental models.

Smith, Irby, Kimball and Verplank (1982) report on the revolutionary Star Interface which was designed by Xerox. It had one of the first "what you see is what you get" (WYSIWYG) GUIs and was the first to use the office desktop metaphor. This was an object-oriented interface and much simplified the interaction process, which made it very different from the code-based operating systems that were prevalent at the time, and started to open up computing to the general public rather than just enthusiasts.

The authors argue that when everything is visible, the display becomes reality; the user model becomes identical with what is on the screen.

One of the design principles was to allow user experience in one area to apply in others. The principles used to design the interface included familiar user's model, universal commands across the system, and consistency. The team decided that the metaphor of the physical office was appropriate to the experience of prospective users and created electronic counterparts of the physical objects in an office. Therefore, users were not exposed to entirely new concepts all at once, as much of their existing knowledge was embedded in this base. The team did this to make the electronic world seem more familiar, less alien and require less training; and their experiences with users and the continued use of similar metaphors have confirmed that this worked.

Their intention was that users would "intuit" things to do with icons (Smith et al., 1982, p258). They predicted that this would happen: if the Star interface modelled the real world accurately enough so that familiar ways of working and existing concepts and knowledge were preserved; and if there was sufficient uniformity in the system, and principles and generic commands applied throughout the system allowed lessons learned in one area to be applied to others. The Star team believed that people do use their existing knowledge when confronted with new situations, and based the design of the system on that knowledge so that people could intuit new uses for the features (Smith et al., 1982). These authors clearly imply that intuitive use depends on previous experience although they do not define intuition or cite any research into intuition and past experience.

Perkins, Keller and Ludolph (1997) report on the design process for the Lisa user interface, an early GUI developed by Apple . The Lisa team had contact with the Star team during the development process through a share deal; also, some of the people were on both teams. The authors claim that the use of graphics in interaction set Lisa apart from its competitors and went a long way towards making the system friendly, usable and enjoyable. They mentioned that "intuitive icons" (Perkins et al., 1997, p42) could be designed to indicate certain messages to the user. As with Star, the desktop metaphor was employed. The development team felt that the interface needed something familiar to the office worker in order to gain acceptance, and they believed that through graphical representation of the familiar desktop, the icons and controls shown on the screen would become more real and the interface would begin to disappear.

Perkins et al. (1997) claim that an interface would be intuitive if modelled on documents and other office-based objects instead of unfamiliar computer concepts. Again it seems that they linked intuitiveness with familiarity but unlike Okoye (1998) they, like the Star team, aimed to design intuitive icons rather than complicating the issue by relating it to mental models. The team also planned for all applications to be similar in appearance and employ commands that would be common to each other so that users would interact with all Lisa applications in the same manner. Perkins et al. (1997) conclude that the team combined clear, concise presentation and an intuitive, smoothly operating set of controls with a distinctive style and therefore popularised a new way of working with computers.

Workers in the HCI field have a much clearer idea of the nature of intuition and intuitive use, and intuitive use is generally accepted as being associated with familiarity. Although many authors write about intuitive use without defining it, their belief that intuitive use depends on past experience does come through fairly clearly. Intuitive interaction has been successfully applied to early and subsequent GUIs and to recent websites, wearable computers and VR software. This makes it a relevant, current (though little understood) design tool. The HCI tradition has tackled intuitive interaction more fully than the product design arena, and Raskin’s (1994) definition is possibly the reason for this greater willingness to tackle the issue in HCI in recent years. Despite the greater depth of understanding in the HCI fields, no authors have yet established empirically how people can use things intuitively, and exactly how designers can apply familiar things to an interface in order to make it intuitive.

4.3 Summary

The concept of intuitive interaction has been widely mentioned and even applied but never addressed in depth. Several authors (for example, Ardey, 1998; Birkle and Jacob, 1988; Frank and Cushcieri, 1997; Kang, 1998; Knopfle and Voss, 2000; McMullen, 2001; Murakami, 1995; Okoye, 1998; Perkins et al., 1997; Rutter et al., 1997; Smith et al., 1982; Thomas and van-Leeuwen, 1999; Vroubel et al., 2001) discuss with varying degrees of detail how they applied intuitive use to new designs. However, none of them describe in sufficient detail exactly how products and systems can be designed to encourage intuitive interaction. Some do not define what they mean by intuitive or intuitive use, not even saying explicitly that they used familiar features in their designs; and many who discuss using familiar metaphors or symbols for new interfaces do not describe in detail how they decided what would be familiar to target users. Some of these authors used a mental models approach to applying intuitive use to software, which is not a successful or appropriate approach in all situations, and those who assumed a mental model for the users did not convincingly argue that a model can be correctly assumed.

In some of the literature, interfaces, features or icons are given the attribute "intuitive". However, the interface, product or feature itself cannot have the trait intuitive, or even familiar, as that depends on the experience of the users; is a characteristic of the user, not the product. The terms "intuitive interface" and "intuitive product" are misnomers. Spool (2005) agrees that an interface itself cannot be intuitive, although he sees nothing wrong with using the terms intuitive interface and intuitive design. One could more correctly say that an interface is designed to be intuitive for a certain user group, or one can talk about the process of intuitive interaction with a product, but stating that an interface itself is intuitive could be misleading. It is likely that this looser use of the term will continue among researchers, practitioners, marketers and users; and although trying to prevent that may be futile, the distinction is useful if researchers and designers are to think clearly and carefully about what they are doing.

This review has shown that intuitive interaction has, in most cases, been related to familiarity and prior experience and some authors have successfully applied these ideas to designing interfaces. Later chapters in this thesis report on research that goes further in empirically establishing how intuitive interaction and familiarity are related and how the different aspects of an interface design can affect intuitive interaction. Prior to this, Chapter 5 will explore the various theories that relate to intuitive interaction with products and systems in order to place intuition as applied to interaction within a theoretical framework.

Chapter 5

Intuitive Interaction, Artefacts and Interfaces

5.0 Introduction

This chapter aims to position this research within the fields of Human Factors, HCI and Design, and to show how it relates to existing theory and practice in these areas. Since the existing work in intuitive interaction itself is limited, this chapter looks at what these related areas can contribute to a better understanding of intuitive interaction. It starts by relating previous work done on the importance of prior knowledge, which is the area most directly related to intuitive interaction. Other areas covered include usability, the ecological approach and affordances, population stereotypes and mapping, applying metaphor, consistency and finally product semantics.

5.1 Prior Knowledge

There is general consensus about the importance of designing artefacts that relate to users' prior knowledge and familiarity, particularly in HCI, but with growing force also in design. This has been related to intuitive use and discussed in Chapter 4. For example, when describing a "good" design, Preece et al. (2002) talk about the advantage of using familiar things in an interface and recommend representing basic functions in terms of the behaviour of everyday objects, which capitalises on ubiquitous everyday actions. Learned conventions, once accepted by a cultural group, become universally accepted; for example, the use of windowing and icons on desktops (Preece et al., 2002). To make systems easy to learn, Preece et al. (2002) believe designers should capitalise on users' existing knowledge. For example, a CAD system does not teach a person how to draw, but should be able to utilise what they know about drawing to allow them to learn the system quickly and easily.

As people use their existing knowledge when they are confronted with new situations, the design of a system should be based on that knowledge (Bonner, 1998; Kellogg, 1989). Rettig (1991) opines that people try things out, think them through and try to relate what they already know to what is going on. They do not read abstract manuals but instead apply their previous experience to a problem. Wickens and Seidler (1995) suggest that familiarity is a good reason for design decisions, and Wickens et al.

(1998) recommend designing interfaces to be consistent with experience, stating that old habits die hard and transfer positively to new products or systems. Fischer (1991) also recommends that designers should exploit what people already know, and use familiar representations based on previous knowledge and analogous to known situations.

Weiss (2002) recommends that designers borrow from well-designed applications when user interface standards are not available or not adequately developed. Designers should not invent new interfaces when one of the existing ones will do the job well, but should be consistent and use existing icons as much as possible. New icons for old concepts will confuse users.

Pearson and van Schaik (2003) investigated the role of previous knowledge in website navigation. They found that, although using blue hyperlinks may be wrong according to some studies (red should be more readily perceivable), they are familiar, and time saved by knowing what to do is probably much greater than time saved by having a word in a colour that is quicker to read (this may be partly because users do not need to read most links in detail anyway). An automatic attention response is formed if a user consistently searches the same environment for the same information and the information is always represented in the same way (Pearson and van Schaik, 2003). Blue links resulted in fewer errors and faster correct responses, and in the more realistic of their search tasks, blue links were found to be significantly quicker to use. Pearson and van Schaik (2003) also found that the most preferred locations for the navigation bar were firstly on the left (most common on existing sites) and then at the top (another common position on current sites).

Smart, Whiting and DeTienne (2001) discuss user tests in which users who lacked awareness of the system and of the online help facility could not complete the task. However, users familiar with several software applications frequently applied what they knew from other applications when they encountered a problem or used the help menu. These users had problems when an application’s conventions differed from those that they had previously experienced.

Bocker and Suwita (1999) tested complex mobile phone prototypes and found that Windows-experienced participants needed less time and fewer attempts to do the tasks, consulted the manual less frequently, and indicated less frequently that the next step was unclear. Windows users agreed that the mobiles were easy to use and understand, were familiar and did not require much thinking. They were significantly more pleased with the phones than Windows novices, and were able to transfer computer-based skills to a handheld device. Owners of mobile phones also drew on their experience with their own phones, some of which had different procedures for particular tasks, and for some tasks mobile owners consulted the manual more often than non-owners (a case of negative transfer). However, mobile owners rated the prototypes more frequently as user friendly and fun to use and they indicated more frequently than non-owners that they would use them themselves. There were no significant differences between the two interface types (icon and text) that were tested, so familiarity was more important than icon or interface type.

van Rompay, Hekkert and Muller (2005) have made an exploratory attempt to apply experientialism to design. Using the image schema ideas put forward by Johnson (1987), they argue that artefacts can make reference to structural properties of image schemata, resulting in a particular experience-related expression. They asked students to demonstrate (on a scale) to what extent a series of terms described a selection of chairs. The terms were based on the four main image schemata: container, back/front, balance and size. They found that many of the terms indeed seemed to relate to the relevant schema. However, the way in which they have linked the chairs and the schemata through linguistic terms seems to be one step removed, and translating bodily experience through language may not be the best way to investigate this issue. Assuming that this kind of knowledge may be non-conscious and that linguistic terms may have all sorts of other meanings for different people unrelated to the schemata, observation of real interaction would be more useful. van Rompay et al. (2005), while acknowledging that their work is speculative and more needs to be done, claim that their findings point towards a schema-based structuring of product form expression, and that products may be understood as expressing characteristics related to bodily experiences.

As discussed in Chapter 4, intuition and intuitive interaction rely on previous experience. These examples show that this notion has been accepted and successfully applied to interface design, although it may have been done in a rather ad-hoc way. The aim of the present research is to enable intuitive interaction with interfaces by extending the understanding of this concept and applying it in a more systematic way.

5.2 Usability

The official definition of usability is "...the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environments" (ISO DIS 9241-11, in Jordan, 1998, p5).

Working from the International Standards Organisation (ISO) definition, Jordan (1998) explains his model of usability, developed to take into account three levels of task performance: guessability, learnability and experienced user performance (EUP). Guessability involves using a product to perform a new task for the first time, and is important for products that have a high proportion of one-off users (Jordan, 1998). Jordan defines learnability as the ease with which users reach some competent level of performance with a task but excluding the special difficulties involved with doing it for the first time. Experienced user performance refers to the relatively consistent performance of someone who has used a product many times before to perform particular tasks. Jordan also added two extra components of usability: system potential (the upper level of EUP) and re-usability (which refers to how easily users can get back into using a product after a comparatively long period away from it).

Nielsen (1993) splits usability into five measurable attributes: learnability, efficiency, memorability, errors and satisfaction. Learnability applies to novice users and incorporates what Jordan calls guessability. Efficiency refers to the ease and speed with which experienced users use a system and is equivalent to Jordan's experienced user performance. Memorability (equivalent to Jordan's re-usability) mainly applies to casual or occasional users. To a great extent, good learnability will tend to contribute to good memorability (Nielsen, 1993). Stanton and Baber (1996) split usability into eight factors: learnability, effectiveness, attitude, flexibility, perceived usefulness or utility of the product, task match, task characteristics and user characteristics. They argue that ISO 9241 falls short of a comprehensive definition and that usability has been defined simply by what can be measured.

To be usable, an interface must provide access to the functions and features of an application in a way that reflects users' ways of thinking about the tasks they do with it, which requires that they must be able to interact with an application in ways that are intuitive and natural (Wood, 1998). However, no authors have yet suggested how intuitive interaction fits into usability. It would appear that the concepts of learnability (Jordan, 1998; Nielsen, 1993; Stanton and Baber, 1996) and guessability (Jordan, 1998), as components of usability, are the most relevant to intuitive usability. Learnability has been linked to intuition (Thomas, 1996; Weiss, 2002). Memorability (Nielsen, 1993; Stanton and Baber, 1996) or re-usability (Jordan, 1998) has been linked with learnability (Nielsen, 1993; Stanton and Baber, 1996), so may also have some applicability for intuitive interaction. Memorability is most important during the first use and the few subsequent uses that occur before the user has become reasonably familiar with the product, or when a user has become unfamiliar with the product through lack of use. One could say that the point of intuitive usability is to reduce the gap between guessability and experienced user performance, both stages of usability theorised by Jordan (1998).

Therefore, intuitive interaction is important for aspects of usability that relate to initial and occasional uses of products. It could have particular impact for products or interfaces that have many one-off or occasional users, but could also make all sorts of products easier to learn and provide more positive first time experiences with things.

5.3 The Ecological Approach

A consequence of the computer metaphor of information processing (eg, Bailey, 1996; Wickens et al., 1998) is that context or background can be ignored or conveniently boxed to fit within the type of flow diagrams prevalent (Hayes, 1995). This leads to limited understanding of what people say and do to one another, and how they interact with the world. Traditionally, Hayes claims, cognitive psychologists see people's thinking as independent of their social, cultural and biological context. Winograd and Flores (1986) concur that a more holistic approach is needed, where the environment is taken into account.

First mooted by Gibson (1977), the ecological theory of perception is based on the fact that the human perceptual system is designed to operate in the environment and therefore the study of perception should begin with analysis of this environment and the information it makes available (Neisser, 1987). One of the fundamental commitments of the ecological approach is that it is not possible to understand human behaviour without simultaneously understanding the context or environment in which people are acting (Hayes, 1995; Vicente, 1997).

In light of the proposition that cognition is embodied (Section 2.3), Gibson's ideas have been given new perspective. Many theorists in various fields share the idea that perception, action and cognitive systems cannot be considered as separated, and defend the claim that cognition is deeply grounded in sensory-motor processes (Clark, 1997; Damasio, 1994; Johnson, 1987; Varela et al., 1991). An implication of this view is that knowledge is anchored in experience and cannot be separated from perception and action.

5.3.1 Defining Affordances

Affordances are a central tenet of the ecological approach. Gibson (1977) defines them thus: "the affordances of the environment are what it offers animals, what it provides or furnishes, for good or ill" (p68). For example, he says that "if a surface is raised approximately to the height of a biped's knees then it affords sitting on – whether it is a manufactured chair, a log or ledge, the affordance is the same" (Gibson, 1977, p68). The Gestalt psychologists called the affordance the demand character of an object (Bruce and Green, 1990; Gibson, 1977). It has also been called invitation character and valence (Gibson, 1977). Other definitions include:

> …the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used (Norman, 1988, p9).

> …what some object or surface offers the perceiver (Bruce and Green, 1990).

> …a specific combination of its substances and surfaces taken in reference to an individual (Zaff, 1995, p240).

> A particular environment has a given affordance if and only if it makes a kind of action possible… (Neisser, 1987, p21).

> …some intuitive way of using an artifact (Wright et al., 2000, p15).

5.3.2 Direct Perception and Mediation

Whereas the value of something is assumed to change as the need of the observer changes, Gibson argues that the affordance of something does not. Whether or not the affordance is perceived will change as the need of the observer changes but, being invariant, it is always there to be perceived (Gibson, 1977). Now this is no longer true as digital products and computers can display different affordances depending on their state and the needs and wants of the user (Norman, 1993). This further demonstrates the division of control.

One of Gibson's (1977) hypotheses is that "the visual system of a mature observer can *pick up* this information [by direct perception] or else can be altered by perceptual learning so that it is picked up" (p80). However, he goes on to discuss how hidden affordances (which can be seen as equivalent to the division of control) have made this more problematic and it has become more necessary to learn rather than directly perceive. Nevertheless, Gibson (1977) concludes that (despite hidden affordances) "the basic affordances of the terrestrial environment are perceivable, and are usually perceivable directly, without an excessive amount of learning” (p82). Maybe *basic* is the operative word here. Microchip-based products are not basic any more, so affordances generally need to be things that have been previously learned.

Mediation is the alternative to direct perception. The mediational account assumes that one must use inference, prior experience, expectancies or calculations to translate the affordance (Zaff, 1995). Vera and Simon (1993) claim, contrary to Gibson (1977), that the thing that corresponds to an affordance is stored in memory. That makes the understanding of affordances intuitive, not innate as some proponents of direct perception have seemed to suggest.

5.3.3 Affordances and Intuitive Interaction

Norman (1988) asserts that the thoughtful use of affordances and constraints in designs allows users to determine the proper course of action, even in a novel situation. Affordances have been much popularised and have been used to describe both physical and virtual interface objects (Preece et al., 2002). Norman (2004a) admits that by popularising the use of the term affordance in the design community he deviated from Gibson’s (1977) original definition. He has generalised the term to include emotional, social, and cultural affordances.

However, Norman (2004b) has recently tried to clarify the situation by talking about perceived and real affordances. Physical objects have real affordances, like grasping, that are perceptually obvious and do not have to be learned. A physical object like a door handle affords actions because it uses constraints; its physical properties constrain what can be done with it in relation to the person and the environment. However, a virtual object like an icon button invites pushing or clicking because a user has learned initially that that is what it does. User interfaces that are screen-based do not have real affordances; they have perceived affordances, which are essentially learned conventions. Despite the slight confusion due to the use of the word perceived, and the potential for misunderstanding with Gibson’s idea of direct perception, this is a useful distinction – between “real” physical affordances that do not require learning beyond experience of being in the human body, and “perceived” affordances which are based on prior experience with similar things.

The concept of the affordance suggests a route to intuitive use. If physical affordances are applied to products, then according to the direct perception account, people should be able to use them successfully, without difficulty, when first introduced to them. However, for more complex products, perceived affordances seem to be based on previous experience (Norman, 2004b), as maintained by the mediational account. It seems likely that physical affordances which are based on basic constraints that are dictated by the human body can indeed be picked up directly by anyone with a normal physique, and could be archetypical. They are related to the body and what can be done with it, and the experience required to use them is limited to experience gained through being embodied in the world; there is no cultural knowledge or even experience with similar things necessarily required here. It is possible that these types of affordances could be “picked up” directly as they are so simple and so directly related to the physical form. However, perceived affordances can be understood only by those who have experienced something similar that they can apply. For many modern digital products and software, affordances are not based on basic physical characteristics, and may even have no physical existence at all, so they require prior experience.

5.4 Activity Theory and Situated Action

Activity Theory originated in USSR psychology in the 1920s. Its object is to understand the unity of consciousness and activity. Activity theorists believe that people are what they do, and what they do is embedded in the social matrix, which is composed of people and artefacts (ranging from physical tools to language).

An “activity” is a human action plus a “minimal, meaningful context” (Kuutti, 1996). The activity is the basic unit of analysis, although of course a person usually participates in several activities at once. Activities are not static and are undergoing constant change. An activity has its own history and always contains various artefacts (from products to laws or methods). Activities can be broken down into shorter-term steps of actions and operations (Kuutti, 1996). Chains or networks of actions and/or operations are linked by overall object and motive. Operations are well-defined and habitual routines used as answers to conditions during an action. Each operation starts off as an action; but when a good model has been developed and the action has been practised enough, it becomes an operation, and a new action with broader scope is created (Kuutti, 1996). An operation can return to being an action if conditions change (action–operation dynamics). The border between action and activity is similarly flexible (Kuutti, 1996).

Activity theorists believe that the internal side of an activity cannot exist without the external one. Cognitive processes develop or occur within the context of activities (Kuutti, 1996). The use of culture-specific tools shapes the way people act and, through internalisation, influences mental development. Tools are thus carriers of cultural and social experience (Kaptelinin, 1996a). These artefacts have a mediating role between the actor (or subject) and the object of doing (Kuutti, 1996). Tools mediation is a way of transmitting cultural knowledge (Kaptelinin, 1996b), and “all human experience is shaped by the tools and sign systems we use” (Nardi, 1996, p10). This seems to be implicit learning using objects, where the object is the mediator in the learning process and the knowledge gained is often non-conscious.

These ideas have some similarities to experientialism and embodiment, seeing people and their actions as being part of the world. They also offer support for the idea that knowledge applied during intuitive interaction can be gained from using other tools. Activity theory helps to position intuitive interaction within the other types of cognitive processing that may occur during product interaction. Intuitive use could be seen as being less automated than the operation and less conscious than the action. The amount of relevant experience a person has will determine at which level s/he is processing.

The central claim of Situated Action (SA), or situativity, is that cognitive activities should be understood as interactions between agents, physical systems and other people (Greeno and Moore, 1993). The term situated action was introduced by Suchman (1987), and underscores the view that every course of action depends on its material and social circumstances. Situated Action proponents also believe that once a task has become automatic, the tools or equipment effectively disappear. The user is no longer consciously solving a problem or planning; he or she is simply doing. The task is now a matter of detecting cues and responding to them with previously learned responses. Of course the user still has the representation of the product that s/he made during the learning process, but at the highest level of functionality, the user is simply aware that s/he is performing a task (e.g. driving along a road), not how s/he is doing it.

Vera and Simon (1993), Baber and Baumann (2002) and Norman (1993) all agree that tools should stay in the background, allowing the user to directly engage with the task. For example, “the most profound technologies are those that disappear. They weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991, in Baber and Bauman, 2002, p285). However, when there is a problem, people become conscious of the activity and may try to formulate procedures or rules (Suchman, 1987). This has also been called breakdown, which Winograd and Flores (1986) explain as the moment when the properties of an artefact suddenly become apparent because of a problem. Until a system stops working, people are not consciously aware of the properties of the artefacts with which they are interacting; they are transparent. Like the Activity theorists’ concept of action-operation dynamics, if there is a breakdown, such as a malfunction or an unfamiliar task or feature, the user can rely on the more detailed representations s/he learned to start with in order to solve the problem (Winograd and Flores, 1986).

Breakdown could be seen as equivalent to the concept of using knowledge-based processing in the SRK model, and is mentioned by Baars in relation to consciousness. If there is a problem that cannot be dealt with unconsciously because there is not enough prior experience to go on, a person has to use knowledge-based processing to get through it. At this point the task becomes more conscious, and generally slower (Baars, 1988).

Richards and Compton (1998) claim that breakdown can be minimised by providing an intuitive environment. It seems that artefacts which appear transparent and are used without much conscious awareness are used intuitively, and those used with no conscious awareness at all are those used automatically. The ecological approach, activity theory and Situated Action are all based on studying people in the context of, and in interaction with, their environments. Action–operation dynamics and breakdown appear to be equivalent processes and have similarities with the SRK model. The role of tools as mediators is also an important aspect that these types of approach have in common. Table 5.1 shows a break-down of the various theories, and demonstrates how these different ideas might refer to equivalent processes.

Table 5.1 Dynamics of consciousness and processing according to various paradigms

Learning/ Familiarity	Activity Theory	SRK Model	Cognitive Processing	Level of consciousness	Tools	Breakdown/ unfamiliarity
↓ ↑	Action	Knowledge	Controlled processing	Process is conscious	Unfamiliar and require conscious focus	↓ ↑
		Rule	Intuitive processing	Possibly some conscious involvement	Familiarity allows intuitive use	
	Operation	Skill	Automatic processing	Process is non-conscious	Transparent	

These approaches help to demonstrate how intuitive interaction may relate to some of the current theories of cognition and interaction, and how these processes are always dependent on the actor being familiar with the tool or interface with which s/he is interacting.

5.5 Designing with Metaphor

Metaphor was examined in Chapter 3. This section will address the application of metaphor to design. Metaphor and metonymy can be embodied visually in a product (Krippendorff, 1990), and a physical metaphor can simplify and clarify a system by using more general concepts (Smith et al., 1982). Smith (1998) suggests that a user will intuitively understand a metaphor from prior experience.

System designers make frequent use of analogues, and tend to look for previous systems (i.e. existing products) to serve as analogues (Dent-Read et al., 1994). At present, however, the use of metaphor is ad hoc, with different metaphors being used for different parts of displays. Designers do not consciously use guidelines or rules for incorporating metaphor into pictorial displays (Dent-Read et al., 1994).

Domains that are well known to both designer and user can be used to coordinate displays and the actions the displays support. Designs that are not useful are those that employ topics not well known to the user (Dent-Read et al., 1994). Klein (1998) agrees that effective metaphors are those that trade on well learned behaviours so that the new task can be preformed smoothly, using skills that have been previously developed. Ineffective metaphors do not coordinate actions. For example, it is not helpful to apply a metaphor that presents a system in an aircraft as "sick", as pilots do not have well learned reactions to sickness and how to fix it. Experimental work has shown that it is far easier to make links using metaphors when surface features match than when situations are similar in an abstract way (Bowden, 1997; Klein, 1998).

Rohlfs (1998) states that a metaphor may be represented through words on a screen (e.g. appropriate titles) or pictorially through icons or graphics. A metaphor which works well for novices may be considered superfluous for experts, and for a metaphor to be successful it must be consistent with existing metaphors used in the workplace, and should be sustainable throughout the interface and extendible to new tasks. The choice of appropriate metaphors for an application is the most challenging and far-reaching decision on any project (Rohlfs, 1998).

Application of experiential knowledge often takes place through the medium of metaphor (Benyon and Imaz, 1999; Johnson, 1987; Lakoff and Johnson, 1981). Rasmussen (1986) claims that intuition can be enabled by this sort of transfer. This is what is required in a product: to enable a new thing to be reminiscent enough of something familiar that immediate intuition from experience is possible (Rasmussen, 1986). Some designers of systems and products (particularly Graphical User Interfaces) have discussed the use of metaphor for improving intuitive usability (e.g. Okoye, 1998), although it has not been addressed in enough depth to be easily applicable.

Some writers suggest that similarity of surface features is the most important thing to allow transfer of meaning through a metaphor (Bowden, 1997; Klein, 1998; Kolodner, 1993), which means that designers can improve an interface (by getting interface features right) without having to change the underlying structure of the system. This makes intuitive use simpler and cheaper to apply to complex products than mental models, although a familiar underlying structure where possible will probably bring added benefits. On occasions when something already familiar can be applied to an interface, designers need not use a metaphor, but a new type of product or feature may benefit from application of a metaphor that links it to something more familiar, making it intuitive to use.

5.6 Population Stereotypes

Humans have assimilated a large number of arbitrary, unnatural mappings from products that were not designed to be usable but that they use easily because they have learned to use them from a young age (Norman 1988, 1993). These are called population stereotypes. Population stereotypes define mappings that are more related to experience than any "natural" spatial layout (Bonner, 1998; Wickens, 1992) and derive largely from experience of natural phenomena or of cultural conventions. They are just customs, but Smith (1981) claims that "expectations based on customary usage can be strongly compelling" (p306). Wu (1997) equates human expectations with population stereotypes.

Crozier (1994) argues that population stereotypes should place constraints upon designers and indicate the meanings of functional properties of objects. Strong stereotypes are less vulnerable to stress, change of body position and use of the non-preferred hand (Loveless, 1963). When population stereotypes were conformed to, Asfour, Omachonu, Diaz and Abdel-Moty (1991) found that reaction or decision time was shorter, the first control movement the operator made was more likely to be correct, the operator could use the control faster and with greater precision and learn to use the control more rapidly.

Population stereotypes have been studied since the 1950s (Smith, 1981). Many researchers have taken the scarcity of new work on this subject compared to the post-war effort, as an indication that all possible research had been done (Simpson and

Chan, 1988). However, Simpson and Chan (1988) claim that many issues remain unresolved, and many recommendations are still based on work done during the 1950s. A lot has changed since then in terms of the population itself and the mediating products that produce the stereotypes, so the existing work is by no means unequivocal (Simpson and Chan, 1988).

Loveless (1963) conducted a review of the work done on population stereotypes during the 1940s, 1950s and early 1960s and from his review the stereotypes whose dominance and lack of ambiguity have been most firmly established are those such as up for increase, forward for up, clockwise for right and clockwise for up or increase. Also, an operator refers display movements to his/her line of sight, and control movements to the orientation of his/her body (Loveless, 1963). These are stereotypes that were established through the use of interfaces based on knobs, dials and sliders, but which can be transferred to digital interfaces. Loveless (1963), Wu (1997), Smith (1981), Simpson and Chan (1988) and Bailey (1996) agree that any proposed solution utilising population stereotypes needs to be tested for the appropriate population, as stereotypes will differ between user groups.

The idea of population stereotypes seems highly relevant to intuitive usability. If designers can make features function in a stereotypical way then they should be familiar and therefore intuitive to use. However, the lack of recent work in this area means that there are few established stereotypes for digital products and interfaces that can be applied to the new products of the 21st century. Research is required to establish which of the conventions established over the past decades have achieved stereotypical status.

5.7 Mapping and Stimulus–Response Compatibility

Stimulus–response work in cognitive psychology has contributed to the Human Factors field and been extended through work on mapping and compatibility. Designers should exploit natural mappings, which are the basis of stimulus-response compatibility (Norman, 1988; Wickens, 1992; Wickens et al., 1998). Stimulus-response compatibility relates to the spatial relationships of controls and the object they are controlling. It is a concept that has been investigated since the 1950s (Smith, 1981), and is important because a system with a greater degree of compatibility will result in faster learning and response times, fewer errors and a lower mental workload (Wickens, 1987; Wu, 1997).

Stimulus-response compatibility has both static elements (where response devices should be located to control their respective displays) and dynamic elements (how responses should move to control their displays). Wickens (1992) calls these "location" and "movement" compatibility respectively. Designers should locate controls next to relevant displays where possible (collocation). When collocation is not possible, two important principles for location compatibility are congruence and rules. Congruence is based on the idea that the spatial array of controls should be congruent with the spatial array of displays, which contributes to faster and more accurate performance (Wickens, 1992). Simple rules seem to be drawn from population stereotypes to map the set of stimuli to the set of responses. The fewer rules have to be utilised, the faster the response time. Movement compatibility defines the set of expectancies that an operator has about how a display will respond to a control activity. Movement compatibility is largely based on the principle of the moving part (Roscoe, 1968, cited in Wickens et al., 1998). Movement should be analogous to the mental model of the displayed variable (Wickens, 1992).

Proctor, Lu, Wang and Dutta (1995) claim that the relative compatibility of alternative S-R (stimulus response) mappings for a variety of stimulus and response sets can be predicted on the basis of the difficulty of the translation required in order to determine which response to make to a displayed stimulus. Less translation is required, and therefore responses are faster, when the structural features of stimulus and response sets correspond and the S-R mappings can be characterised by rules. Wickens (1992), Barker and Schaik (2000) and Norman (1993) concur that more compatible mappings require fewer mental transformations from display to response.

Ravden and Johnson (1989) provide a checklist for compatibility which includes such aspects as colour, abbreviations, jargon and acronyms, icons and symbols, format of data, directional movement, similarity with other familiar systems, sequences of activities and expectation of system architecture. Here they relate compatibility not just to movement or location of control and display components, but to similarity of the interface with other familiar systems and with users' expectations and mental models of the system. This highlights the fact that mappings are all learned conventions and rely on past experience (although some may be very basic and based more on embodied knowledge). Consequently, like population stereotypes, they can be applied to intuitive interaction.

5.8 Consistency

Consistency is assumed to enhance the possibility that the user can transfer skills from one system to another, which makes new systems easier to use (Nielsen, 1989; Preece et al., 2002; Thimbleby, 1991). It improves users' productivity because they can predict what a system will do in a given situation and can rely on a few rules to govern their use of the system (Nielsen, 1989).

Kellogg's (1989) framework distinguishes between internal and external sources of consistency. Internal consistency is consistency within the system. External consistency is the consistency of the system with things outside the system; for example, metaphors, user knowledge, the work domain and other systems (Kellogg, 1987).

Nielsen (1989) argues that the consistency of a device with users' expectations is important, whether those expectations have come from a similar system or something different. The Apple company principles for consistency include using metaphors from the real world (Tognazzini, 1989); that is, external consistency. Koritzinsky (1989) states that a consistent interface would be predictable, habit-forming, transferable and natural (consistent with the user's understanding). The main point of consistency is to establish a behaviour pattern; similar physical actions in similar situations can establish habits and teach the end user what to expect (Koritzinsky, 1989). Consequently, Koritzinsky (1989) recommends that the same commands should be used across applications. Dayton, McFarland and Kramer (1998) agree, while Bonner (1998) argues that to conform to user expectations, a system should be consistent with the user's mental models of the product and with population stereotypes.

Ravden and Johnson (1989) state that consistency is concerned with creating and reinforcing user expectations by maintaining predictability across the interface. If users can predict what the system will do, or what information will appear when and where, then they can learn more quickly and effectively. Further, their confusion is reduced as they are not surprised by the unexpected, search and response times are likely to be reduced, they learn quickly what actions are required, can generalise across the system and are less likely to make errors (Ravden and Johnson, 1989).

Kellogg (1987) describes her research in testing consistent and inconsistent software and concludes that users of an inconsistent system do not have a clear idea of how to perform simple, routine tasks. Intermittent users, or users attempting to carry out new tasks, would continue to have problems with an inconsistent interface (Kellogg, 1987). Users tended to see the inconsistent system as undependable and unfriendly, whereas users of the consistent system performed the tasks more quickly, had near perfect recall of procedures, were able to infer correct procedures for tasks they had not attempted, and had greater confidence (Kellogg, 1987).

In order to get consistency throughout the Star system, Smith et al. (1982) used several paradigms for operations. The paradigms they used were editing, information retrieval and copying. These paradigms changed the way users of GUIs think and led to new habits and models of behaviour that are more powerful and productive.

Intuitive interaction depends upon consistency, especially external consistency with things outside the system (for example, user knowledge, the work domain and other systems). External consistency relies on experiential knowledge of, or familiarity with, similar systems, and it is prior experience which allows intuition to function. Internal consistency is also important because a system which is not internally consistent could be detrimental to intuitive use. If different features or metaphors were applied for different parts of a system, the benefit of applying prior experience could be reduced as users would become confused. As Rohlfs (1998) states, a metaphor must be consistent with existing metaphors used in the same context, and should be sustainable throughout the interface and extendible to new tasks.

5.9 Product Semantics

Product Semantics was proposed by Krippendorff and Butter, who define it as "the study of the symbolic qualities of man-made forms in the context of their use and the application of this knowledge to industrial design" (Krippendorff and Butter, 1984, p4). Through product semantics, they claimed, designers can demystify complex technology, improve the interaction between artefacts and their users and enhance opportunities for self-expression. Krippendorff (1990) states that product semantics should be concerned not with the forms or surfaces of artefacts but with the understanding that penetrates them.

Burnette (1994) sees product semantics as the capacity of a product to afford meaning through its form and use, and Taylor, Roberts and Hall (1999) suggest that product semantics should be considered as a central issue in design, since the human context has become a driving force behind product design. Now that it is no longer possible to derive the shape and meaning of something from its moving elements, the need to understand semantics has been brought to the fore. Product volume has lost importance, and size and shape are determined more by user interaction than by the works inside (Lannoch, 1989).

Krippendorff (1995) explains that one way to make many different things understandable to many different people is to promote a uniform understanding; another way is to build redundancy into the operational meanings of things. The former he calls "functionalism" and the latter "semantics". It seems that functionalism can be compared to the metal models approach, where all users are expected to have the same model of a device. Semantics recognises that individuals differ in several ways; for example, by sensory preferences, cognitive models and cultural histories. Unless designed for very homogeneous populations, products must allow for these differences. Using semantics allows users to identify and manipulate products through self-evident operation (Krippendorff and Butter, 1984).

Blaich (1986) discusses a workshop held at Philips on semantics. At the seminar, Krippendorff argued that product semantics is essential as a study because new classes of products are making traditional conceptions of tools obsolete. Two important methods used by the people who attended were: shape coding to make operations clear, self-evident, more ergonomic and easier to use, and metaphor and analogies to well known objects. For example, one delegate said that the obscurity associated with black boxes of electronics can be countered by employing metaphoric symbols, which can help consumers derive meaning from technology and also satisfy their need for personal expression. In the experience of the people there, consideration of semantics sells products. Blaich (1989) gives examples of products that came about as a results of the workshop, and which led to economic success for Phillips. However, while the main ideas, metaphors or characters of these products were evident, the semantics had not been extended to the detail of the interface.

Lannoch (1984) has developed a method which he terms “semantic transfer”. Semantic transfer begins with an exploration of words that describe the nature of objects and the orientation and action of people in relation to objects. It starts with the semantic analysis of verbal descriptions – not an exact definition of words but a wide description of their meanings, including socio-cultural and metaphorical meanings. Next, designers can transfer the complex verbal imagery into a spatial representation. For example, to express the word “hard”, precise edges and abrupt form changes can be used. There is no definite form for a certain word, however. The aim of the approach is to bring people’s image of 3D form closer to their verbal understanding of the environment. Lannoch (1984) claims that semantic transfer is a valuable tool for defining how a product’s surface can best perform the function of interaction. This approach assumes that the user communicates only with the physical surface of an object (which could make it less useful for today’s devices), but it is one of the most practical examples of the use of product semantics that has been published. Lannoch (1989) also claims that the semantic transfer technique does not limit creativity.

However, Richardson (1994) argues that the linguistic model, as used by Lannoch (1984, 1989) and also advocated by Buchanan (1989), is inadequate and has the potential to conceal as much as it once revealed because it is a dead metaphor. His most significant objection to it is that products or objects are not discursive; they do not present themselves in a pre-determined order and the designer has very little control over the way users will approach the project (unlike a writer who can always set the scene). Products and objects also have much less freedom to express novel concepts than language does, as language is a powerful combinatorial medium. Also, he claims that the linguistic model fails to reflect the way designers think during the design process. Richardson (1994) states that users draw on previous experiences to help define the object before them and to assimilate it into their lives. He proposes gestures as an alternative model that is more appropriate than the linguistic model. Gestures are seen all at once and are not so much based on a sequential communication of information. Projects and gestures are both physical, 3D manifestations of concepts, which cannot be said of texts.

Butter (1989) introduced a method for applying semantics that is intended to be inserted into the design process. He and his colleagues found that as an approach it was general and flexible enough to be applied to many product categories, from toys to truck cab interiors. The method has eight steps but the unique ones involve generation of desired attributes expressing the projected semantic performance characteristics, and analysis, grouping and ranking of attributes and search for concrete manifestations capable of supporting desired attributes. Butter (1989) describes student projects in depth. However, he does not equate semantics with usability or ergonomics, and does not mention previous user experience. The semantics applied in these projects communicate the character of the product more than hinting about its use (although character itself can contain some hints).

McCoy (1989) discusses the use of metaphor to relate a new technology to something familiar. He describes this as an attempt to make a product reach out to its users by informing them about how it operates, where it resides and how it fits into their lives. McCoy (1989) states that there is a need for the language of design to expand to fulfil people’s desire to understand and intuit the artefact environment. In his examples, it can be seen that metaphor has been used to create something more familiar; but again this kind of metaphor does not go into the details of how a user should interact with the product; it just gives an overall hint about the nature of the product.

Bush (1989) asserts that product semantics expresses some relationship between object and user. An object designed in this way may approach becoming an extension of the body because of its visual metaphors and imagery. Bush proposes the use of more anthropomorphic signage in order to achieve this. He discusses body reflectors: products or parts that resemble or mirror the body because they come into close contact with it. Examples include headsets, glasses, shoes, gloves and combs. He claims that humans are pre-disposed to perceive body images for evolutionary reasons. Damasio (1994) also suggests this with his ideas about primary emotions. Therefore, designs which use body images should be more readily perceivable (this idea has also been discussed by Norman (2004b) in relation to physical, or real, affordances). Bush claims that it is not necessary to be familiar with a body reflector in order to ascertain its relation to a person; these forms are self evident in relation to people. Any person would be able to make the association whether familiar with similar things or not.

Athavankar (1989) claims that new products that enter the man-made world quickly become part of the mental world of people. New product variants will become part of the mental world and in the process realign or disturb the semantic space. Athavankar (1989) bases his ideas on the prototype theory of categorisation (Rosch, Mervis, Gray, Johnson and Boyes-Braem, 1976, cited in Lakoff, 1987, and Varela et al., 1991), stating that all products have a place in a category. For most categories, it is the typical (or prototype) case that is treated as a central member for the metonymic representation of a category. All other incarnations of the category can be arranged along a gradation more or less like the prototype.

Athavankar (1989) claims that new product variations bring in new semantic devices and help redefine the semantic space. Redefinition involves a shift in the perception of the central member or the realignment of boundaries. This happens constantly, with perceptions of the central member shifting along the gradation. An innovation can be a bold departure from the norm that challenges the category boundary. Such examples extend and redefine the existing accepted notions and enrich the category by adding new shades of meaning. They can also cause centrality to shift towards them, but bold departures are unlikely to become central members immediately. When new compound products (e.g. camera phones) emerge for the first time, the compound concept depends heavily on the visual expressions of the new functional features as its semantic devices. If this new product is accepted, it will be treated as a central member of a new subcategory (Athavankar, 1989). All the existing categories and all the cues used to link these to new things are of course based on existing products, which are part of the past experience of users.

Athavankar (1989) argues that it is difficult to see the strategies illustrated by some authors as repeatable approaches because the metaphors used came from the personal perspective of the designer. These kinds of personal interpretations can lead to vast variations within the category and there may not be a proper central member. Learning about the category through deviant members is not an effective way of learning about the world. He claims the essential first step is to recognise category identity as a primary and dominant visual expression in design.

Many ideas from various disciplines support this notion. For example, Krippendorff (1990) agrees that in order to recognise artefacts, people approach them with certain ideal types (prototypes) in mind. This is also what people do when imputing knowledge; they start off with an assumption and adapt it according to the emerging situation (Nickerson, 1999). The notion is also supported by Kolodner's (1993) theory of case-based reasoning. Krippendorff's (1995) idea that users describe forms in relation to their own body, vision or motion accords with the ideas of Lakoff and Johnson (1981) and others about the embodiment of metaphor. All these ideas and theories suggest that users base their understanding of a product on their previous experience, from which they have formed prototypes.
Burnette (1994) claims that products semantics has remained more a conjecture than a way of designing and understanding how meaning becomes associated with products. He states that not enough has been done to develop ways to express intent in a product or to investigate whether the intent is understood by those who use the product. This seems to be a reasonable claim, as it is not easy to apply product semantics theory as it stands directly to the design process. More work needs to be done to make it possible for designers to apply the theory easily to their work.

It seems likely that physical affordances, which require only the very basic experience of being in a normal body, are equivalent to Bush's (1989) body reflectors. Semantics

seems to be a good approach to include these kinds of cues in products, although testing is required to make sure signals applied through semantics are understood and responded to correctly (Giard, 1989).
However, semantics is more about form and surfaces than the detail of features and their familiarity. It can provide an overall character for a product, and characters can be used in anticipating the behaviour of artefacts. For example, the characteristic "slow" implies that the artefact will be slow in all its operations. The process of ascribing characteristics will also tell users which characteristics of theirs should be used when dealing with the artefact (e.g. be persistent if the artefact has a slow character), and combined characteristics increase the predictive power (Janlert and Stolterman, 1997). A character does not prescribe functions and actions on a detailed level, but it can be used as a context for interpreting particulars of behaviour and appearance.

Therefore, semantics can be a useful technique for the physical form of a product but does not seem to be applicable to the detailed design of complex electronic artefacts and interfaces. There appears to be a continuum of intuitive interaction, including at different points metaphor and real and perceived affordances. The physically based, experiential cues can be picked up easily by people who have not seen anything similar before, but these cues tend to be more based on form and physicality (body reflectors). More complex cues such as those in an electronic interface can also be based on past experience but tend to be less based on the fundamental physical characteristics and more on actual experience with something similar or metaphorical.

5.10 Conclusions

Some rules and techniques have been explored that would allow application of intuitive interaction. All these revolve around the central tenet of experiential knowledge. Prior knowledge, affordances, population stereotypes, compatible mappings and external consistency all depend on previous experience. Experience can be transferred from other products or other aspects of life, including the basic knowledge all humans have from being embodied in the world, knowledge about how their body will fit with a physical affordance, or knowledge that is drawn from an applicable metaphor. Internal consistency is also an important principle as it allows users to apply the same knowledge in analogous situations and prevents the application of inappropriate metaphors.

It seems likely that there may be physical affordances or body reflectors that relate to physical characteristics, and are familiar because of embodiment and based on learning that occurs from birth. These would be so unconscious that people would rarely consider that some of these things have been learned at all. There also seem to be more complex cues and symbols (Norman's perceived affordances) that become familiar through experience of interaction and in some cases may even require more explicit learning.

As all of these ideas and principles rely on relevant past experience, the things that humans use intuitively are those that employ features which they have encountered before, and encouraging users to access their past experience to use a new product could induce them to use intuitive processing. Incorporating familiar features and controls into a product (in a logical way that is easy to follow and is consistent with the user's expectations according to her/his past experience), should increase the intuitive usability of that product.

Based on the understanding of intuition detailed in Chapters 2 and 3, and the literature reviewed in Chapters 4 and 5, the following definition of intuitive interaction or intuitive use has been developed for the purposes of this study:

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

5.11 Summary

This chapter has discussed further research relevant to the theoretical foundation of this thesis, and has positioned intuitive interaction within other theories of interaction. Intuitive interaction is seen as a non-conscious but not totally automated process using prior experience to guide interaction with tools that mediate between actor and world. The complex relationships between intuitive interaction, semantics and affordances have also been examined, and basic and more complex levels of intuitive interaction have been theorised. This chapter has highlighted the importance of past experience in intuitive interaction and provided a definition of intuitive interaction that can be tested experimentally. Although the authors discussed here have developed related theory, and some have touched on the issue of intuitive use, none have linked intuitive interaction to the existing theoretical knowledge base as has been done here. Chapter 6 will cover the methodology adopted for the purposes of this research and outline the research plan and experiment design.

Chapter 6

Research Methodology

6.0 Introduction

To re-iterate, the research problem to be investigated here is that products are often difficult to use, especially at first. The research question that was asked was how can designers utilise users' intuition in order to make products easier to use? The aim of this research is to provide designers with principles and tools which they can employ during the design process in order to make their products more intuitive to use.

In order to achieve this aim it is necessary to base the research on a theoretical foundation which includes an understanding of the nature of intuition itself and how it relates to product use. This understanding has been explained in Chapters 2 to 5. The next step is to empirically test that understanding in order to see how it can best be applied to design. This chapter discusses the research tools and methods employed in order to do that. A combination of quantitative and qualitative approaches, methods and analyses were necessary in order to achieve the most reliable results possible from a complex set of variables.

Firstly, the limited previous experimentation involving intuition is reviewed. Next, the overall methodology devised to investigate the issue is covered, the experimental approach used in this research is explained and the individual methods and tools chosen are discussed. Lastly, the raw data analysis is explained in detail, particularly focussing on the specialist observation software used for detailed video observation and analysis.

6.1 Investigating Intuition

The nature of intuition presents certain problems for its study. Few experiments have been conducted which specifically target intuition (Bastick, 1982, 2003), so there is no established method to follow. There has been very little contemporary research into intuition, partly as a result of the division between psychologists on the concept of insight and intuition; notably between Gestalt and Behaviourist psychologists. As a result of this controversy, research into intuition was stymied. Any reference to the concept avoided the term "intuition" and instead designations such as "preconscious concept formation”, “preverbal concepts”, “instinctive knowledge” or “cognitive reorganisation” were used. Even research under these synonyms failed to use operational definitions of intuition embodying the properties commonly attributed to it (Bastick, 1982, 2003). Experience, on which intuitive interaction is based, has been controlled as a possible confounding variable in many cases (Klein, 1998; Woolhouse and Bayne, 2000), with tasks often being specially selected so that they will be unfamiliar to participants (e.g. artificial grammar and nonsense words are commonly used).

Bastick (1982; 2003) gives details of the few experiments that have investigated intuition. All of the experiments he mentions took place more than thirty years ago and most of them were trying to define an intuitive “type” in line with Jung’s thinking. Most of the tasks used in the experiments mentioned by Bastick involved participants guessing numbers or words in sequences or associations. Kahneman and Tversky (1973, in Bastick, 1982, 2003) found that more consistent information helped participants to complete a probability assessment task. They also used a confidence rating as a subjective measure, as did Westcott (1961) during interviews after a number guessing task. Confidence is a measure of previous experience in a similar type of problem (Bastick, 1982, 2003), so it can conceivably be used to obtain an understanding of participants’ use of intuition, although in Westcott’s case it was used to determine “types”. Earle (1972, in Bastick, 1982, 2003) and Thorsland and Novak (1972, in Bastick, 1982, 2003) used lack of analytical processing as an indication of intuition, but Bastick criticised this approach, saying it was negative and assumed intuition has only one property. Crutchfield (1960, in Bastick, 1982, 2003), tested two groups on three spatial puzzles. The experimental group worked beforehand on similar puzzles containing spatial cues related to the puzzle solution while the control group worked on similar puzzles without such cues. The experimental group did much better than the controls. Crutchfield called this “intuitive use of cues”.

Of all of these experiments only Crutchfield’s had an approach similar to the one adopted here: grouping participants by previous real world experience to see what effect that experience would have on performance of a relevant task. Those experiments which used a confidence rating may also have been measuring past experience indirectly but could also or alternatively have been measuring other variables such as general personality traits or current mood. However, Woolhouse and Bayne (2000) still used confidence rating as a measure of intuition (although their intention was to measure intuition as a personality type rather than intuition as based on past experience).

Klein's (1998) research focuses on intuition of experts. His main research method is semi-structured interviews of these experts, as well as some observation in the field. Klein uses his own version of cognitive task analysis to analyse the data and determine when intuition is used. His central conclusion has been that past experience is the main contributor to intuition.

Intuitive interaction is most relevant to the concepts of learnability (Jordan, 1998; Nielsen, 1993; Stanton and Baber, 1996) and/or guessability (Jordan, 1998). Stanton and Baber (1996) recommend experimentation and observation for investigating learnability. Thomas (1996) links the word intuitive with learnable. He states that the degree to which a product is intuitive and learnable can be determined by setting a user a specified task with a product and recording the number of attempts made, the time taken to complete the task, any assistance required to complete the task, and whether participants can complete the task. Nielsen (1993) stresses that learnability is easy to measure as one can simply measure the time it takes novice users to reach a specified level of performance, for example to complete certain tasks successfully or within a minimum timeframe.

However, this research was not designed to investigate simply the learnability of a product, but to try to establish whether participants are transferring knowledge from other products in order to use the various features of a new one – which makes the experiments rather more complex. All participants were using a product new to them, so although the users had varying degrees of relevant experience they had not seen this product (or sometimes even this type of product) before. This means the experiments were designed to test the most difficult part of the product experience – using something new for the first time – and to establish how intuition could play a role in that situation.

6.2 Research Plan

An overall plan for the research project was prepared to investigate the thesis that intuitive use of products is based on relevant past experience with similar products or other experiences. The plan consisted of four stages; three sets of user experiments and a re-design exercise which involved making changes to a product based on the findings of the first two experiments. All the experiments involved the same approach although minor modifications were made to the design of each one according to the objectives of that experiment and the success or failure of the tools used in previous experiments. Each experiment involved participants undertaking set tasks with the mediating product while delivering concurrent (talk aloud) protocol. They were videorecorded for later detailed analysis.

The experiments were designed to use real products and to draw on participants' real experience in order to achieve ecological validity. Other experiments that have looked at transfer of knowledge between tasks (e.g. Berry and Broadbent, 1988; Dixon and O'Reilly, 2002) involved invented tasks. Often in these cases, in conditions where participants required prior experience, they were given practice sessions immediately before the experiment (Sommer and Sommer, 1997). These kinds of tests took no other type of prior experience into account, which could have confounded the experiments if some participants were transferring experience from outside the laboratory to the tasks they were asked to do. This research has been designed to be more ecologically valid in order to prevent these kinds of problems and also to allow an easier transfer of the results to the real world.

For similar reasons, university staff, friends and family of staff and staff of nearby companies as well as students were used as experimental participants. Those in the workforce form a more heterogeneous population than cohorts of students in terms of age, level of education and previous experience. However, industrial design staff and students were not accepted as participants because of their special knowledge of product interfaces.

6.2.1 Experiment 1

This exploratory experiment was designed to establish whether or not people can use product features with which they are familiar in an intuitive way. The experiment's objectives were to establish if relevant past experience of product features increased the speed and/or ease with which people could use those features, and to establish if interface knowledge was transferred from known products to new ones. A digital camera, as a member of a new product family, was used as the test product. This first experiment was also intended to reveal the most effective ways of measuring intuitive processing. For example, it was an opportunity to compare the use of psycho-physiological recordings, observation, verbal protocol, questionnaires and interviews and to decide whether or not some or all of these techniques were useful and should be used in further experimentation.

6.2.2 Experiment 2

Following the successful first experiment, Experiment 2 employed most of the same methods: questionnaire, observation, verbal protocol and interview. The product used (referred to here as a "remote"), was a universal remote control (which was chosen for its capacity to be re-configured in order to allow re-design and further experimentation to take place). The objectives of the experiment were: to establish if relevant past experience of the remote control features increased the speed and/or intuitiveness with which people could use those features and therefore the product; to further establish that interface knowledge is transferred from known products to new ones; and to gain an understanding of the level of "intuitiveness" of features of the remote in order to redesign it.

6.2.3 Redesign

Following Experiment 2, a preliminary set of principles for designing for intuitive interaction was developed. A detailed and controlled redesign exercise was undertaken with the remote control used for Experiment 2. The design principles developed through Experiments 1 and 2 were applied to the remote as far as possible (some limitations were imposed by the design of the remote itself). Twelve features which were commonly used in Experiment 2 (and which it was possible to change) were re-designed.

6.2.4 Experiment 3

Experiment 3 used the same methods and tasks as Experiment 2 to re-test the remote control. The objective of this experiment was to test three new designs for the remote control interface against the default design in order to establish if changing the location and/or the appearance of the icons on the device would make it more intuitive to use than the default design. This experiment was also used to investigate the effects of age on intuitive use.

6.2.5 Experimental Approach

The approach adopted used real products as mediators to reveal participant knowledge and behaviour. Products are mediators of activities and communities (Kuutti, 1996) and can be used to allow the study of complex human behaviour (Popovic, 2003). In order to select products as the mediators to be used in the experiments, the devices and accompanying documentation were thoroughly evaluated. Products were located through web searches and magazine reviews, and dealers and distributors were visited in order for the researcher to be able to actually use all the potential products (which it is often not possible for consumers to do on a shop floor).

There were several criteria used in the selection process. Firstly, it was important to get a variety and mix of common (familiar) and uncommon (unfamiliar) features in order to be able to design an experiment that allows comparison of how easily people can use familiar and unfamiliar features. Secondly, new product types that would require transfer of existing knowledge from elsewhere were favoured. This would make it easier to find participants who had not used the product type before and also allow the experiment to test whether or not familiar features from other product types could or could not be transferred. Thirdly, availability of the product within the country and within a reasonable timeframe was important. Finally, price was a factor, the budget allowing about AU$1000 for each product.

The approach of using real, contemporary, finished products was intended to ensure that the experiments were ecologically valid. A person draws on the resources of mind, body and world in order to accomplish tasks (Clark, 1997; Varela et al., 1991). Therefore, it seems reasonable to suppose that the real body, real world set-up of many tasks will deeply influence the nature of the problems participants encounter when tackling them.

As has been discussed in Chapter 5, various levels of processing can work together to perform complex tasks (Berry and Broadbent, 1988). The experimental method employed for this research assumes that various levels of processing occur during one task and attempts to distinguish intuitive processing from the other processes (such as automatic and conscious processes).

When research is being conducted into the intuitive interaction of users with products, it is the use of individual product features that is important, rather than use of the product as a whole. This is because it is not the product, but its features, with which users have relevant past experience. This is especially relevant when so many new products and product types are appearing on the market. Often the most advanced products draw their functionality and interface predominantly from computers and software rather than more traditional products. The definition of a feature, as the term is used here, is a function of a product that is discrete from others, has its own function, location and appearance and can be designed as a separate entity. A shutter button on a camera, a print icon on software or an earpiece on a stereo are all examples of features.

From observations made during pilot studies and product reviews, it appeared that there were three factors of intuitive use for each feature on a product: location of the feature, appearance of the feature and function of the feature. Each of these factors could be intuitive or not, without precluding the intuitiveness of other factors of the same feature. These factors were investigated in depth during the experiments.

6.3 Data Collection Methods and Techniques

This research utilised the triangulation of multiple methods. These were questionnaires, observation during set tasks, verbal protocol, rating scales and interviews. Further details of these methods in relation to their applicability for this research are available in Blackler, Popovic, and Mahar (2004b).

6.3.1 Observation during Set Tasks

As product features are the mediators of this research, looking at each feature use individually is the only way that this issue can be studied in the depth required to formulate theory. It was therefore necessary to observe participants in great detail. Video recordings were used, as they allow a much more detailed analysis than live observation. However, observation alone often provides insufficient data for meaningful conclusions to be drawn. What is observable might not reveal details such as the decisions being made, or the alternatives not selected (Stanton and Baber, 1996). Observation of real people using a real product is the only way to understand if the features can be used intuitively, but a verbal protocol is needed to capture the unobservable information (Bainbridge and Sanderson, 1992).

Tasks in user trials can be seen as substitutes for real user goals. It is important that selected tasks are realistic, as unrealistic tasks provide unrealistic goals which may lead to unrealistic behaviour (Vermeeren, 1999), so correct selection of tasks is vital to the success of a user trial. They must involve the use of all features that are under investigation, must accurately simulate real product use and must be relevant to the user (McClelland, 1995). McMullen (2001) attempted to observe real but non-uniform tasks selected by participants and found this unsuccessful as each person had completed a different task and it was therefore impossible to compare results.

Most importantly for this project, "…with tasks one can make people use functions that they otherwise would not use" (Vermeeren, 1999, p54). Therefore, participants were required to use the features of the product that were most likely to yield results about intuitive use. This was essential for this study as the features of the product were studied in depth, contrary to usability testing when it is the whole product that is under test.

6.3.2 Verbal Protocols

For this research, participants were delivering concurrent protocols (also known as “think aloud” or sometimes “talk aloud” procedures). The think aloud protocol has been found to be very useful for studying interface design (Jorgensen, 1990) and has been used in different studies in human–computer interaction (Hewett and Scott, 1987) and design (Dorst and Cross, 2001; Gero, 1998)

This protocol method was chosen because it eliminates the problems involved with people forgetting the details when using retrospective protocol. Conscious events may decay after a few milliseconds so immediate report is essential (Baars, 1988), and Kleinmuntz (1987) recommends unprompted concurrent protocol to avoid users giving inaccurate reports in retrospect. Recognition is one thing that is often forgotten and omitted from a retrospective protocol (Ericsson and Simon, 1984); recognition is particularly important for this research where the emphasis is on users recognising familiar features.

Intuition, being non-conscious, utilises memories and learning without the conscious mind being aware of it. The non-conscious aspect of intuition has been used in experiments as a criterion for the involvement of intuition or insight (Bastick, 2003). Conscious experience is difficult to observe in a straightforward way. Non-conscious processes can only be inferred, based on experience and observation (Baars, 1988). The conscious/non-conscious distinction is generally determined by verbal reportability in experimental situations (Baars, 1988; Schooler, 2002), and the terms *reportable* and *unreportable* are operational definitions of conscious and unconscious, respectively (Bowden, 1997). The use of reportable to refer to events which do reach consciousness is non-controversial (Baars, 1988; Baars and Franklin, 2003). That is, one must be conscious of an event to be able to report it accurately.

In contrast, the use of "unreportable" to refer to events which do not reach consciousness is more controversial (Bowden, 1997). Unreportable may not be equivalent to unconscious because one may be unable (or unwilling) to report certain events which do reach consciousness. However, because there is currently no operational definition of unconscious which is without critics, many researchers, such as Bowden (1997), use the term unreportable. The same operationalisation has been used for this research. In a concurrent protocol the intuitive process is conspicuous by the absence of detail and logical thinking steps in the commentary, as the commentary is generated in the conscious mind, which does not have access to the intuitive process.

Schooler, Ohlsson and Brooks (1993) argue that both retrospective and concurrent verbalisation interferes with the successful solution of insight problems, and their experiments supported this hypothesis. This interference does not occur with non-insight problems. Schooler et al. (1993) hypothesise that verbalisation disrupts the non-reportable processes associated with this type of problem solving; possibly the unreportable processes become overshadowed as the focus of concentration/attention is on reportable processes during verbalisation. One such component that is unreportable is memory retrieval, and in particular the spreading activation process (Bainbridge and Sanderson, 1992; Schooler et al., 1993) used by the connectionist brain. In problem solving situations many things quickly pass through the mind and are forgotten before there is time to report them, so people may not mention everything in this situation (Bainbridge and Sanderson, 1992).

This was a potential problem for this research. Schooler et al. (1993) recommend that researchers should consider using silent control groups if they are using verbal protocols to assess non-reportable cognitive processes, which would establish if verbalisation is influencing performance. However, this is not possible in this case as one cannot assess performance without the protocol.

Therefore, the problem was addressed by not pushing for protocol unless participants were absolutely silent. This lack of requirement to verbalise every single thought meant that the protocol could be used to decide when participants were processing unconsciously, as the unconscious processing was unreportable. When participants did not verbalise in detail because the detail was not consciously available, they were very likely processing unconsciously and so could be using intuition. This is discussed in depth in Section 6.5.3.

6.3.3 Questionnaires

Questionnaires were used during this research as a recruitment and screening tool. Screening participants for a trait involves writing questions that will identify those for whom the trait is evident and eliminate those for whom it is absent (Weiss, 2002). For example, “early adopters” can be defined by their possessions and how frequently they use them (Weiss, 2002). The questionnaires used in this instance asked volunteers for demographic information, and for Experiments 2 and 3 they also asked for details about their experience with certain products (Appendices A and B). The technology familiarity questionnaires (Appendix B) were developed specifically to establish a technology familiarity score for each participant in order to be able to sort participants into experimental groups. Appendix C contains an example of a completed questionnaire showing how the technology familiarity (TF) score was calculated. They were sent by email or given out as hard copies to potential participants.

6.3.4 Interviews

Interviews were used after the users had completed the tasks in order to get information about how familiar each feature was to the user and how the function, location and appearance of each feature accorded to their expectations. These were complex issues that required constant explanation and demonstration and it was not possible to get this sort of detailed information in any other way. The interviews were structured and the researcher used an identical proforma for each one (Appendix D), so that all participants were treated in the same way and the potential for bias was reduced. Filter questions and careful wording were also used so that answers that could be seen as low-prestige answers appeared equally as acceptable as high prestige ones (Sinclair, 1990). The structure also enabled quantitative data to be generated and compared between participants (Sommer and Sommer, 1997).

6.3.5 Rating Scales

Simple rating scales with the addition of intermediate labels in the form of numbers were used in this research as part of the structured interview to rate the expectedness of the function, the location and the appearance of each feature (Appendix D). Labels were kept consistent and were explained clearly by the researcher prior to the participant completing the scales. This followed Sinclair's (1990) recommendation that researchers take care about the meanings for the scale anchor points and the labels used along it. To avoid the leniency effect, where respondents are unwilling to be critical (Sinclair, 1990), the scale used in this research had no middle point so that respondents could not simply remain neutral; they had to make a judgement as to whether their answer should go in the top or bottom half of the scale. Even so, the data show a tendency towards leniency on the part of most participants.

6.4 Data Analysis

This research takes an essentially quantitative approach. The main reason for this is that the most successful way to investigate such rich and complex data was believed to be through statistical analysis. Also, due to the novel nature of this research, it was felt that quantitative measures would be required to support the claims made.

The performance parameters common to all the experiments were time on tasks, number or percentage of intuitive uses and intuitive first uses and subjective measures of familiarity and expectedness of product features. Time on task is relevant as intuitive processing is assumed to be faster than more conscious types of processing (Agor, 1986; Bastick, 2003; Salk, 1983), so participants interacting intuitively with the product should be able to complete tasks more quickly.

However, it cannot be assumed that completing the task quickly is always the same as completing it intuitively; there also needs to be a measure of intuition or intuitive uses. Number or percentage of intuitive uses and intuitive first uses are problematic variables to measure, but are also the most direct way of quantifying intuitive interactions. The way in which intuitive uses were extracted from the data and coded is discussed in detail below (Section 6.5.3).

Ratings of expectedness are relevant because intuition has been equated with users' expectations and expectations are associated with remembered situations (Dreyfus et al., 1986; Klein, 1998). Further, adhering to users' expectations is acknowledged as desirable for ease of use and consistency (Nielsen, 1989). Okoye (1998) also used time on tasks and subjective ratings of satisfaction to investigate intuitive interaction.

The challenge was to find ways of coding the observations so that this level of detail could be extracted from the observations. These issues were addressed by using the Noldus Observer software to analyse video data of observations in conjunction with the concurrent protocol. Noldus Observer is a complete manual event recorder for collecting, managing and analysing observational data (Noldus, 2002). It captures a level of detail not possible in live situations, and which cannot be analysed easily without an automated system. The process of using the program consists of the three stages of configuration, observation and analysis.

6.4.1 Configuration

This is the set-up stage and must be completed before data can be entered or analysed. For this research, three parameters were entered into the configuration: independent variables, behavioural classes and modifier classes. Table 6.1 shows part of the configuration designed for Experiment 2.

Each behavioural class can contain several behaviours, and can have up to two modifier classes attached to it. This allows analysis of complex procedures such as intuitive use of products. A behaviour can be an event or a state. An event (such as one use of one feature) may take a second or two, while a state (such as performing operation one) continues for a longer period of time. Events can occur within states. The behavioural class shown in Tables 6.1 and 6.2 is called features; there are 21 behaviours (which are simply uses of the features named) and two modifiers (correctness of use and type of use). The most commonly used features on the mediating products were the ones counted and coded on Observer and included in the interview.

Table 6.1. Configuration for Experiment 2

Behaviour name	Code	Type	Modifier 1	Modifier 2
On	on	Event	Correctness	Type
TV on/off	tv	Event	Correctness	Type
VCR on/off	vc	Event	Correctness	Type
Windows	wi	Event	Correctness	Type
Back/ahead	ba	Event	Correctness	Type
Home	ho	Event	Correctness	Type
Touch screen	to	Event	Correctness	Type
Play	pl	Event	Correctness	Type
4-way	4w	Event	Correctness	Type
Forward/rewind	fw	Event	Correctness	Type
Skip/index	sk	Event	Correctness	Type
Number pads	nu	Event	Correctness	Type
Navigation	na	Event	Correctness	Type
Volume/channel	vo	Event	Correctness	Type
AV function	av	Event	Correctness	Type
Menu	me	Event	Correctness	Type
Stop	st	Event	Correctness	Type
Enter	en	Event	Correctness	Type
Other	ot	Event	Correctness	Type

6.4.2 Observation

The observation module is where the coding of the raw audiovisual data takes place (Figure 6.1), using the coding system set up as part of the configuration. Observer was used to log participants' time on each operation, to code the video footage and to produce quantitative data. For the behavioural class "features," the configuration shown in Table 6.1 was applied to the audiovisual data coding as shown in Table 6.2. Section 6.4.3 explains the heuristics used to apply these codes during the analysis.

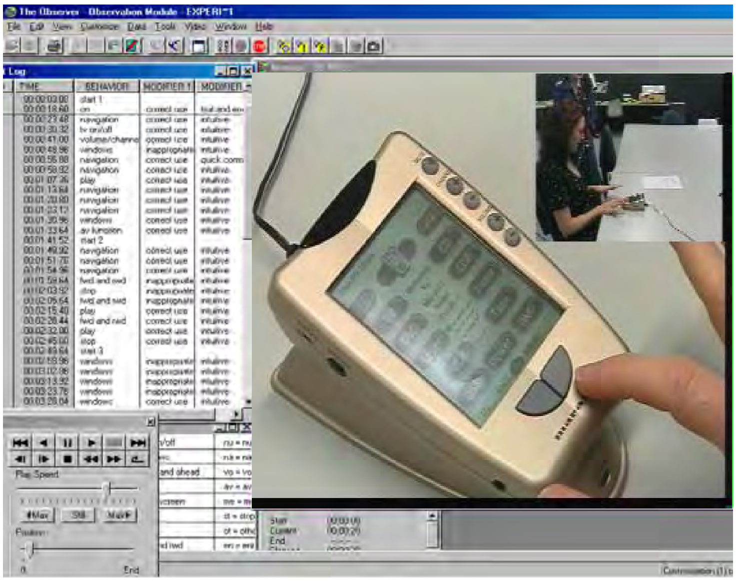


Figure 6.1 Observer observation module

Table 6.2. Data coding for behavioural class "features"

Behaviours	Modifiers	Categories within modifier
Feature used	Correctness of each use	Correct
		Correct for feature but in-appropriate for task
18 for camera		
19 for remote		Incorrect
		Attempted
	Type of each use	Intuitive use
		Quick use
		Use by trial and error
		Logical reasoning use
		Getting help during use
		Mistaken use

6.4.3 Coding Heuristics

Analysis categories must be repeatedly refined by using and trying them out, and then adapting them (Bainbridge and Sanderson, 1992). These categories were conceived from the observation of the participants while recording the audiovisual data and developed through pilot experimentation. One test of the suitability of categories is whether they can be meaningfully applied to other data (Bainbridge and Sanderson, 1992). The categories developed for Experiment 1 were successfully applied to Experiments 2 and 3. This consistently successful application supports the suitability of these categories.

Overall time and duration of each operation were coded using the state facility of the program. Occasions when a participant consulted a manual or received verbal assistance from the Experimenter were also coded. These categories are simple and it is self-evident how they were applied during the observation of the video data. The correctness of use and type of use categories are more complex and require further explanation.

Correctness

A “correct” use was taken to be one that was the right use of the right feature at the right time; in other words, it was correct for the feature and also correct for the task or subtask at the moment of use. A “correct-but-inappropriate” use was one that was correct for the feature but not for the task or subtask. In other words, users knew what they wanted to do and used the right feature to do it, but it was the wrong thing to do at that moment. “Incorrect” uses were wrong for both the feature and the task or subtask and “attempts” were uses that did not register with the product, for example due to failure to activate a button on the touch screen.

Intuition is defined by some writers as necessarily correct (some researchers have even operationalised intuition as a correct answer), whereas most say it is only a useful guide that rarely misleads (Bastick, 1982, 2003). Bastick maintains that intuition is always considered to be subjectively correct but where there is an accepted answer for comparison (as in this case), intuition may not always completely agree. It was possible to have an incorrect intuitive use where a participant was using intuition but still did the wrong thing. This occurred only rarely, and when it did it was usually because the feature was similar in appearance but worked in a very different way from one the participant was familiar with. Therefore, during the coding of feature uses, a few incorrect uses were coded as intuitive. For example, in Experiment 1, several people tried to use the shutter as a confirm or OK button, and although this was incorrect it was affirmed during the interviews that they had felt that that was the right thing to do as it was a confirm button for taking an image. This supports Bastick's (1982, 2003) contention that intuition is generally correct but not infallible.

When calculating the statistics relating to intuitive uses and intuitive first uses, only correct or correct-but-inappropriate uses were counted, because incorrect intuitive uses (of which there were very few) do not contribute to the successful operation of the product. Correct-but-inappropriate uses are relevant as these experiments were focusing on the features of the products, and these uses were correct uses of the particular features although they were not correct for the relevant task or subtask.

Type of use

The possible types of use ranged from intuitive (fast decision with no evident reasoning), through quick use (enough reasoning to verbalise a couple of words) and trial and error (random playing with buttons or exploratory behaviour), to logical reasoning use (thorough reasoning evident), mistaken use (feature used by genuine mistake) and finally getting help (relevant past experience masked). The definition of intuitive use formulated for the purposes of this study states that intuitive use involves utilising knowledge gained through other experience(s), is fast and generally non-conscious. The coding heuristics used to determine which uses were intuitive were based on this definition and the research and reading conducted into intuition. The main indicators of intuitive uses that were employed to make the decisions about types of use during the coding process are explained below.

Evidence of conscious reasoning

Since intuitive processing does not involve conscious reasoning or analysis (Agor, 1986; Bastick, 1982; Fischbein, 1987; Hammond, 1993; Noddings and Shore, 1984), the less reasoning was evident for each use, the more likely it was that intuitive processing was happening. Accurate report is the standard operational index of consciousness used in psychological experiments (Baars, 1988; Baars and Franklin, 2003; Eysenck, 1995; Schooler et al., 1993). Based on this accepted method, Bowden (1997) uses the term "unreportable" to operationalise non-conscious reasoning. This same operationalisation was used for these experiments.

Commonly, participants processing intuitively would not verbalise the details of their reasoning. They may briefly verbalise a whole sub-task rather than all the steps involved although they did perform all the steps; or they would start to press a button and then stop to explain what they were about to do; or perform the function and then explain it afterwards. Their verbalisation was not in time with their actions if they were processing unconsciously while trying to verbalise consciously. Table 6.3 shows examples of an intuitive use and a reasoning use of the four-way feature (Experiment 2), with times for each use shown. Both were correct uses on the first encounter of this function.

Table 6.3. Intuitive and reasoning uses.

Reasoning 21 seconds	I'll just experiment …I'm not sure. This changes the screen so I'll change..…this is an arrow up so I'll change …ahh …demonstration …ah …language ...clock set. I've reached the dot by clock set so that's the point of that dot there. OK, so it looks as though I'm getting there.
Intuitive 5 seconds	Aha! OK here we go and I want to go to clock set. OK.

These examples show quite clearly how, although both participants were completing the same action, the level of reasoning is different for each. The intuitive use lacks the detail of the reasoning process and is therefore much faster. This is obvious from the protocol combined with the observation.

Expectation

Intuition is based on prior experience and therefore linked to expectations. If a participant clearly had an established expectation that a feature would perform a certain function when they activated it, they could be using intuition.

Subjective certainty of correctness

Researchers have suggested that intuition is accompanied by confidence in a decision or certainty of correctness (Bastick, 1982, 2003; Hammond, 1993), and intuition is a useful guide that rarely misleads (Bastick, 1982, 2003). Degree of confidence has been used in some experimental situations as an index of intuition (Eysenck, 1995; Westcott, 1961). Those uses coded as intuitive were those that participants seemed certain about (although they were not always correct), not those where they were just trying a feature out.

Latency

When users were able to correctly locate and use a feature reasonably quickly, it could be coded as intuitive. In problem solving research, time to make a move can be used to measure thinking time required (Cockayne et al., 1999), and longer thinking time would indicate more conscious reasoning (Baars, 1988). If a participant had already spent some time exploring other features before hitting upon the correct one, that use was unlikely to be intuitive as intuition is generally fast (Agor, 1986; Bastick, 1982, 2003; Hammond, 1993; Salk, 1983), and is associated with subjective certainty (Bastick, 1982, 2003). Those uses coded as intuitive involved the participants using the right feature with no more than five seconds hesitation, and often much less, commonly closer to one or two seconds. Table 6.3 shows this quite clearly; the reasoning use took longer than the intuitive use.

Relevant past experience

Participants would sometimes mention that a feature was like their remote at home, or that they had seen a feature before, showing evidence of their existing knowledge. One can infer from verbal protocol that knowledge exists although there may be very little direct evidence in the protocol about its structure and use (Bainbridge and Sanderson, 1992).

“Intuitive use” codes were applied cautiously, only when the use showed two or more of these characteristics and the researcher was certain about the type of use. Any uses about which there was doubt were coded as “quick comment” rather than “intuitive”. All recordings were double-checked to make sure codes were correct. One researcher did all the coding (due to the lack of suitable second coders). The researcher checked all the coding at least twice for every observation to make sure the code assigned was not a mistake and was a fair decision according to the heuristics described. Between the first and second sessions of coding, the researcher took a break of at least a week in every case. This ensured that coding was approached with a fresh mind for all sessions.

6.4.4 Analysis

Every feature use for all participants was coded. The result of this exercise is a time-event log, showing all the behaviours in chronological order with a time stamp in seconds and their appropriate modifiers. Table 6.4 shows an example of part of a time-event log.

Table 6.4. Time-event log

Start time (secs)	Behavioural class	Behaviour
3.08	Time on task	Start 1
18.60	Features	On correct use trial and error
23.48	Features	Navigation correct use intuitive
30.32	Features	TV on/off correct use intuitive
41.00	Features	Volume/channel correct use intuitive
48.96	Features	Windows inappropriate use intuitive
56.88	Features	Navigation correct use quick comment
58.92	Features	Navigation correct use intuitive
67.36	Features	Play correct use intuitive
73.64	Features	Navigation correct use intuitive
80.80	Features	Navigation correct use intuitive

This raw data was used within Observer to generate basic descriptive statistics such as total numbers of each type of use (which allowed calculation of percentages of different types of uses and amount and type of help received), latency of each use (which allowed calculation of intuitive first uses), time on each task, and duration of each event. These basic results were then exported to an Excel spreadsheet for further manipulation (e.g. weeding out intuitive uses from other uses and calculating percentages) and then into SPSS (Statistical Package for the Social Sciences) for full statistical analysis.

6.5 Summary

The methodology described here was devised to allow a converging investigation as knowledge about intuitive use of products was generated and built upon. The multi-method approach of the experimentation borrowed methods commonly employed in user trials, but was designed to allow detailed study of a complex and little-understood topic by more detailed analysis of the data than is usual for usability and similar studies.

The methods used were very successful in getting the important detail out of a lot of complex data and obtaining useful results. The Observer software allows organisation and thorough analysis of very rich and complex raw data. Although data coding is a time-consuming process, it is a necessary step in generating the sort of detailed knowledge required for statistical analysis and theory building. The fact that the results from all three experiments largely agree suggests that the method has reliably extracted the facts from all the raw data. Chapters 7, 8 and 9 will describe the experiments and the re-design process, and explain the results and their implications in detail.

Chapter 7

Experiment 1

7.0 Introduction

This chapter covers the first experiment, which was undertaken to investigate the initial hypothesis that intuitive interaction is based on past experience. Experiment 1 was planned with three objectives: firstly, to establish if past experience of product features increases the speed and/or intuitiveness with which people can use those features and therefore the product; secondly, to establish if interface knowledge is transferred from known products to new ones; and thirdly, to establish if psychophysiological measures of anxiety can be useful in measuring intuition during product use. If the participants with past experience with the different features showed faster and/or more intuitive use of those features, and also exhibited less anxiety, then it could be concluded that past experience was a contributing factor.

7.1 Method

7.1.1 Participants and Experiment Design

This was a between-groups, matched-subjects experimental design. Queensland University of Technology staff members were asked if they could volunteer to take part in the study. Of these volunteers, twenty people were recruited for the experiment. As this was an exploratory experiment, partially designed to investigate the efficacy of the measurements and tools used, twenty people was felt to be a suitable number. None of the participants had encountered the camera used in the experiment before it began, and all participants were volunteers who received no payment in return for their participation.

The levels of experience, motivation and skills of users of digital or smart products vary considerably (Sade, 1999). The participants were chosen from the pool of volunteers to represent the range of levels of expertise. Level of expertise was the independent variable (IV). The levels of the IV were classified as expert, intermediate, novice and naïve with digital cameras. The participants were matched as shown in Table 7.1 so that there was a realistic distribution of gender and age groups throughout the four experimental groups. All of this information was collected at the recruitment stage using a very simple survey instrument (Appendix A).

Table 7.1. Experiment 1 grouping of participants

Expertise (IV)	Age group	Male	Female	Total
Expert	1 (<25)	1	1	2
	2 (25–35)			
	3 (35–45)		2	2
	4 (45–55)			
	5 (55+)		1	1
	Total	1	4	5
Intermediate	1 (<25)			
	2 (25–35)	1	2	3
	3 (35–45)	1		1
	4 (45–55)	1		1
	5 (55+)			
	Total	3	2	5
Novice	1 (<25)			
	2 (25–35)	1	1	2
	3 (35–45)	1	1	2
	4 (45–55)		1	1
	5 (55+)			
	Total	2	3	5
Naive	1 (<25)			
	2 (25–35)		1	1
	3 (35–45)	1	1	2
	4 (45–55)		1	1
	5 (55+)	1		1
	Total	2	3	5
Total		8	12	20

7.1.2 Apparatus and Measures

The Fuji 4700 zoom digital camera (Figures 7.1 and 7.2) was chosen for use in this experiment. This particular product was selected as it has a mix of features, some of which are unique to this model and others of which should be familiar to some users as they have been employed in other cameras, other digital cameras, and other products. The features that the tasks were designed to investigate are shown in Table 7.2.

Table 7.2 Camera features investigated in Experiment 1

Features common to many digital devices	Features common to many cameras of various types
Execute or OK button Nested menu Four direction button for navigation Cancel/back button Play icons Power button	Zoom function Shutter Button Mode dial Camera icon
Features common to many digital cameras	Fuji camera specific features
Playback icon for viewing pictures Colour LCD screen DISP button	Small lever for playback or photo modes Greyscale LCD screen which provides directions for 4-way button

Figure 7.1 Fuji 4700 front

Figure 7.2 Fuji 4700 back

Two digital video cameras were used to record the activity. As per Bocker and Suwita (1999) and Vermeeren (1999), one was trained on the participants' hands as they operated the Fuji camera, and the other recorded the whole scene. These images were synchronously mixed and recorded, and later used for the analysis. The variables measured through this experiment and the methods and tools used are shown in Table 7.3.

Table 7.3 Variables, methods and measurement tools

Dependent variables	Methods and measurement tools
Time to complete operations	Observation using Observer Video Pro
Correct, inappropriate and incorrect uses of camera features	Observation using Observer Video Pro
Type of each use	Observation using Observer Video Pro Concurrent protocol
Percentage of first or only uses of features per participant that were intuitive	Observation using Observer Video Pro Concurrent protocol
Percentage of uses of each feature that were intuitive	Observation using Observer Video Pro Concurrent protocol
Participants' level of technological familiarity	Technology familiarity questionnaire
Familiarity of each feature	Structured follow up interview
Intuitiveness of each factor of each feature, based on user expectations	Structured follow up interview (rating scales)
Tendency to use experience of previous products when encountering a new one	Structured follow up interview
Heart Rate	Plethysmograph Bioview software
Skin conductance	Electro-dermal activity (EDA) monitor Bioview software

The technology familiarity (TF) questionnaire (example in Appendix B) was designed to reveal information about the participants' experience and behaviour with products related to digital cameras. The products mentioned in the technology familiarity questionnaire were chosen as they were examples of common consumer electronic products that employed features and devices similar to those of the camera used in the study. The questionnaire asked participants about whether and how often they used certain products, and how much of the functionality of those products they used. The technology familiarity questionnaire was used to calculate the technology familiarity (TF) score for each participant (example in Appendix C). A higher level of exposure to, and depth of knowledge of, the various products in the questionnaire produced a higher technology familiarity score. The maximum possible score on this questionnaire was 100, and the hypothetical minimum was 0.

During the interview (Appendix D), participants were asked to rate (from 1 to 6) how familiar each feature was, from other products they had used or from any other situations. This question was designed to establish whether or not relevant past experience is transferable between contexts. Participants were also asked to assess how the location, function and appearance of each feature they used on the camera conformed to their expectations using simple rating scales (scale from 1 to 6). This exercise was designed to reveal how each of the three factors of the features compared with each other in terms of their intuitiveness, based on users' expectations from their past experience.

Simonton (1980) claims that intuition is more effective than analysis at low arousal levels, and Hammond (1993) states that intuitive processes are characterised by low control and low conscious awareness, rapid processing and high confidence in the answer. Laughlin (1997) notes that intuition seems to perform best on an inverted "U" curve between no stimulation and extreme stress. He relates this to play and the conditions under which it occurs; "The neurocognitive growth facilitated by play involves intuitive learning, and intuitive insights frequently arise as a result of 'playing around' with a problem." (Laughlin, 1997, p28). There is good evidence that high cortical arousal (typical of conscious problem solving) narrows the associative field and suppresses remote association, which would limit the connections to past experiences that can be made by the brain. A lower degree of cortical arousal allows remote and unusual associations to emerge (Eysenck, 1995). Bastick (1982, 2003) describes fluctuating anxiety during intuitive processing as related to emotional sets, and claims that these fluctuations can be physiologically monitored. As emotional sets are combined and answers found, anxiety decreases.

It was therefore hypothesised that participants showing low levels of anxiety and arousal during product use could be using intuition, and it seemed possible that measuring arousal could be used to assess whether participants were processing intuitively during the different stages of the tasks. Psychophysiological measures were taken during this experiment for heart rate and electrodermal activity. It was hoped that the data from these measures would correlate with actions that were undertaken intuitively during the operations and so form a link between psychophysiological measurements and observations.

Heart rate and skin conductance are suitable variables to choose for monitoring psychophysiological experiments on intuition (Bastick, 1982, 2003). Heart rate is defined as the number of beats per time period (i.e. minutes). The ecrine sweat glands used in electrodermal activity (EDA) are concentrated on the palms of the hands and soles of the feet. They respond primarily to a “psychic” stimulation, whereas other sweat glands respond more to increases in temperature (Stern, Ray, and Davis, 1980). The psychophysiological measuring equipment consisted of an EDA monitor that was attached to the finger using a Velcro strap, and a heart rate monitor that clipped onto the ear.

7.1.3 Procedure

Situational variables were minimised as much as possible. All experiments took place in an air-conditioned room with the same level of artificial light and the recording equipment was positioned in the same way for each participant. The set-up of the laboratory during Experiments 1, 2 and 3 is illustrated in Figure 7.3. The video camera in view is the one focussed by the experimenter on the participant’s hands. The second camera was positioned approximately two metres to the left of the participant’s right shoulder.

Figure 7.3 Laboratory set-up during experiments

Participants were first welcomed to the room and were given an information package and consent form to read and sign (Appendix E). Then all the equipment to be used and the tasks to be performed were explained clearly using a pre-determined script (Appendix F). Intuition has been shown to be vulnerable to anxiety (Bastick, 1982, 2003; Laughlin, 1997). Thus a calm and "permissive" environment should be provided for experiments concerned with intuition (Bastick, 1982, 2003). Participants were encouraged not to worry about the experiment or their performance, and were reminded that they themselves were not being tested, a procedure recommended by Allen and Buie (2002). They were then talked through the tasks that they would be asked to perform and the researcher made sure they were clear about what they had to do before they commenced the tasks, as recommended by McClelland (1995).

The psychophysiological measuring equipment was attached to the participant. The participants were asked to wipe their hands with an alcohol swab before attaching the EDA monitor (for EDA to be measured reliably, the skin must be cleaned before attaching electrodes). Both of these sensors were attached to a PC via an RS232 cable. The Bioview software was initiated on the PC a couple of minutes before the experiment started in order that problems, incorrect attachments of sensors or irregularities could be fixed before the experiment began, and to allow a stable baseline to establish before interaction with the product started. At the moment when the video recording was started, the Bioview software was set to start recording the EDA and heart-rate output. The monitor displaying the results was kept out of view of the participants to prevent possible biofeedback.

The participants were asked to complete two operations, each of which consisted of a number of tasks, and which between them involved use of most of the functions and features of the camera (Table 7.4). Participants were delivering concurrent protocol while they performed the tasks.

Table 7.4 Operations

1	Use the camera to take a photograph in auto-focus mode using the zoom function.
2	Find the picture you took. Erase your picture. Search through the other images stored in the camera to find (a specified image). Zoom in on the image so that the details become larger.

People differ in the way they explore their worlds, in the errors they are willing to risk when trying out a new practice, and in the amount of feedback they feel is needed before they act (Krippendorff, 1990). Consequently, some people will be inclined to look at the manual earlier than others. The manual for the camera was available only on request, and participants were asked to try to work out the operations for themselves. Reference to the manual would mask use of relevant past experience. The experimenter answered questions (where the answer did not give too much information as to how to proceed) and reminded participants to think aloud, but otherwise did not intervene during the operations. Where the experimenter was asked for more concrete advice, it was coded as assistance.

Figure 7.4 Conducting the interview

Immediately after the completion of the operations, the technology familiarity questionnaire was completed and the structured interview conducted (Figure 7.4). As part of the interview, participants were asked if they had been anxious during the test, either because of the presence of the experimenter, the video cameras and other equipment, or for any other reasons. None of the participants reported that they were especially anxious, so it can be assumed that intuition was not inhibited by anxiety during any of the tests.

7.2 Results

The Noldus Observer software was used to code the video footage as explained in Chapter 6. For Experiment 1 the coding differed slightly from the example given in Table 6.2 in that the codes attempted and mistaken were not used. Table 7.5 shows the mean and standard deviation for the variables time to complete operations and technology familiarity score, for each level of expertise and overall.

Table 7.5 Means and standard deviations for time and technology familiarity score

Variable	Expert		Intermediate		Novice		Naïve		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
TF (%)	43.4	7.5	50.2	6.6	43.2	5.2	36.8	11.1	43.4	8.7
Time (secs)	573	564.6	657	216.9	581	386.5	1031	638.9	710.5	481.2

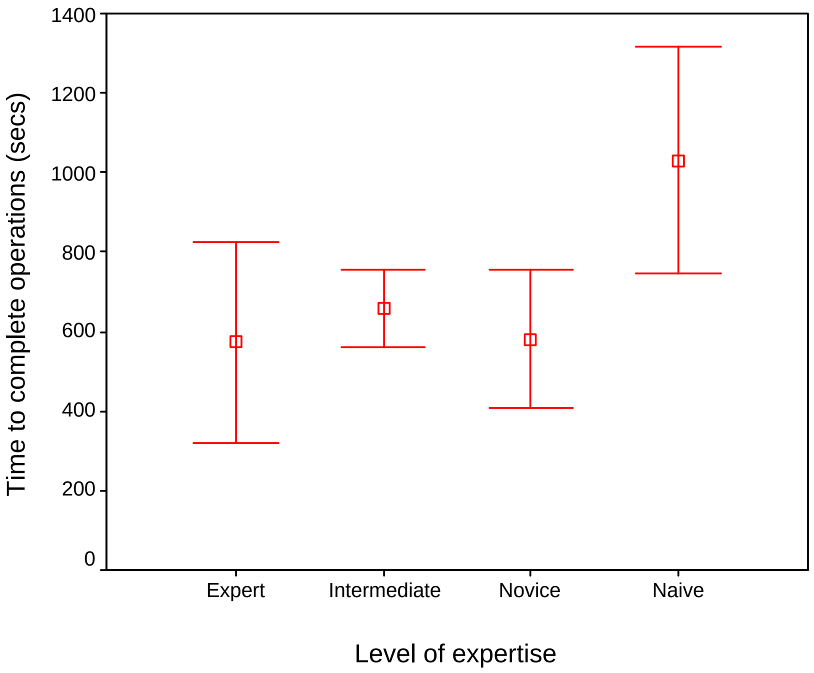


Figure 7.5 Time to complete operations plotted against level of expertise (NB. All error bars are standard error of the mean x1).

Figure 7.5 presents means of time to complete the operations as a function of level of expertise. These data suggest that no strong relationship exists between time and level of expertise, and a one-way ANOVA reveals no significant differences between the times of the participants in the four groups, $F(16) = 1.033$, $p > .05$. However, the power is low for this calculation (.23) and the effect size relatively high (2 = .16), so there is a possibility of a Type II error here, and the effect could be obscured by the low power. Nevertheless, despite the relatively large effect size and low power, there is still no systematic pattern of decrease in time with increase in level of expertise.

Figure 7.6 presents the relationship between time to complete the operations and the technology familiarity (TF) score, and shows the strong negative correlation between these two variables, $r(18) = -0.69$, $p < .01$ (NB. all correlations are Pearson's product moment correlation coefficients). The level of expertise of each participant is also shown.[1]

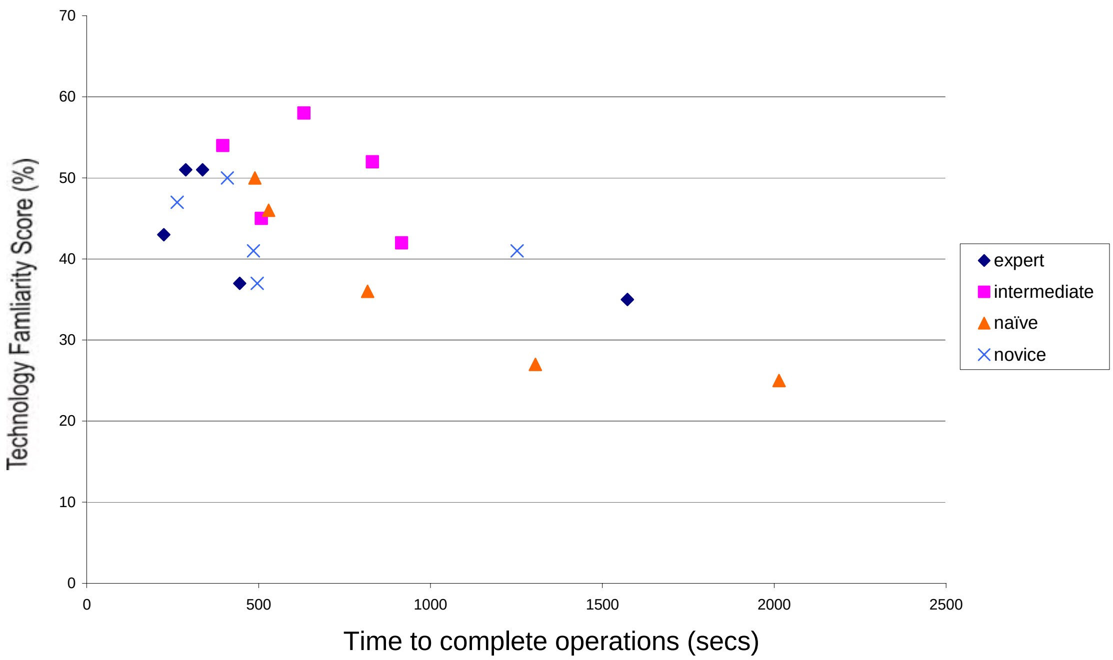


Figure 7.6 Time to complete operations plotted against technology familiarity score

Table 7.6 shows the percentages of correct, correct-but-inappropriate and incorrect uses for each type of use. The majority of intuitive, quick comment and reasoning uses were correct, while the majority of trial-and-error uses were incorrect. It must be remembered that these numbers represent all feature uses, including re-uses.

Table 7.6 Type of processing and level of correctness for all feature uses.

	Intuitive	Quick	Trial & error	Reasoning	Using manual	Total
Correct	64.5%	62.5%	9.6%	79%	46.2%	46%
Inappropriate	31%	12.9%	7.9%	5.3%	23%	19.3%
Incorrect	4.5%	24.6%	82.5%	15.7%	30.8%	34.7%

[1] This data set was also tested after removal of the outlier evident at 1995 seconds in Figure 7.6 and the result was still a significant negative correlation, $r(17) = -0.56$, $p < .05$

There was a strong positive correlation between the percentage of intuitive first or only uses (correct and correct-but-inappropriate) throughout the operations and the technology familiarity score, $r(18) = 0.643$, $p < .01$, and a strong negative correlation between the percentage of intuitive first or only uses (correct and correct-but-inappropriate) and the time on the tasks, $r(18) = -0.465$, $p < .05$. Therefore, participants who had a higher level of technology familiarity were able to use more of the features intuitively first time and were quicker at doing the tasks. This trend can be clearly seen in Figures 7.7 and 7.8.

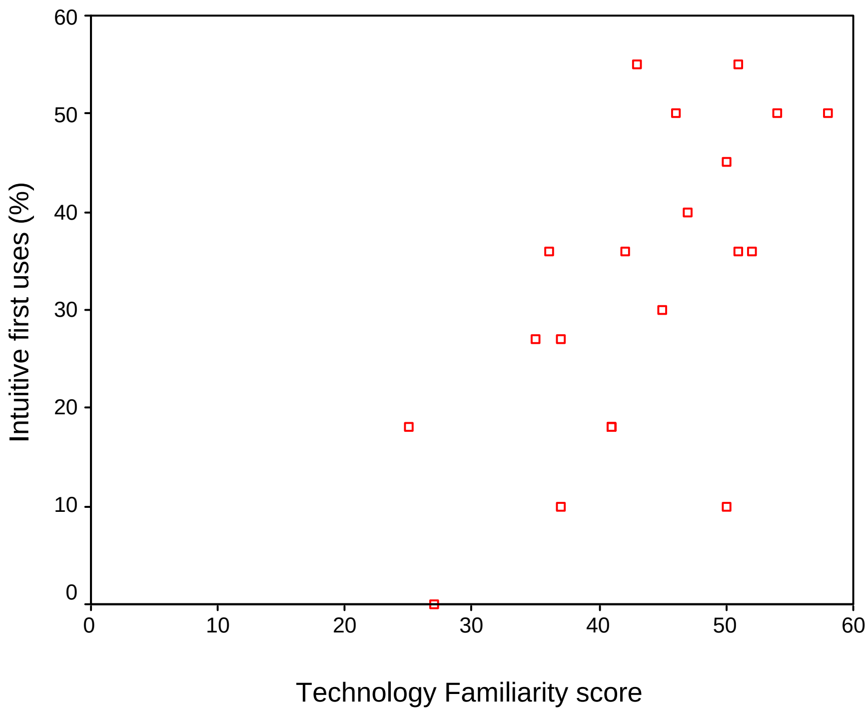


Figure 7.7 Technology familiarity score plotted against percentage of intuitive first or only uses (correct and correct-but-inappropriate)

The total percentage of intuitive uses of the features (correct and correct-but-inappropriate) was compared with the familiarity of the features. It was found that the mean familiarity of the features correlated strongly and positively with the mean of the percentage of intuitive uses of the features, $r(18) = 0.523$, $p < .05$. This is shown in Figure 7.9.

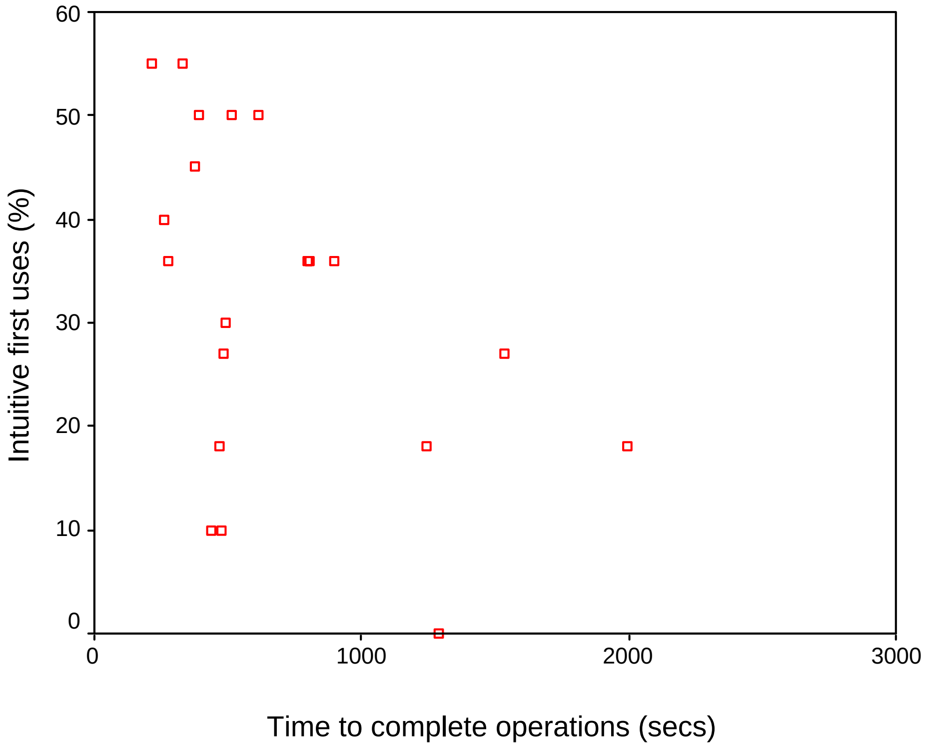


Figure 7.8 Time to complete operations plotted against percentage of intuitive first or only uses (correct and correct-but-inappropriate)

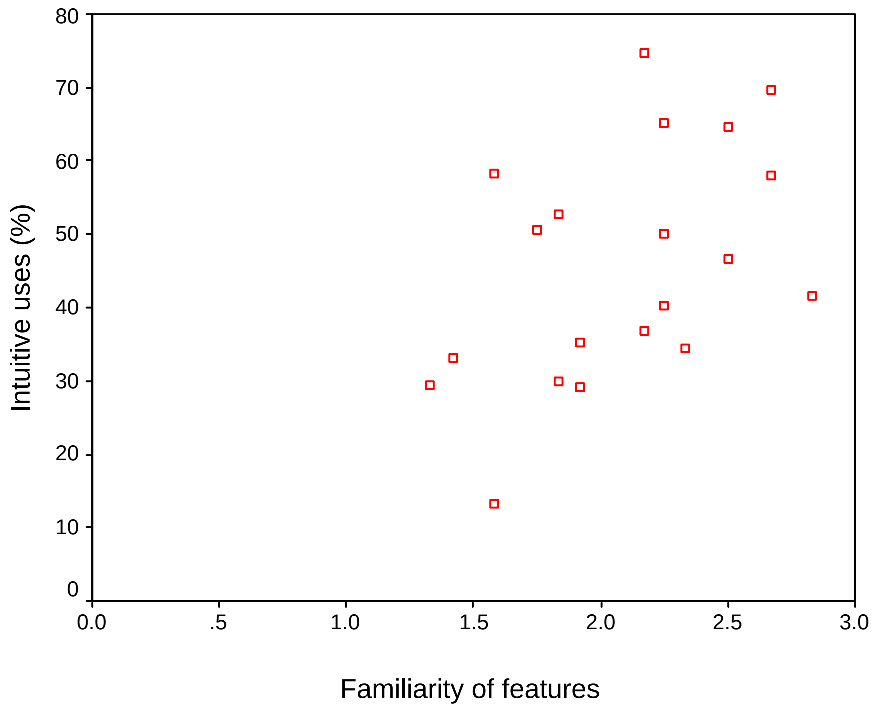


Figure 7.9 Mean familiarity of features plotted against mean percentage of intuitive uses of features (correct and correct-but-inappropriate)

Thus, features that were more familiar were intuitively used more often. For example, the power button showed a high level of familiarity and a high percentage of intuitive uses. The navigate function of the menu also achieved a high percentage of intuitive uses and a high level of familiarity. The DISP function, which controls the displays on the LCD screen, showed a very low level of familiarity and a correspondingly low percentage of intuitive uses. Only experts who had used similar digital cameras picked up this function easily.

During the interview, participants were asked to indicate their level of agreement with two statements. Statement 1 was: "I use my knowledge of products that I am familiar with to guide me in using a new product of the same type." A total of 65% agreed strongly with this statement and 35% agreed (none disagreed). Statement 2 was: "I use my knowledge of products that I am familiar with to guide me in using a new product of a different type." A total of 55% agreed strongly with this statement, 35% agreed and 10% disagreed. Figure 7.10 shows these relationships, and demonstrates that those who agreed less strongly with the statements took more time to complete the operations.

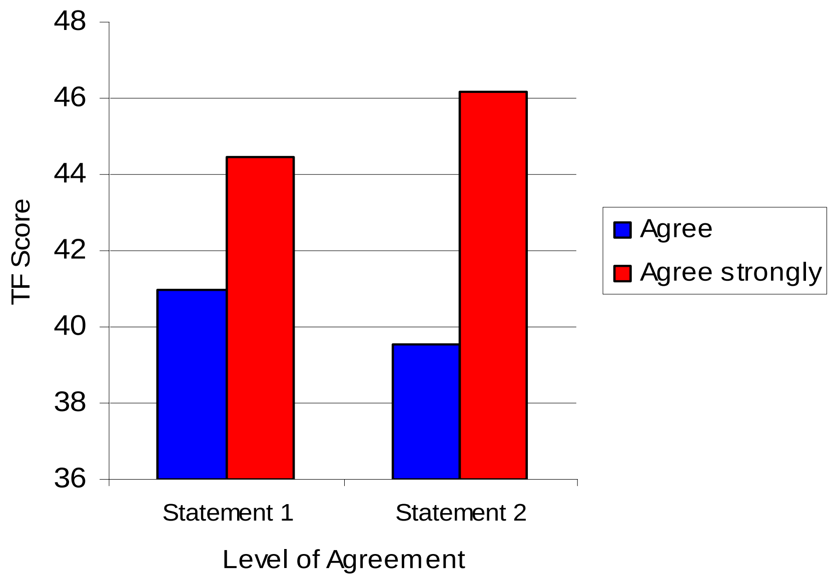


Figure 7.10 Time to complete operations against responses to Statements 1 and 2

A t test for Statement 1 showed a significant difference in time taken between those who agreed and those who strongly agreed, $t(18) = -2.671$, $p < .05$. There was also a significant difference in time between those who agreed with Statement 2 and those who strongly agreed, $t(16) = -2.73$, $p < .05$. In both cases those who strongly agreed were significantly faster at completing the operations than those who only agreed.

When asked about the intuitiveness (based on expectations) of the three factors of each feature (function, location and appearance), some participants rated one factor of a feature at one end of the scale and another factor of the same feature at the other end. Ratings ranged from 1 (low, unexpected factor) to 6 (high, very familiar and expected factor) For example, the camera icon had high means of 4.00 for function and 4.20 for appearance but a lower mean of 2.95 for location. This icon is located in an ambiguous position (Figure 7.11) so it could be a label for one of two or three different buttons on the interface. The power button had a high mean of 5.15 for function, but lower means of 4.10 for appearance and 3.10 for location. The power button is located inside the mode switch (Figure 7.11), and is neither colour coded nor clearly labelled. This made it difficult for many participants to find, although all knew they had to find a power button or switch of some kind as the first step.

Figure 7.11. Detail of camera icon and power button

An ANOVA showed that the difference in heart rate between the start and end of the operations was significant, $F(3,16) = 7.324$, $p < .01$. A Tukey HSD post hoc test revealed that the expert group was significantly different from the naïve (p =.027) and intermediate (p = .002) groups but not the novice group (p = .18). The experts all showed an increase in heart rate during the test, rather than the decrease that may be expected if the experts were more relaxed. For electrodermal activity, the ANOVA was not significant, $F(16) = 1.337$, $p > .05$ (power = .288, $E^2 = .2$). As the effect size is large and the power low, it is possible that any differences were masked by the low power. However, only 3 of the 20 participants showed a decrease in EDA over the experiment, so the expected decrease in anxiety for those with a higher level of expertise did not occur. Correlations between TF score and differences in both heart rate, $r(18) = –.186$, $p > .05$, and EDA, $r(18) = –.886$, $p > .05$, were not significant. It was not possible either to draw out specific instances of increases or decreases in EDA or heart rate and map them to particular uses during the operations, as the Bioview data showed no relation to the sequence of events during the operations.

7.3 Discussion

These results suggest that prior exposure to products employing similar features helped participants to complete the operations more quickly and intuitively. The Fuji camera borrows, or transfers, features from other digital products, so even expert users of digital cameras who had limited experience with other digital products completed the tasks more slowly and effortfully than novices with digital cameras who did have experience with the features employed in the camera from using other products. This is shown in the strong negative correlation between time and TF score.

The fact that there is no correlation between time and level of expertise with digital cameras also supports this conclusion, and suggests that grouping participants into expert, intermediate, novice and naïve with the product seems to be less relevant when investigating intuitive use than some other aspects of usability, because intuitive use involves applying knowledge from other contexts and other products. A grouping based on a technology familiarity (TF) score may be more relevant in this situation.

Participants who had little or no experience with digital cameras but who had used other digital devices seemed to be able to use familiar features intuitively. This conclusion is supported by the correlations between familiarity of features and percentage of intuitive uses, and intuitive first uses (correct and correct-but-inappropriate) and technology familiarity scores. The first uses results are particularly important as the participants had not yet had the opportunity to learn about the feature but used it either correctly or correctly-but-inappropriately the first time they encountered it. They could base their actions only on relevant past experience of similar features or objects, so this result offers strong support for the idea that including familiar features in a product will allow people to use them intuitively first time. The high percentage of intuitive uses that were correct seems to confirm Bastick's (1982; 2003) statement that intuition is generally correct but not infallible.

The close association between level of agreement by participants that they use knowledge gained from the use of one product to help them learn about another and their time to complete the operations could also be seen as support for the hypothesis that intuitive use is governed by past experience. People who took longer to complete tasks because they did not use their existing knowledge of other products were less likely to transfer knowledge from other products and apply it to the use of the camera. The camera borrowed many features from other digital products (not primarily from cameras), so transferring knowledge from other types of products was necessary in order to complete the tasks quickly and intuitively.

Through the interview process, it has been confirmed that location, function and appearance of features on the product are factors that need to be separated for the purpose of this type of analysis. Also, this differentiation can show quite clearly which factor of a feature may be responsible for problems that people have with using that feature. This would allow designers to correct the right problem (e.g. location of the power button), not the wrong one (e.g. function of the power button).

The results from the psychophysiological data were disappointing. However, it has proved extremely difficult to mark a clear cut difference or sudden shift between conscious and unconscious thought (Eysenck, 1995). Bastick (1982; 2003) claims that the resolution of discordant requirements results in the most awesome of intuitions:

the Eureka experience. The most mundane intuitive judgement of suitability occurs where the simultaneously perceived novel requirements are concordant with the current emotional set because of their shared attributes with the stimuli evoking the emotional set. Few new associations have been created to obtain this structure, and little satisfaction and reduction of anxiety accompanies the small increase in redundancy. This could explain the lack of coherent results from the psychophysiological measurements; the small successes that the participants had when they used a feature intuitively were too close together to be distinguishable and not large enough to affect the level of arousal.

Also, EDA can be affected by other variables such as age, gender, menstrual cycle, race, temperature, humidity, time of day, day of week and season. Sometimes even a deep breath will produce a response, and Stern et al. (1980) suggest discounting responses for 20 seconds after such a disturbance. The latency of EDA is the time from stimulus to onset of the electrodermal response, which is usually 1.3 to 2.5 seconds. In this case the latency of EDA could not keep up with the rate at which some participants were using the product, and stopping the experiment after a deep breath was not possible as it would have interfered with the measurement of other performance parameters and may have affected performance itself. Therefore, it is not really a suitable measure for this type of experiment.

7.4 Summary

Experiment 1 was conducted in order to test the thesis that intuitive interaction involves utilising knowledge gained through other products or experience(s). Participants were video-recorded using a digital camera while delivering concurrent protocol. Afterwards, participants were asked how familiar each feature was to them and they completed a technology familiarity questionnaire. In the questionnaire, participants indicated how often they used common consumer electronics products, and how much of the functionality of those products they used. This questionnaire was used to calculate each participant’s technology familiarity (TF) score.

The results suggested that prior exposure to products employing similar features helped participants to complete the operations more quickly and intuitively, and more familiar features were intuitively used more often. The camera borrowed features from other digital products, so expert users of digital cameras who had low technology familiarity completed the tasks more slowly and effortfully than digital camera novices who had higher technology familiarity.

Chapter 8 will detail the second experiment, which was based on Experiment 1. A different product was used as mediator for Experiment 2, and there was also some adaptation to method and measures based on lessons learned from Experiment 1.

Chapter 8

Experiment 2

8.0 Introduction

Experiment 1 established that there was no significant difference between the time taken to perform the tasks for the different levels of experience with a particular product type if the product transferred features from similar products and other things. Instead, the strong correlations were between the TF score and fast, intuitive use of the product, and familiarity and intuitive uses of features. Grouping participants into expert, intermediate, novice and naïve with the product type seems to be less relevant when investigating intuitive use than some other aspects of usability.

Experiment 2 was based on the same method as Experiment 1. However, the psychophysiological measurements, which revealed no useful data, were not taken. Also, a different product was employed: a universal remote control rather than a camera. The questions about whether participants accessed their previous experience when using a new product were also not used as they were seen as being more subjective than the rest of the data.

This experiment was designed: to further establish if relevant past experience of remote control features increases the speed and/or intuitiveness with which people can use those features and therefore the product; to further establish that interface knowledge is transferred from known products to new ones; and to gain an understanding of the intuitiveness of features of the remote control used in the experiment, in order to redesign it for Experiment 3.

8.1 Method

8.1.1 Participants and Experiment Design

University staff were asked to volunteer to take part in the study. Participants were selected from the pool of volunteers. None of the participants had encountered the remote control used in the tests before the experiment began, and all participants were volunteers who received no payment in return for their participation.

Technology familiarity (TF) was the independent variable (IV) used to group the participants. This experiment was also a between-groups matched-subjects design, and thirty people in three groups (high, medium and low level of technology familiarity) participated (Table 8.1). The group splits are as follows: 33rd percentile is at TF score of 56 and the 66th percentile is at 73.6. Individual differences were controlled by choosing a cross-section of the community in terms of age, level of education and gender for each group.

Table 8.1. Participant groups for Experiment 2

TF group	Age group	Gender	Education level
High	25–35	Female	Postgraduate
High	25–35	Female	Postgraduate
High	25–35	Female	Graduate
High	25–35	Female	Further Education
High	<25	Female	School
High	25–35	Male	Graduate
High	25–35	Male	School
High	25–35	Male	Postgraduate
High	25–35	Male	Graduate
High	<25	Male	School
Medium	25–35	Female	Postgraduate
Medium	25–35	Female	School
Medium	25–35	Female	Graduate
Medium	35–45	Female	Postgraduate
Medium	35–45	Female	Postgraduate
Medium	44–55	Female	Further Education
Medium	44–55	Female	Postgraduate
Medium	25–35	Male	Graduate
Medium	25–35	Male	Postgraduate
Medium	35–45	Male	School
Low	25–35	Female	Postgraduate
Low	35–45	Female	Postgraduate
Low	44–55	Female	Postgraduate
Low	44–55	Female	School
Low	44–55	Female	Further Education
Low	55+	Female	Further Education
Low	55+	Male	Postgraduate
Low	55+	Male	Postgraduate
Low	55+	Male	Postgraduate
Low	55+	Male	School

The technology familiarity questionnaire (Appendix B) was used as a recruitment tool in this case. It was adapted from the one used for the first experiment to include products with features similar to the remote rather than products with features similar to the camera. The maximum possible score for this questionnaire was 110 and the hypothetical minimum was 0. The score was calculated as shown in Appendix C.

8.1.2 Apparatus and Measures

The Marantz RC5000i universal touch screen remote control was programmed to control a Panasonic NV SD 220 VCR and NEC Chromovision TV. The operations were designed to investigate seventeen of the features of the product (Figures 8.1 to 8.2), some of which are common to many digital devices, and others of which are found on most audiovisual (AV) equipment and software. The experiment was performed using the default interface on the remote control, and the programming involved teaching the remote to control the devices using the remote controls supplied with those devices. The tasks were designed to investigate the features of the product detailed in Table 8.2 and representative examples are illustrated in Figures 8.1 and 8.2.

Table 8.2 Remote control features investigated in Experiment 2

Features common to digital devices and software	
On function	Drop down menu
Tabbed windows or screens	Navigation within and between devices
Back/ahead	Scroll arrows
Home	4-way navigation arrows
Home page	Enter key
Touch screen/soft keys	Menu
Features common to remotes and AV equipment	
TV on/off	Skip/index
VCR on/off	Pause
Play	Volume control
Stop	Channel selection
Forward/rewind	AV function

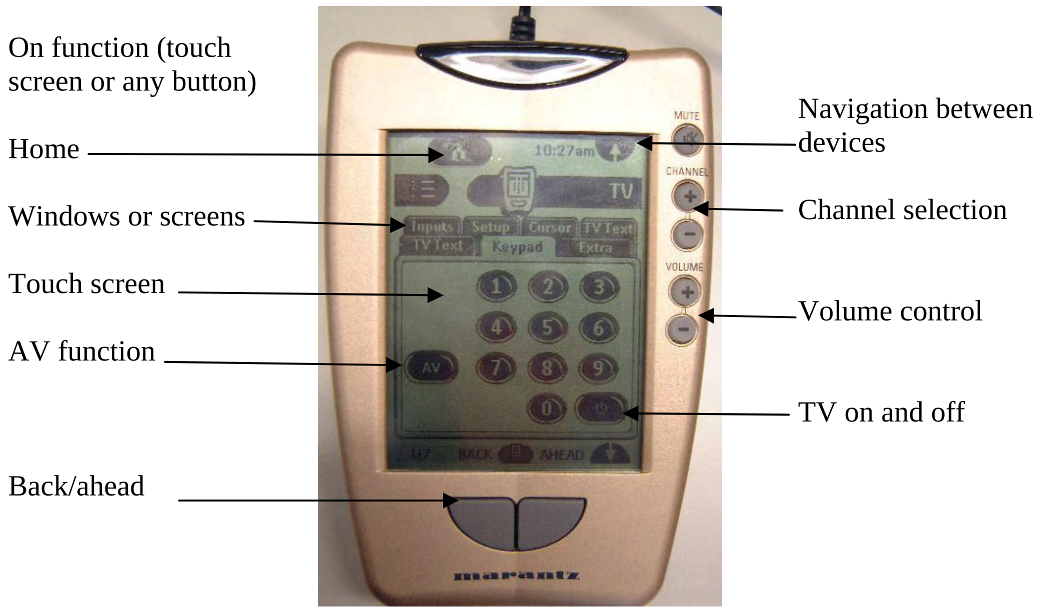


Figure 8.1 Remote on TV keypad screen

Figure 8.2 Remote on VCR main screen

As per Experiment 1, two digital video cameras were used to record the activity. These pictures were digitally mixed to produce one MPEG file that showed both scenes (Figure 8.3). One camera was trained on the participants' hands as they operated the remote, and the other recorded the whole scene which showed especially where they were looking: at the TV and VCR or at the remote. This helped to reveal their expectations of the features.

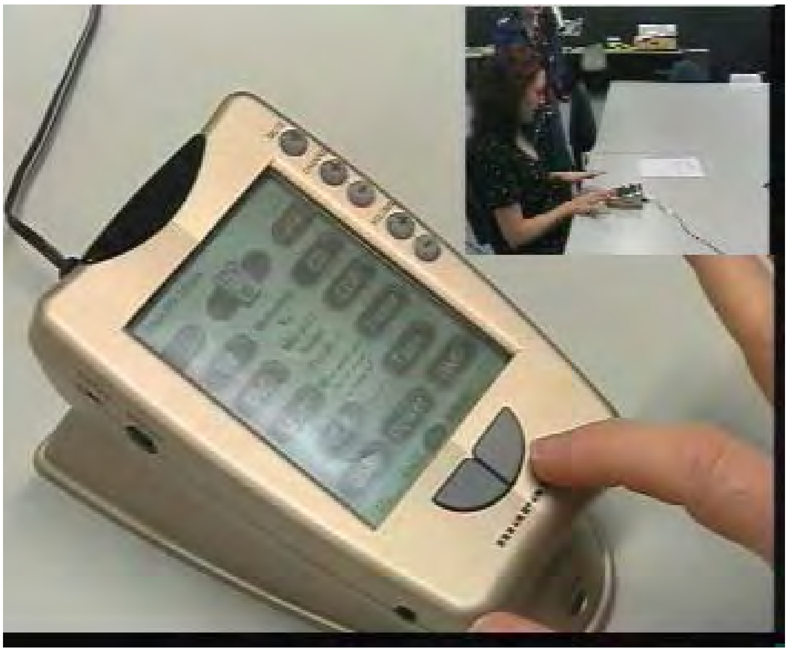


Figure 8.3 Mixed views from both video cameras

The following methods and tools were chosen to measure the dependent variables (Table 8.3). It can be seen that these variables and measurement tools are very similar to those in Experiment 1.

Table 8.3 Variables, methods and measurement tools

Dependent variables	Methods and measurement tools
Time to complete operations	Observation using Observer
Number of first or only uses of features per participant that were intuitive	Observation using Observer Concurrent protocol
Assistance received	Observation using Observer Concurrent Protocol
Familiarity of each feature	Structured follow up interview
Intuitiveness of each factor of each feature, based on user expectations	Structured follow up interview (rating scales)
Percentage of uses of each feature that were intuitive	Observation using Observer Concurrent protocol
Mistakes for each feature	Observation using Observer Concurrent protocol
Unsuccessful attempts on each feature	Observation using Observer Concurrent protocol

8.1.3 Procedure

The procedure was the same as for Experiment 1, except that the psychophysiological equipment was not used, and the remote control was the mediating product instead of the camera. The remote control was left on the home screen or panel, the TV and VCR were on the same channels, and the videotape in the VCR was left in the same position in the program for each experiment. The tasks that participants were asked to complete were also different because of the new product (Table 8.4).

Table 8.4 Operations

1	Use the remote control to turn on the television and VCR and start playing the tape in the VCR
2	Go to the start of the current recording (give name of program), play that scene for a few seconds and then stop the tape.
3	Reset the clock on the VCR to 1724

Following completion of these operations, participants were interviewed using a structured proforma (Appendix D). During the interview, participants gave ratings for familiarity of each feature and the expectedness of the function, the location and the appearance of each feature. They were also asked if they had been anxious and, if so, why. The majority of those who felt anxious became so because of their frustration with the product, not because they were being watched and recorded. It can therefore be assumed that reactive effects from being observed were minimal. A one-way ANOVA revealed no significant differences in numbers of intuitive uses between those who were anxious, a little anxious or not at all anxious, $F(2, 27)$ 1.153, $p > .05$.

Noldus Observer was used to code the video footage as explained in Section 6.5. The mistake code was added for this experiment as the touch screen had small “buttons” and mistakes were relatively common compared to the number made with the camera. Attempted use was also added, based on experience with the previous analysis.

8.2 Results

The coded data were compared with the answers given during the interview to give two sets of results: those concerned with the features of the remote and their performance, and those concerned with the participants and their performance. This two-pronged approach was taken in order to fulfil all the objectives of the experiment: to learn more about the way people use their past experience when using a new product, and to assess the product features with a view to re-designing them.

8.2.1 Participant Focussed Results

The performance measures used were the same as those employed in Experiment 1: time to complete tasks and number of intuitive uses, particularly intuitive first uses. There were no significant differences in the time to complete the tasks based on level of education, $F(3,26) = .84$, $p > .05$ ($E^2 = .088$, power = .206), or gender, $t(28) = .55$, $p > .05$ ($E^2 = .011$, power = .083). The ANOVA for anxiety and time showed no significant effect on time to complete operations, $F(2,27) = 3.42$, $p = .048$ ($E^2 = .202$, power = .592), as the Levene's test revealed a breach of homogeneity, $F(2,27) = 4.90$, $p < .05$ so a strict alpha level of .025 was adopted in accordance with Keppell's (1998) recommendation. An ANOVA showed that anxiety, $F(2,27) = 1.15$, $p > .05$ ($E^2 = .079$, power = .23) also did not affect the number of intuitive first uses. Level of education had no significant effect on intuitive uses, $F(3,26) = 2.03$, $p > .05$ ($E^2 = .19$, power = .46). A *t* test revealed that gender also had no significant effect on number of intuitive first uses, $t(28) = 1.59$, $p > .05$. In these cases, where the power is low to moderate and the effect size moderate, there is a possibility of a Type II error and it may be the one or more of these variables has an effect on time and/or intuitive uses.

Table 8.5 shows the means and standard deviations for the variable time to complete operations, and Figure 8.4 presents the relationship between time to complete the operations and the technology familiarity (TF) group. A one-way ANOVA revealed that Levene's test showed that homogeneity was breached, $F(2,27) = 10.22$, $p < .0001$. Therefore, again in accordance with Keppel (1998), a strict alpha level of

.025 has been adopted. The ANOVA showed a significant difference in time to complete tasks, $F(2,27) = 5.77$, $p < .008$. According to the Tukey HSD test, this difference was between the high TF and low TF groups ($p = .006$). Therefore, participants who had a higher level of technology familiarity were quicker at doing the tasks.

Table 8.5 Means and standard deviations for time to complete operations

TF Group	Low TF		Medium TF		High TF		Total	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Time (secs)	1380.9	834.45	952.4	352.95	554.9	261.88	962.7	627.48

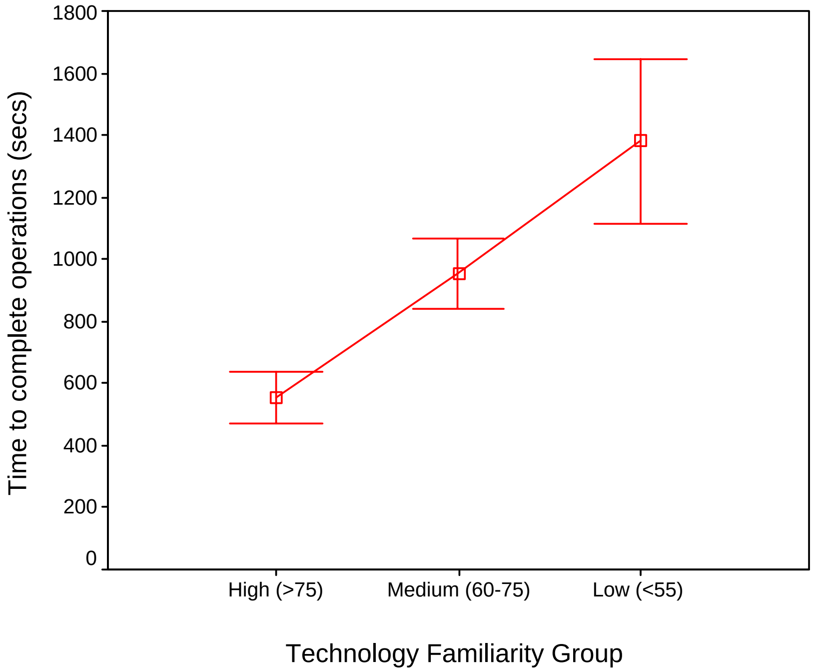


Figure 8.4 Time to complete operations for each technology familiarity group (NB. All error bars are standard error of the mean x1).

Table 8.6 shows the mean and standard deviations for time to complete tasks for each age group. Levene's test showed a breach of homogeneity , $F(3,26) = 8.73$, $p < .000$, so the alpha level of 0.25 was adopted. Age group had a significant main effect on time to complete operations, $F(3,26) = 11.26$, $p < .0001$. This relationship is shown in Figure 8.5. The Tukey post hoc test showed that there were significant differences in time to complete tasks between the 18–34 age group and the 45–54 ($p = .005$) and > 55 ($p = .001$) age groups. In addition, there was a significant difference between the 35–44 group and the >55 group ($p = .015$).

Table 8.6 Means and standard deviations for time to complete tasks by age groups

Age Group	Age 18–34		Age 35–44		Age 45–54		Age >55	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Time (secs)	605.6	257.07	797	283.1	1446	393	1754.6	882.6

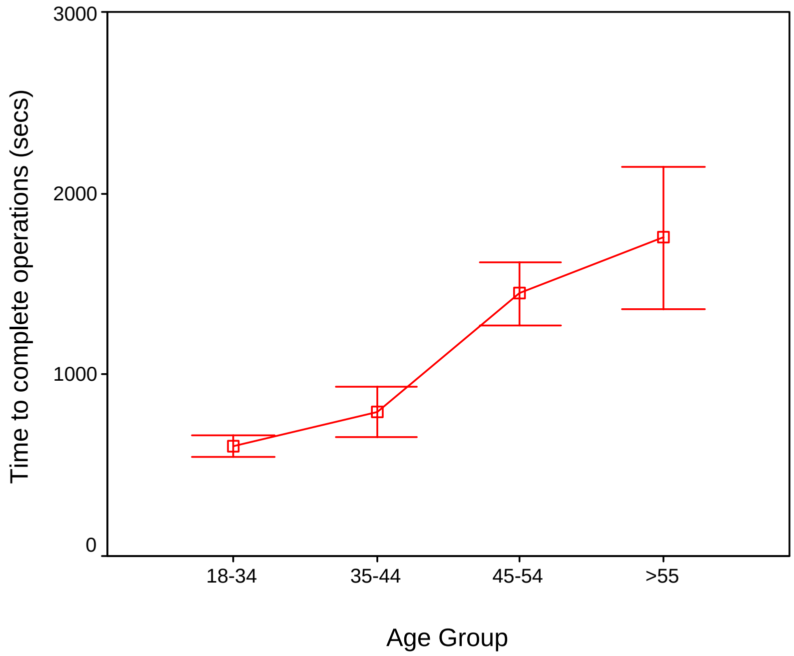


Figure 8.5 Time to complete tasks by age group

Unfortunately, the recruitment questionnaire asked people for their age group rather than their exact age, so it is not possible to re-arrange the groups to give a more even spread of people within each group. Also, age was distributed across the technology familiarity groups but was not strictly grouped, so the effect of age on performance needed to be investigated further with a stricter grouping. This was done through Experiment 3 (Section 9.3).

A one-way ANOVA revealed that TF group had a significant effect on the number of intuitive first uses (correct or correct-but-inappropriate), $F(2,27) = 8.58$, $p < .001$ (Figure 8.6), with a Tukey post hoc test showing that the high TF group had significantly more intuitive first uses than the low TF group ($p = .001$). Therefore, participants who had a higher level of technology familiarity were able to use more of the features intuitively the first time they encountered them.

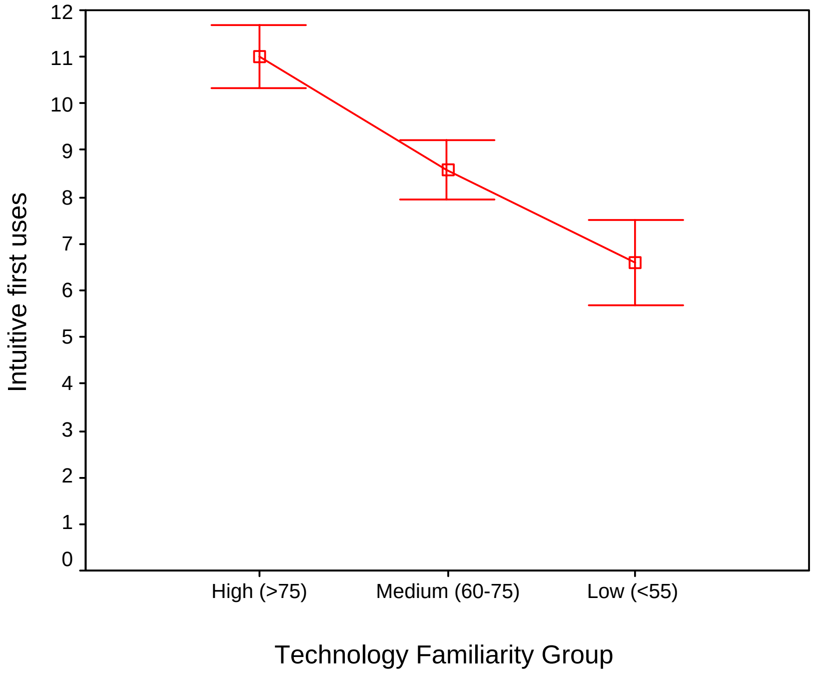


Figure 8.6 Intuitive first uses (correct and correct-but-inappropriate) by TF group.

A one-way ANOVA showed that age group significantly affected the number of intuitive first uses, $F(3, 26) = 8.62$, $p < .0001$ (Figure 8.7), with the Tukey post hoc test showing the significant difference between the 18–34 groups and both the 45–54 group ($p = .003$) and the >55 group ($p = .002$).

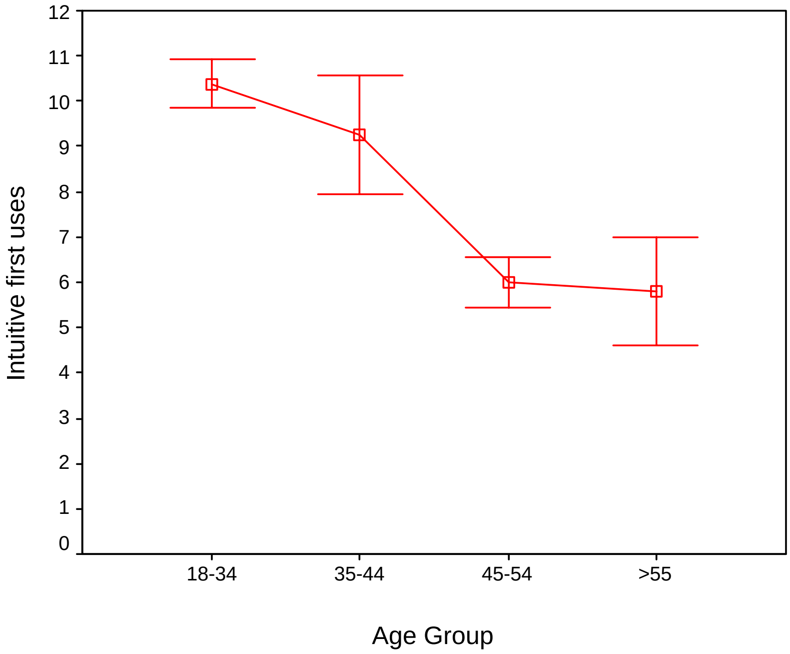


Figure 8.7 Intuitive first uses (correct and correct-but-inappropriate) by age group.

Those with a lower technology familiarity score, as well as taking more time and using the features less intuitively, also required more assistance. There was a strong positive correlation between time and number of times help was given, $r(28) = .86$, $p < .0001$, and a significant negative correlation between TF score and number of times help was given, $r(28) = –.53$, $p < .005$ (Figure 8.8).[2]

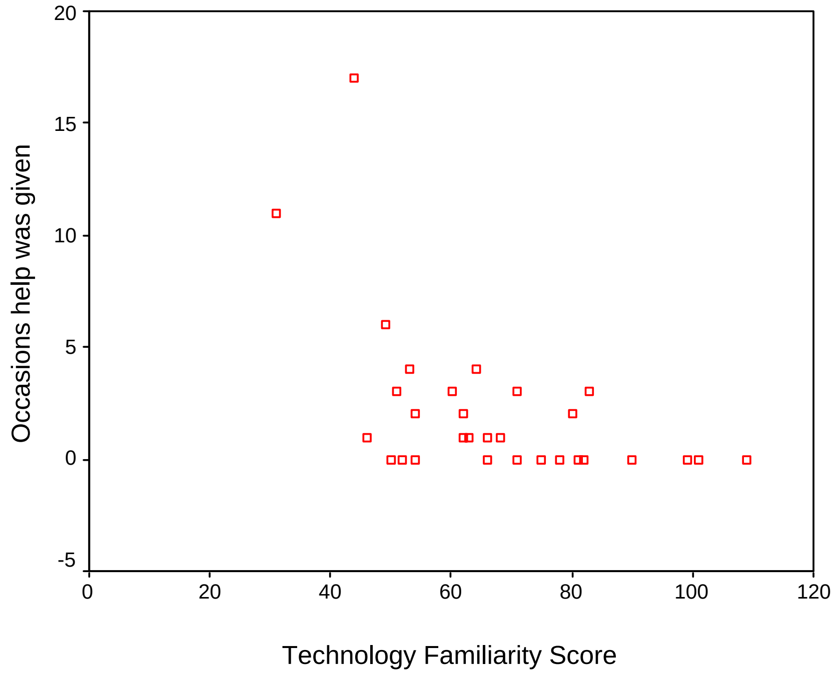


Figure 8.8 Number of occasions help was given by TF score

8.2.2 Feature Focussed Results

Table 8.7 shows the mean familiarity, mean percentage of intuitive uses (correct and correct-but-inappropriate) and mean percentage of intuitive first uses (correct and correct-but-inappropriate) per feature. This table highlights the features that needed to be focussed on as part of the re-design process. Those nearest the bottom of the table were those that participants had the most trouble with (i.e. smaller percentage of intuitive uses and intuitive first uses and more mistakes).

[2] This data set was also tested after removal of the two outliers evident in Figure 8.8 and the result remained significant, $r(26) = –.419$, $p < .05$.

Table 8.7 Mean familiarity, mean percentage of intuitive uses and intuitive first uses

Feature	Mean familiarity	Percentage of intuitive uses	Percentage of intuitive first uses
Play	5.87	97.0	100
Windows	4.92	90.0	80
Stop	4.90	85.7	73.3
Home	4.92	85.5	57
Forward/rewind	5.81	80.2	85
4-way	4.67	72.0	56.6
Number pad	5.72	70.5	57
VCR on/off	4.83	66.6	60.71
Enter	N/A	64.4	50
Menu	5.05	64.3	60
Navigation	4.50	57.1	46.67
Volume/channel	5.82	45.7	73.3
TV on/off	4.77	40.0	50
AV function	3.78	36.0	28.57
Remote on	3.03	36.0	6.67
Back/ahead	4.80	32.5	11.10
Skip/index	2.76	6.3	15.38

The percentage of intuitive uses of the features was compared with the familiarity of the features. It was found that the mean familiarity of the features correlated strongly and positively with the mean of the percentage of intuitive uses of the features (correct and correct-but-inappropriate), $r(n = 17) = .698$, $p < .002$ (Figure 8.9). Mean familiarity of features and intuitive uses of features (correct only) did not correlate significantly, $r(n = 17) = .38$, $p > .05$. However, the correlation is moderate so it is possible that this result was not significant due to low power.

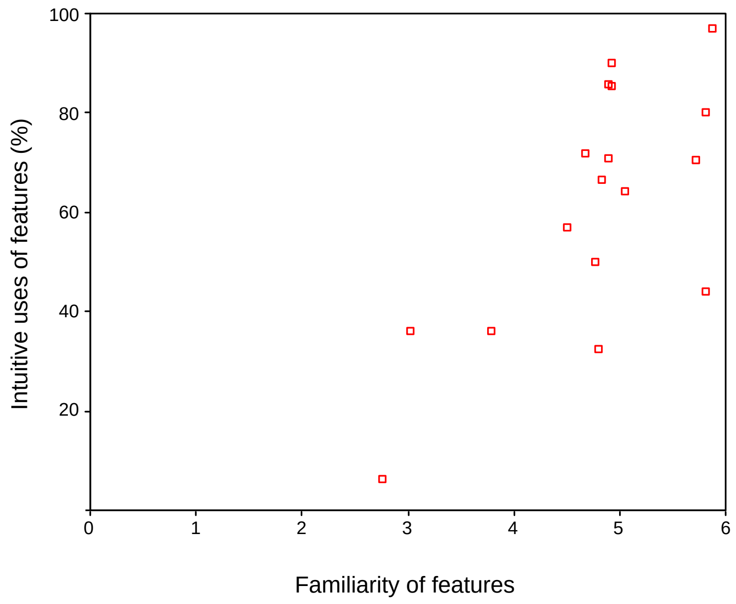


Figure 8.9 Mean familiarity of features plotted against mean percentage of intuitive uses of feature (correct and correct-but-inappropriate)

The percentage of intuitive first uses of features (correct and correct-but-inappropriate) also correlated strongly and positively with familiarity, $r(15) = .80$, $p < .0001$ (Figure 8.10), as did the percentage of intuitive first uses of features (correct only), $r(14) = .75$, $p < .001$.

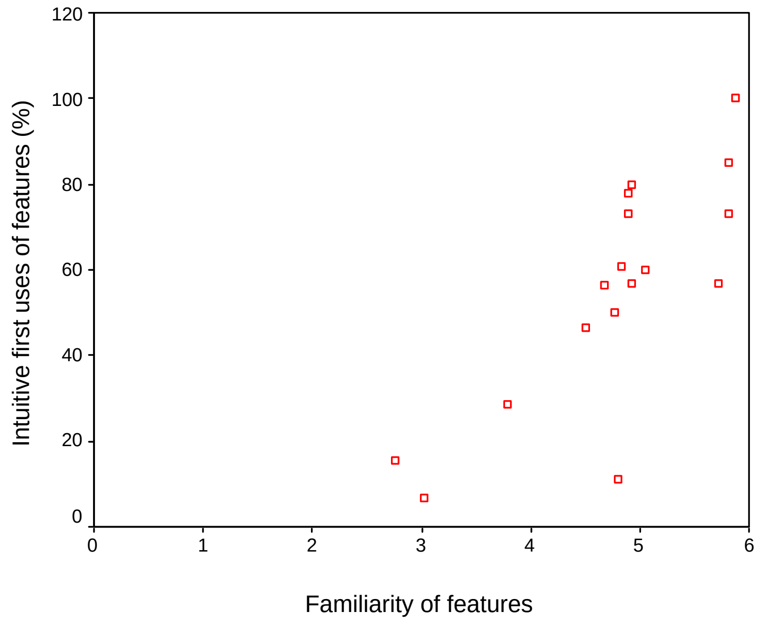


Figure 8.10 Intuitive first uses of features (correct and correct-but-inappropriate) by familiarity of features

These data show that features that were more familiar were intuitively used more often. For example, the play and forward/rewind functions both had high means from the familiarity ratings, and high percentages of intuitive uses.

No clear pattern was evident in the function, location and appearance data and there were no correlations between scores on these ratings and percentages of intuitive uses. Table 8.8 has been organised with lowest scores nearest the bottom, so it can be seen that some of the same features that had lower familiarity and lower percentage of intuitive uses also scored lower on these rating scales.

Table 8.8 Mean function, location and appearance score for each feature

Feature	Mean function	Mean location	Mean appearance
Volume/channel	5.87	5.53	5.67
Remote on	5.74	5.48	5.48
Numbers	5.53	5.37	5.37
Stop	5.43	5.17	4.63
Touch screen	5.40	5.67	5.10
VCR on/off	5.30	4.93	4.73
TV on/off	5.13	4.03	5.03
4-way	5.00	4.93	5.20
Play	4.83	3.87	3.40
Navigation	4.83	5.20	5.40
Menu	4.70	4.33	4.13
Forward/rewind	4.68	4.72	4.64
Windows	4.63	4.53	4.10
Home	4.43	4.40	5.05
Back/ahead	4.40	3.84	3.56
AV function	4.18	3.45	4.18
Skip/index	3.58	3.47	3.63

This suggests that the data from this exercise are not completely random, but there is no evidence of any clear differentiation between function, location and appearance as there was in Experiment 1. This may have been because the remote control is a more complex product than the camera and it is harder for participants to distinguish the different factors from each other, so many participants put similar scores for each factor on most features. Also, they were not supervised while completing this section, so it was decided that for Experiment 3 this rating exercise would be more a part of the interview and participants would be supervised and assisted where necessary while doing this.

Other problems with several features have also been revealed by this analysis. For example, knowing the number of mistakes and attempts with each feature helped to evaluate button size and sensitivity. Incorrect uses for each feature also give an indication of how difficult each one was to use. Most mistakes and attempts were due to the size or labelling of the buttons. Incorrect uses could be due to lack of familiarity or poor labelling; people were unable to tell what a feature did, so used it to try to do something else. Tables 8.9 to 8.11 show those features that had mistaken, incorrect and unsuccessful uses. Those features not listed in each table had none of that type of use. Again the poorest performing features are nearest the bottom of the tables.

Table 8.9 Mistakes per feature.

Feature	Percentage of uses that were mistakes
Back/ahead	0.41%
Windows	0.54%
Stop	0.5%
Navigation	0.76%
Menu	1.3%
Forward/rewind	2.0%

Table 8.10 Unsuccessful attempts per feature.

Feature	Percentage of uses that were unsuccessful attempts
Windows	0.36%
Play	0.61%
Navigation	1.52%
Remote on	4.26%
Skip/index	9.38%
Back/ahead	26.83%

Participants were also asked during the interview to nominate the main things they would like to see changed on the remote control. This was an optional question and not all participants answered it, while some mentioned several points. The answers are summarised in Table 8.12. It can be seen that more problems or desired changes were mentioned by low and medium TF participants compared to high TF participants, but there were some features that caused problems for several of them. Again these are placed at the bottom of the table.

Table 8.11 Incorrect uses per feature.

Feature	Percentage of uses that were incorrect
TV on/off	2.94%
Number pads	2.94%
Windows	3.78%
Forward/rewind	7.69%
VCR on/off	8.64%
Stop	8.93%
Menu	11.04%
4-way	12.77%
Back/ahead	19.51%
Navigation	20.56%
Enter	23.9%
AV function	24.0%
Volume/channel	29.76%
Skip/index	40.63%

Table 8.12 Main problems mentioned by participants

Feature or problem	Number of times feature or problem was mentioned by participants			
	High TF	Medium TF	Low TF	Total
AV function		1		1
TV on/off		1		1
Home unexpected	1		1	2
Stop	1		1	2
Remote on		2		2
Menu		1	1	2
Windows unclear		1	2	3
Help function requested		1	2	3
Size of buttons	1		3	4
Navigation	2	1	3	6
Back/ahead	4	5	2	11
Total	9	13	15	37

8.3 Discussion

The relationships reported here between time, TF score and intuitive uses of the features support the findings of Experiment 1. People seem to use their previous experience with similar features in order to use new features intuitively. These results also suggest that the decision to use TF score as the independent variable to group participants rather than level of expertise was the right one as the groups show significant differences between them whereas in Experiment 1 the novice, naïve, intermediate and expert groups did not. Again, the data on intuitive first uses are particularly important as they strongly suggest that people are able to use a feature intuitively the first time they encounter it if they are already familiar with a similar feature.

Lower TF users did not seem to differentiate the hierarchy in the remote; they were not always sure if they were in VCR or TV mode, and often did not seem sure where they would end up if they went “back”. Higher TF users often were able to infer the hierarchy of the system through using it, whereas the very lowest TF users got more confused and made more mistakes the longer they tried to work out a task. Towards the end of the sessions they made mistakes even with features they had used correctly earlier. This could possibly be an example of anxiety interfering with their intuition, or may be indicative of fatigue. These users were also more likely to keep on doing the same thing to try to get the remote to “hear” them, rather than trying something else. For example, one participant was convinced that she should be able to enter the time through the number pads, and she kept on trying to do that although the system never responded to her attempts.

The relationship between age and intuitive uses and time on task is an interesting one and needs further clarification. Because of the design of the experiment, the results for age can only be treated as preliminary at this stage. This issue was addressed for Experiment 3 and will be investigated further in Chapter 9.

Features that are less familiar to users have less intuitive uses, more mistaken uses, more unsuccessful attempts and more incorrect uses. Therefore, using familiar features in new products should be the key to intuitive use. The detailed data on the features obtained from this experiment have enabled the re-design of the remote control in a systematic way that is aimed at increasing the intuitiveness of the product.

Features that appear near the bottom of Tables 8.6 to 8.11 presented the most problems and became the priorities for re-design. They were less familiar to users, and showed less intuitive uses, more mistaken uses, more unsuccessful attempts and more incorrect uses. There were several that appeared at the bottoms of each of the charts and therefore the features chosen to focus on were back/ahead, remote on, navigation, 4-way, AV function, menu and skip/index.

8.3.1 Redesign Issues

In this discussion, some features will be examined in detail, as examples of features that caused particular problems. Further discussion of the usability and re-design issues that were revealed by this experiment can be found in Blackler, Popovic and Mahar (2003a).

Back/ahead (Figure 8.1) had 20% incorrect uses, 26.83% unsuccessful attempts, 32.5% intuitive uses (correct and correct-but-inappropriate) and only 11.1% intuitive first uses (correct and correct-but-inappropriate both 11.1%) but familiarity was reasonable with a mean of 4.8 on a 1 to 6 scale. Although the majority of participants were familiar with a feature of this sort, mostly from Internet browsers, they performed badly when using it. There are several reasons for this. The back/ahead buttons appear to be unlabelled. They are in fact hard keys with soft labels, but very few of the participants realised this. Many of the uses were simply frustrated attempts to find something to press, especially at the start of the operations when some people did not realise that the remote had a touch screen. Most of the unsuccessful attempts occurred when people saw the back/ahead labels but did not realise they related to the hard buttons and tried to press the labels on the screen instead.

These buttons therefore needed redesigning. The most obvious problem was lack of labelling, so the hard buttons could be labelled with arrows similar to the Internet browsers that users said were familiar, and the labels on the screen, if retained, needed to be made bigger and clearer and related more definitely to the physical buttons.

Another factor that has been highlighted by this experiment is the lack of consistency in the existing design. Consistency is assumed to enhance the user’s possibility for transfer of skill from one system to another, and it allows the user to predict what the system will do (Nielsen, 1989). Consistency in the design should therefore allow more intuitive use. The TV and VCR on and off features are a good example (Figures 8.1 and 8.2). The two appliances are often used together but are not turned on in the same way in the default remote design tested. The VCR window had two separate buttons labelled with the words on and off, while the TV window had a single, rather inconspicuous power button with an icon very similar to the standard power symbol on it. The VCR on/off buttons were in the “main” window, while the TV power button was in the “keypad” window. This confused many of the participants, with some lower TF users saying the VCR buttons were clearer and easier to spot; for them the words on/off were more familiar than the power symbol used for TV on/off. The TV on/off feature had only 50% intuitive first uses, while the VCR on/off feature had 60.71%.

The stop and play features (Figure 8.2) also demonstrate this. Stop had only a symbol and not a word whereas the play function used the word “play”. Play had 100% intuitive first uses, 10 per group. Stop had 10 for the high TF group and only 6 for each of the medium and low groups (73% overall). Of the eight people who failed to use the stop function intuitively the first time, six were in the 45–54 and >55 age groups, so it is possible to assume that age might have been the contributing factors in the result.

There could have been two reasons for this: the size of the button or the familiarity of the symbol. Because the button was so small, it is possible that older users found it more difficult to see (indeed, both the younger users who also failed to use it intuitively first time wore spectacles). Several people pressed the circular skip button, which actually does nothing, when looking for stop; so making the stop button an equivalent size to the play button may also make it more obvious and communicate its status as a function on the same level as the play button. Alternatively, the symbol stop was less well recognised by these people than the word play. A solution would be to use both words and symbols, or words only.

8.4 Summary

Experiment 2 was conducted using a universal remote control to further test the thesis that intuitive use is based on past experience with similar features. Technology familiarity score was the independent variable. This was determined by the technology familiarity questionnaire which was adapted to include products similar to the remote rather than the camera. The results from Experiment 2 accord with those from Experiment 1; the more familiar a feature is, the more quickly and intuitively people are able to use it by transferring knowledge of known products to the new one. The detailed data enabled the re-design of the remote control in a systematic way that was aimed at increasing the possibility of intuitive interaction with the product. The new design and further experimentation will be discussed in Chapter 9. Neither of the first two experiments revealed which factors of the features (function, location or appearance) have the most influence on intuitive interaction. This is also addressed in Chapter 9.

Chapter 9

Redesign and Experiment 3

9.0 Introduction

Experiments 1 and 2 revealed that prior knowledge of features of a digital camera and a universal remote control allowed participants to use those features intuitively. Three factors – function, location and appearance – were investigated in Experiments 1 and 2 through subjective feedback from participants, with some measure of success. However, the subjective data were not definite enough for the more complex product (the remote), so Experiment 3 was designed to investigate the factors more empirically. This involved re-designing and testing the remote control.

This chapter first details the principles for intuitive use that were developed, based on the results from Experiments 1 and 2, and which were used to re-design the remote control. It then describes Experiment 3, which was developed to test several different interface designs on the remote control. The intention was to further explore the factors of function, location and appearance by manipulating them. Since function was pre-determined by the product, the experiment was designed to establish whether the location or appearance of a feature was the dominant factor in intuitive use. It was predicted that the new designs would result in quicker times and more intuitive uses than the default interface, and that the experiment should determine whether location or appearance would have the most effect.

9.1 Principles of Intuitive Interaction

A method, or at least a formalised approach, is needed to increase the probability of designers developing display designs that support the nature of decision making in dynamic environments (Wong, 1999). Existing methods contain procedures for exhaustive analysis and description of the cognitive work and the complexities of the task domain. “However, the literature provides little advice on how the understanding and insight gained from these processes should be represented. This is the design gap” (Wong, 1999, p2). Numerous guidelines for detail design are available; for example, colour, placement of text and so on (for examples, see Wickens et al. 1998), but there are currently no guidelines that are directed explicitly at intuitive interaction. The following preliminary principles were developed, based on the experimentation reported in Chapters 7 and 8 and cover all three factors of function, location and appearance of the features on a product or interface.

1. Use familiar symbols and/or words for well-known functions, put them in a familiar or expected position and make the function comparable with similar functions users have seen before.
2. Make it obvious what less well-known functions will do by using familiar things as metaphors to demonstrate their function. Again use familiar symbols and/or words and location.
3. Increase the consistency between devices and features so that function, location and appearance of features are consistent between different parts of the design (in this case between AV devices) and on every page, panel and/or part.

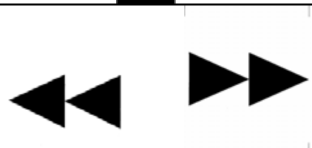
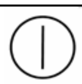
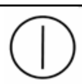
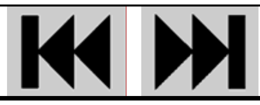
9.2 Re-Design

These principles were applied to the re-design of the remote control. Since the functions of the remote control's features were already determined, it was possible to make changes only to the location and appearance of the features. There were several features with which participants performed the worst in terms of mistakes, intuitive uses and incorrect uses, as explained in Chapter 8. Those selected to focus on for the re-design were back/ahead, AV function, skip/index, remote on, 4-way and menu. Navigation was flagged as a problem area in Chapter 8 but is not included in this analysis as it was not possible within the constraints of the remote control programming to re-design the navigation structure or interface. However, some very minor changes were made to the scroll arrows that are part of the navigation system.

9.2.1 Interface Design Process

Eighteen postgraduate industrial designers were asked to re-design the remote control interface according to the principles proposed above. The researcher developed a brief, specifying the icons to be used for particular features (Appendix G), and students were given copies of the icons specified in enlarged format. Before starting the design process, the students watched a presentation explaining the research and the previous findings. They also attempted the tasks used for Experiment 2 in order to gain experience at using the remote control, and completed the ratings for function, location and appearance of features which were part of the interview for Experiment 2 (Appendix D).

Table 9.1 Re-designed features

Feature	Reference for design	Illustration
Play	CEI/IEC 60417-2 ISO/IEC 18035	
Stop	ISO/IEC 18035	
Forward/rewin d	CEI/IEC 60417-2 ISO/IEC 18035	
4-way	Designers choice	
VCR on/off	CEI/IEC 60417-2	
Enter	Designers choice	
Menu	Label as VCR menu Exact style designers choice	
TV on/off	CEI/IEC 60417-2	
AV function	Label as TV/Video Exact style designers choice	
Remote on	Label as “Touch screen to start” or similar Exact style designers choice	
Back/ahead	Label Back and → as Internet Browsers Mark hard keys as mobile phones	
Skip/index	ISO/IEC 18035	

The icons were developed from international standards where such standards existed (CEI/IEC, 1998; ISO/IEC, 2003), as it was assumed that standardised icons would be frequently applied to similar interfaces and therefore be most familiar to users. Where standards did not exist, similar products, such as software and other remote controls, were investigated to see which icons and/or designs should be most familiar to users. For features that had no clearly established precedent, the designers were asked to develop a design which would be familiar to users. The icons chosen for each feature are shown in Table 9.1.

Four test designs (or configurations, as Marantz calls them) were required for Experiment 3 (Table 9.2). The designers worked only on the total re-design (Location–Appearance), not the Location and Appearance designs. (The Location design used only the new locations for the features, while the Appearance design used only the new appearances.)

Table 9.2. Interface designs

Configuration	Explanation
Default	Default design used in Experiment 2
Location	New location for features, default appearance
Appearance	New appearance for features, default location
Location-Appearance	New appearance and location.

The features changed were those that were most frequently used in Experiment 2, and which it was possible to change within the constraints of the remote control technology (some of the features of the default design could not be changed). Designers were told that all designs must be suitable for application to the product. They had therefore to be of an appropriate size to fit into panels and greyscale. Designers were asked not to add new commands and to produce a final design with each feature as a separate bitmap. The chosen Location–Appearance Design is shown in Figures 9.1 to 9.3

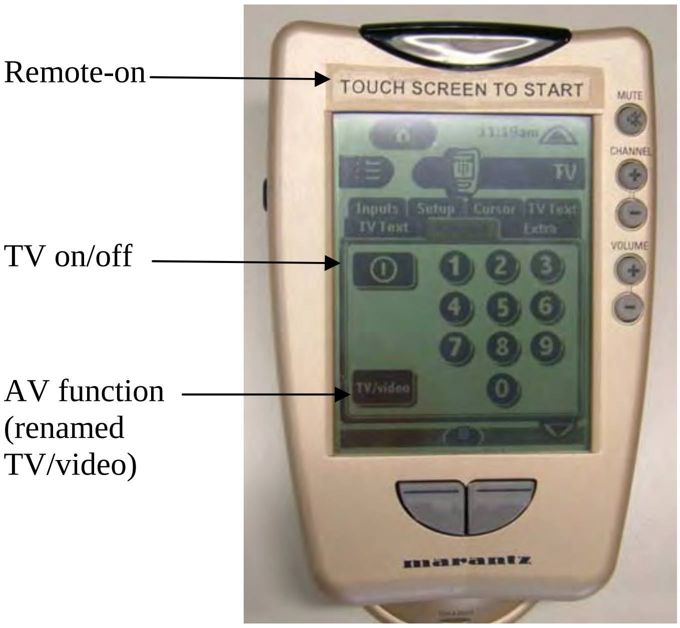


Figure 9.1. Location–Appearance design on TV main screen

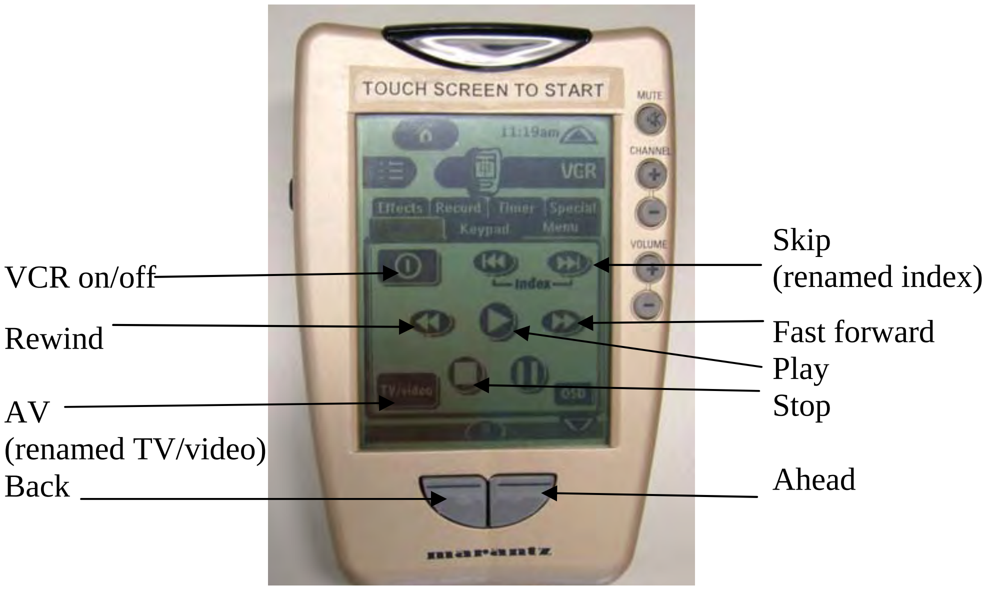


Figure 9.2. Location–Appearance design on VCR main screen

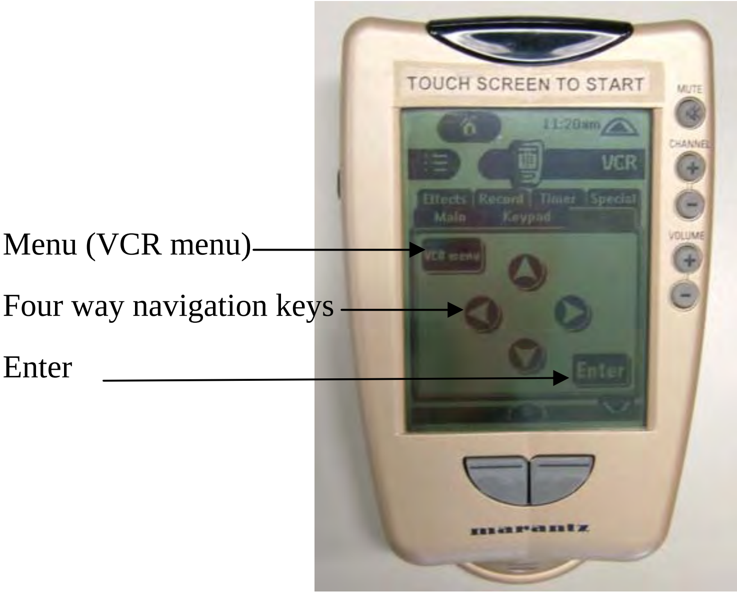


Figure 9.3. Location–Appearance design on VCR menu screen

The Location–Appearance design selected (Figures 9.1 to 9.3) was simple and clear, similar enough to the existing interface so as not to confound the experiment by revealing to participants which screens were changed from the original, and easy to adapt to the Location and Appearance designs. Some fine-tuning was done by the researcher before the design was ready for testing. Much of this consisted of refining the location of the features by looking at existing audio, TV and VCR remote control devices and software in order to establish the most common (therefore most familiar) locations for the features. The Location–Appearance design was then transposed into the Location and Appearance designs to create the three new configurations used in Experiment 3.

The software used to produce the configurations from the individual bitmaps was the Marantz RC5000 setup package version 2.3 (available through Marantz) and designed for the purpose of re-configuring the remote. This basic package had to be used to assemble the bitmap images of the buttons onto the screens and download each configuration into the device.

9.2.2 Familiarity of Features (Principles 1 and 2)

This section discusses in detail how the principles for intuitive interaction explained previously were applied to the re-designed remote control, for the factors location and appearance.

Appearance

Weiss (2002) recommends that icons should have audio or visual feedback to show that they have been pressed. Inverting colours is a popular way to provide visual feedback (Weiss, 2002), and indeed the default and new designs all use this method. These recommendations were also followed in order to make the interface as standard as possible. Weiss (2002) also discusses the typical ways of finding a home page or menu: menu key (e.g. mobile phones), home button (Palm), Start button (Windows CE), up or back keys (mobile phones and WAP). The back function key was re-designed to look like the keys on a mobile phone and gain familiarity that way. The home button was part of the navigation system that could not be changed.

As previously mentioned, icons from international standards were used where applicable, under the assumption that these would be the most commonly used and therefore the most familiar. Norman (1995) supports this assumption, claiming that "Standards are forever, because once established, they simplify and dominate the lives of millions, even billions." Other icons were transferred from existing remotes and other similar types of devices, such as PC software, mobile phones and PDAs.

Location

Much of the fine tuning consisted of refining the location of each feature by looking at existing audio, TV and VCR remotes and software in order to establish the most common (therefore most familiar) locations for the features. Arnold (year unstated, in Wheildon, 1984) believed that the design of a page should take into account the linearity of the Latin alphabet and the physiology of the act of reading. People start at the top left and work their way across and down, left to right until they reach the bottom corner. This is called reading gravity. Arnold devised the Gutenberg diagram, which has the Primary Optical Area in the top left corner, where the eyes fall naturally. From there, the eyes move across and down the page, returning to an axis of orientation after each left–right sweep. In the bottom right is the terminal anchor where readers expect to end their interaction with that page. The top right and bottom left are called fallow corners, where the eye does not fall naturally and where objects may be missed. The eye does not willingly go against reading gravity (Wheildon, 1984).

Wheildon (1984) investigated this and other principles in a large study over several years. He presented articles about current affairs (such as would be seen in a newspaper) to 224 participants. Half of them were given an article which complied with the Gutenberg diagram; the other half were given an alternative layout. The conditions were reversed each time an article was presented. The participants read the articles and were then asked questions to determine their level of comprehension. It became apparent that the layout which defied Arnold's ideas was "faulty" (Wheildon, 1984, p190).

Smith (1998) found that within a screen there was generally a top-to-bottom, left-to-right hierarchy, which was building on the users' experience with the typical layout of newspapers, books and other paper-based graphical information. This suggests that the ideas put forward by Wheildon (1984) relating to page layout should be transferable to screen applications. Therefore, where there was no established position for them based on familiarity of other remotes, the features were placed according to the Gutenberg diagram, using the familiar printed page as a metaphor to make the design more intuitive to use.

9.2.3 Increase Consistency (Principle 3)

Hafner (2004) mentions a review that Jakob Nielsen conducted on his own remote controls. Nielsen was struck by the lack of universal standards for remotes, most noticeably in terms of the power button. In an examination of six remotes, he found three different ways of turning the devices on, and he suggests that the proliferation of remotes (i.e. several in each household) leads to a multiplying complexity that would overwhelm anybody. Universal remotes should help to address this problem but even the default design of the Marantz remote was not internally consistent. Consistency between the same functions on different devices was a particular problem identified in Experiment 2 (Section 8.3.3). This problem was addressed by making the location and appearance of these functions the same in each device.

To make the location of features as consistent as possible, the screens that were chosen all followed the layout recommended by Wheildon (1984) and flowed from top left to bottom right. Also, the buttons all followed the same style so that their appearance was consistent. The chosen design also has some aesthetic similarities to the default design. There were two advantages to this. Firstly, it meant that the whole product still retained some consistency, and secondly it meant that participants could not easily tell which screens had been changed, thus avoiding a confound in the experiment.

9.3 Experiment 3

Following the re-design of the remote control, a third experiment was planned with the objective of testing the three new designs against the default design in order to establish if changing the location and/or the appearance of the icons on the remote would make it more intuitive to use than the default design. This experiment has also been reported by Blackler, Popovic, and Mahar (2004a).

It was predicted that either the Location configuration, the Appearance configuration or the Location–Appearance configuration would be more intuitive to use than the other three so it would be possible to determine that either location of features, appearance of features or a combination of the two would be the determining factor of intuitiveness. However, it was also possible that some or all of the Location, Appearance and Location–Appearance configurations would be more intuitive to use than Default but have no significant differences between themselves; in this case it would be impossible to establish for certain which factor increases intuitiveness.

9.3.1 Method

Participants and Experiment Design

University staff and students, and employees of three local companies were asked to volunteer to take part in the study, and participants were selected from the pool of volunteers. None of the participants had encountered the remote control used in the tests before, and none received payment. A sample size of 15 for each condition in a 4x3 matched-subjects between-groups design (Table 9.3) was chosen to yield adequate power. The Independent Variable (IV) configuration had four levels: Appearance, Default, Location and Location–Appearance. The IV age group had three levels: 18–29, 30–39 and >40.

Table 9.3. Experimental groups for Experiment 3

Configuration	Age group	Male	Female	Total
Appearance (A)	18–29	1	4	5
	30–39	2	3	5
	40+	4	1	5
	Total	7	8	15
Default (D)	18–29	2	3	5
	30–39	1	4	5
	40+	4	1	5
	Total	7	8	15
Location (L)	18–29	2	3	5
	30–39	2	3	5
	40+	3	2	5
	Total	7	8	15
Location–Appearance (LA)	18–29	1	4	5
	30s	3	2	5
	40+	3	2	5
	Total	7	8	15
Total		28	32	60

This was a matched subjects design and in order to balance the groups, potential participants were asked to fill in a technology familiarity questionnaire (Appendix B) when they volunteered so that all four groups had a good representation of gender, level of education and technology familiarity (TF) score. This questionnaire had a hypothetical minimum score of zero and a hypothetical maximum score of 110, and was essentially identical to the one used in Experiment 2; however, volunteers were asked for their exact age in order for the age variable to be investigated more thoroughly. Appendix C show an example of how the scores were calculated.

Apparatus and Measures

The variables measured in this experiment and the methods and tools used are shown in Table 9.4. Again the main performance measures were time to complete operations and intuitive uses.

Table 9.4 Dependent variables and measures used.

Dependent variables	Measures required
Intuitive and correct uses of features (%)	Observation through Observer Concurrent Protocol
Familiarity of features	Structured follow up interview
Expectedness of function, location and appearance of features	Structured follow up interview (rating scales)
Intuitive first uses per participant (correct only)	Observation through Observer Concurrent Protocol
Intuitive uses per participant (correct only)	Observation through Observer Concurrent Protocol
Intuitive first uses per participant (correct and correct but in appropriate)	Observation through Observer Concurrent Protocol
Intuitive uses per participant (correct and correct-but-inappropriate)	Observation through Observer Concurrent Protocol
Assistance received	Observation through Observer Concurrent Protocol
Time on tasks	Observation through Observer

The Product used in the experiments was the Marantz RC5000i universal touch-screen remote control, used with Panasonic NV SD 220 video and NEC Chromovision TV. These were identical to those used in Experiment 2, except that the remote used four configurations instead of just the default one.

Procedure

Apart from some minor differences (reported below), the procedure followed was identical to that for Experiment 2. The participants were asked to complete the same three operations as those set in Experiment 2 (Table 8.3), so that some comparison could be made between the two experiments, and also because they forced the use of many of the features being investigated. As previously, participants were delivering concurrent protocol during the operations.

The first difference was that the interface configurations was downloaded into the Marantz RC5000i universal touch screen remote control from the Marantz RC5000 setup software prior to each session, according to the group into which the participant had been placed. Labels for remote on and back/ahead were also added for the Appearance and Location–Appearance configurations. Secondly, two digital video cameras were again used to record the activity. One was focussed close-up on the participants' hands as they operated the remote; the other recorded the whole scene for Operations 1 and 2 and was then moved to focus on the TV screen once the menu was brought up during Operation 3 (Figure 9.4). This was done to allow for easier coding of the clock-set task. Thirdly, participants were supervised and assisted where necessary while completing the rating scales in the follow-up interview (Appendix D).

Figure 9.4 Mixed view from both video cameras showing TV screen

9.3.2 Results

The assumptions upon which this work was based were drawn from the findings of Experiments 1 and 2. The assumptions were that those with a higher technology familiarity (TF) score would perform the tasks more quickly and intuitively than those with lower scores, and that there would be no significant differences in performance due to either gender or anxiety level. There was a significant negative correlation between TF score and time to complete operations, $r(58) = -.57$, $p < .0001$, and a significant positive correlation between TF score and the percentage of features that were used intuitively and correctly the first time, $r(58) = .45$, $p < .0001$. The relationship between time and technology familiarity is shown in Figure 9.5. These results are similar to those achieved during Experiments 1 and 2. A *t* test revealed that gender had no significant effect on time to complete operations, $t(59) = .72$, $p < .05$. Time to complete operations was also not significantly different for those who said they were anxious and those who did not, $t(59) = 1.594$, $p > .05$. An ANOVA showed that level of education also had no significant effect on time to complete tasks, $F(3,56) = 1.58$, $p > .05$ ($E^2 = .078$, power = .39), although this is a moderate effect with low power so it is possible that there was a Type II error in this case and the effect is masked by the low power. However, the assumptions are met and the comparisons between the interfaces can be seen as valid.

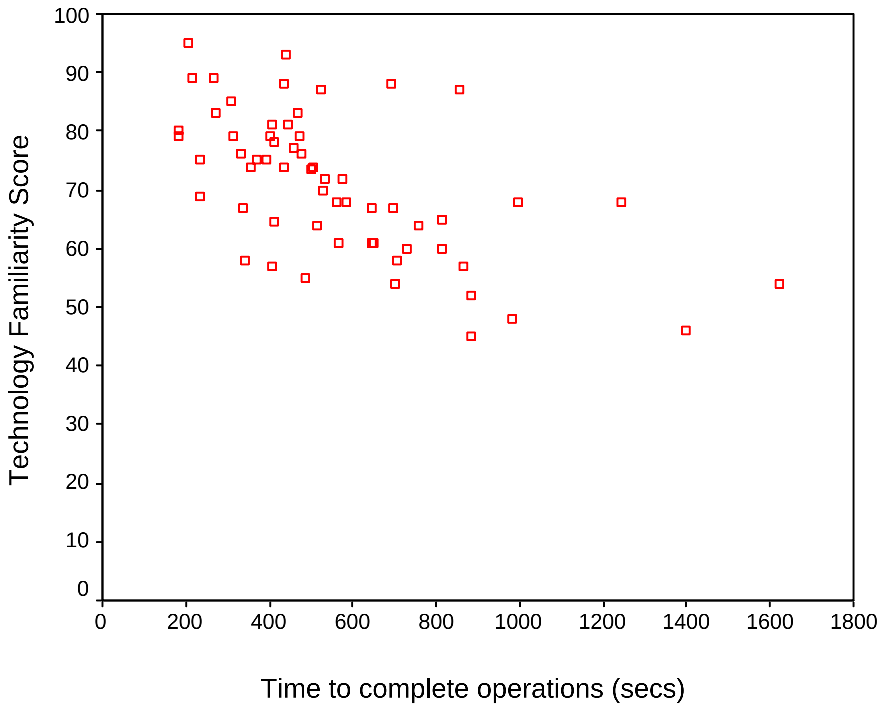


Figure 9.5 Time to complete tasks by TF score

The performance indicators were again time to complete operations, percentage of uses that were intuitive and percentage of first uses that were intuitive. The data on intuitive first uses are particularly important as they confirm that people are able to use a feature intuitively the first time they encounter it if it is something they can recognise.

Time to complete operations showed variation between the groups (Figure 9.6). A two-way ANOVA revealed that configuration had a significant main effect on time to complete tasks, $F(3,48) = 3.801$, $p < .016$. The Location–Appearance group was quickest, followed by Appearance, Location and then Default. A Tukey HSD post hoc test was used to explore the main effect (Table 9.5). Age group also had a significant main effect on time to complete tasks, $F(2,48) = 5.627$, $p < .006$. The significant difference between age groups indicates that age is a predictor of the time it will take to do the tasks (Table 9.6), with both the younger groups completing the operations significantly faster than the oldest one. There was no interaction between these factors, $F(6, 48) < 1$, n.s.

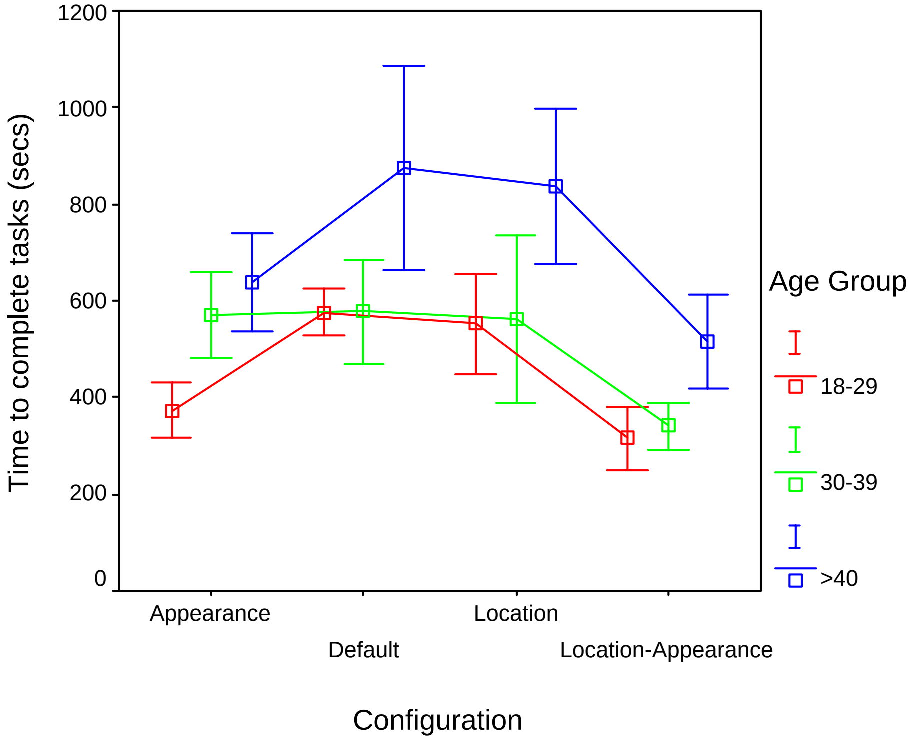


Figure 9.6 Time to complete tasks by configuration and age group

Table 9.5 Tukey HSD post hoc test showing differences in time to complete operations between configurations

Configuration	Configuration	Mean Difference	Standard Error	Significance
Appearance	Default	–148.81	94.85	.406
	Location	–121.72	94.85	.578
	Location-App.	137.04	94.85	.478
Default	Appearance	148.81	94.85	.406
	Location	27.09	94.85	.992
	Location-App.	285.85(*)	94.85	.021
Location	Appearance	121.72	94.85	.578
	Default	–27.09	94.85	.992
	Location-App.	258.76(*)	94.85	.043
Location-App	Appearance	–137.04	94.85	.478
	Default	–285.85(*)	94.85	.021
	Location	–258.76(*)	94.85	.043

* The mean difference is significant at the .05 level.

Table 9.6 Tukey HSD post hoc test showing differences in time to complete operations between age groups

Age group	Age group	Mean Difference	Standard Error	Significance
20s	30s	–58.36	82.14	.759
	40s	–262.4(*)	82.14	.007
30s	20s	58.36	82.14	.759
	40s	–204.04(*)	82.14	.043
40s	20s	262.4(*)	82.14	.007
	30s	204.04(*)	82.14	.043

* The mean difference is significant at the .05 level.

A two-way ANOVA revealed that the percentage of intuitive first uses (correct only) did not show any significant variance according to age group, $F(2,48) = 2.403$, $p > .05$ ($E^{2\,=}$ .09, power = .46). However, due to the lower power and moderate effect here, it is possible that the low power is masking an effect. The percentage of intuitive first uses (correct only) showed a significant main effect between the configurations, $F(3, 48)= 5.584$, $p < .002$. All the new designs had a higher percentage of intuitive (correct only) first uses than the Default, but the Location group had a mean closer to the Default group (lowest) and the Appearance group nearer to the Location–Appearance group (highest) (Figure 9.7).

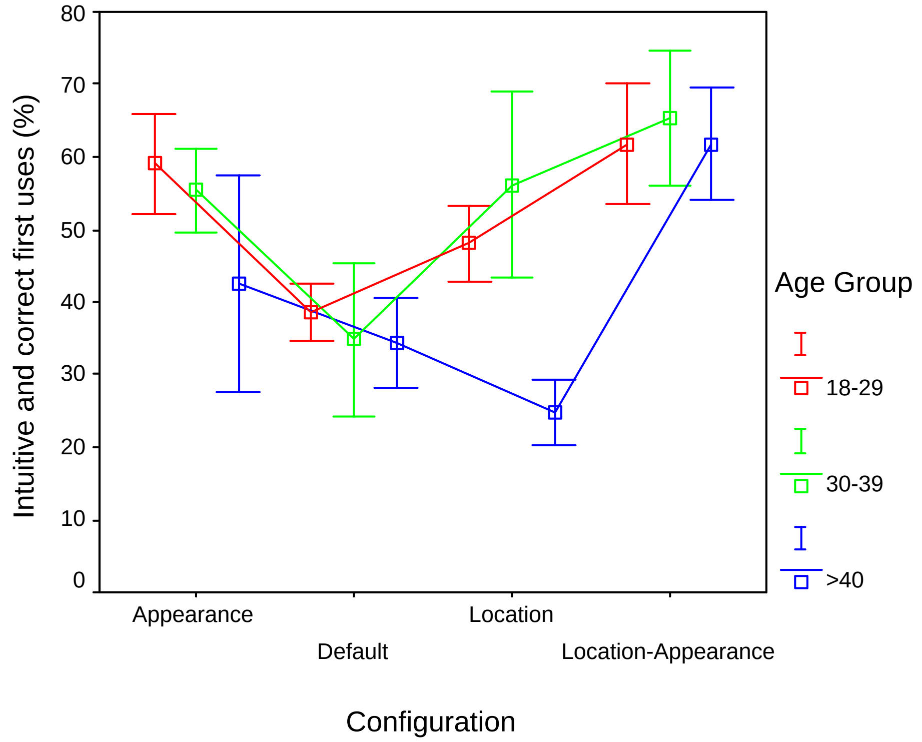


Figure 9.7 Percentage of intuitive first uses (correct only) by configuration and age group

Again a Tukey HSD post hoc test was used to explore the significant main effect (Table 9.7). Intuitive uses were significantly higher for the Location–Appearance group than the Location and Default groups.

Table 9.7 Tukey HSD post hoc test showing differences between configurations for the variable percentage of intuitive (correct only) first uses.

Configuration	Configuration	Mean Difference	Standard Error	Significance
Appearance	Default	16.43	7.04	.105
	Location	9.36	7.04	.549
	Location-App.	–10.7	7.04	.434
Default	Appearance	–16.43	7.04	.105
	Location	–7.07	7.04	.747
	Location-App.	–27.13(*)	7.04	.002
Location	Appearance	–9.36	7.04	.549
	Default	7.07	7.04	.747
	Location-App.	–20.06(*)	7.04	.032
Location-App.	Appearance	10.70	7.04	.434
	Default	27.13(*)	7.04	.002
	Location	20.06(*)	7.04	.032

* The mean difference is significant at the .05 level.

The percentage of intuitive first uses (correct and correct-but-inappropriate) showed similar results. Levene's test for homogeneity was significant, $F(11,48) = 2.608$, $p < .05$, so a strict alpha level of .025 was adopted, as before. Configuration had a significant effect on performance in this variable, $F(3, 48) = 6.896$, $p < .001$ (Figure 9.8). The significant difference was between the Location–Appearance group and both the Default ($p = .001$) and Location ($p = .008$) groups. Age group did not have a significant effect, $F(2,48) = 3.523$, $p = .037$ ($E^2 = .13$, power = .63), although the power is moderate and the effect large, so it is possible that adoption of the stringent alpha level with the low power has masked the effect.

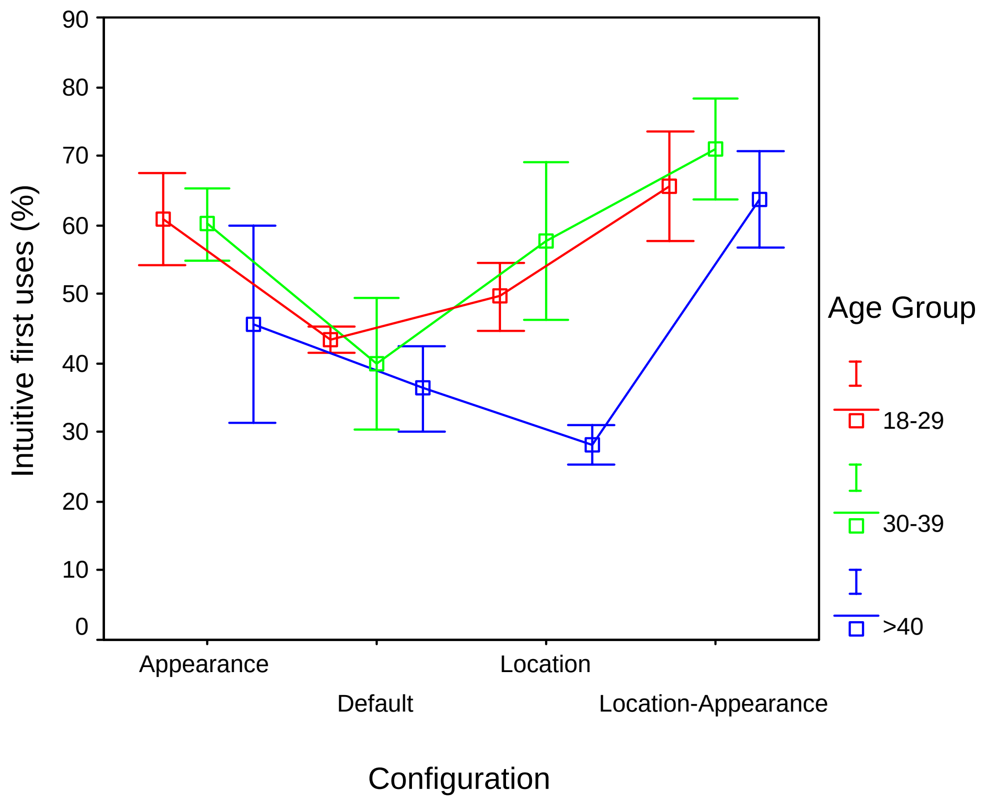


Figure 9.8 Percentage of intuitive first uses (correct and correct-but-inappropriate) by configuration and age group.

A two-way ANOVA revealed that the effect of configuration on the percentage of intuitive uses (correct only) throughout the operations was also significant, $F(3,48) = 4.66$, $p < .01$, with differences shown by the Tukey HSD post hoc test as between the Location–Appearance configuration and both Location ($p = .011$) and Default ($p = .012$). There was also a significant main affect between age groups, $F(2,48) = 4.45$, $p < .05$ (Figure 9.9). The significant difference here was between the >40 age group and both the 18–29 group (p = .035) and the 30–39 group (p = .031). There was no interaction between age group and configuration, $F(6,48) < 1$, n.s.

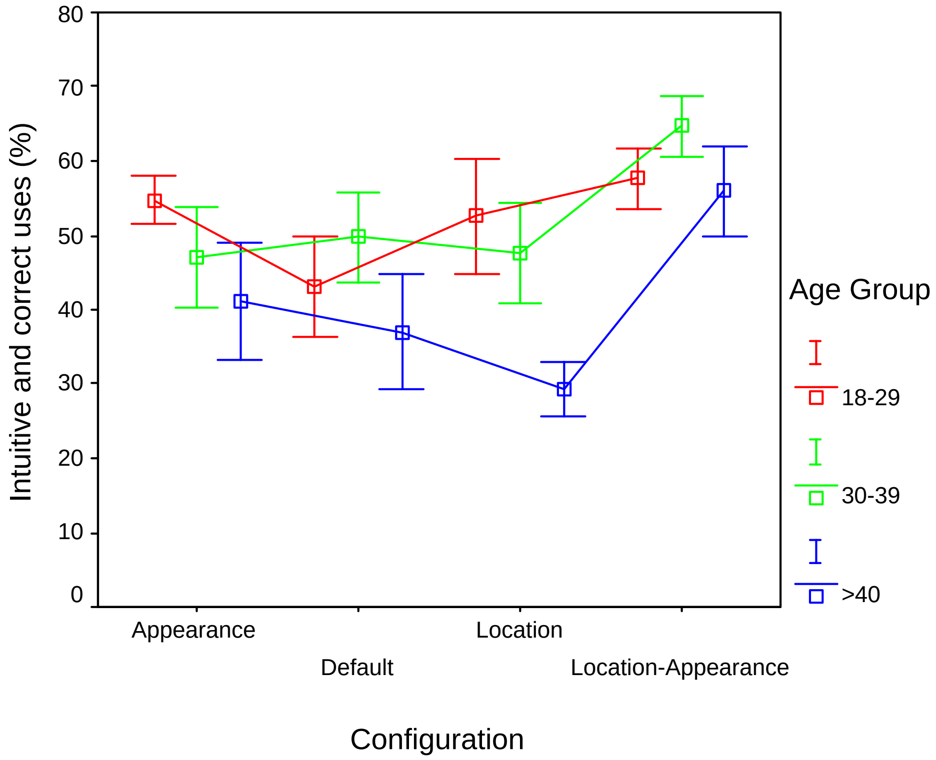


Figure 9.9 Percentage of intuitive uses (correct only) by configuration and age group

The percentage of intuitive uses (correct and correct-but-inappropriate) throughout operations showed a significant effect for configuration, $F(3,48) = 4.25$, $p < .01$, with the Tukey post hoc test revealing the significant differences between the Location–Appearance group and both the Location (p = .015) and Default (p = .02) groups. For age group, there was also a significant main effect, $F(2,48) = 5.34$, $p < .05$. The differences here were between the 30–39 and >40 age groups (p =.008) (Figure 9.10). Again there was no interaction between configuration and age groups, $F(6,48) = .502$, $p > .05$.

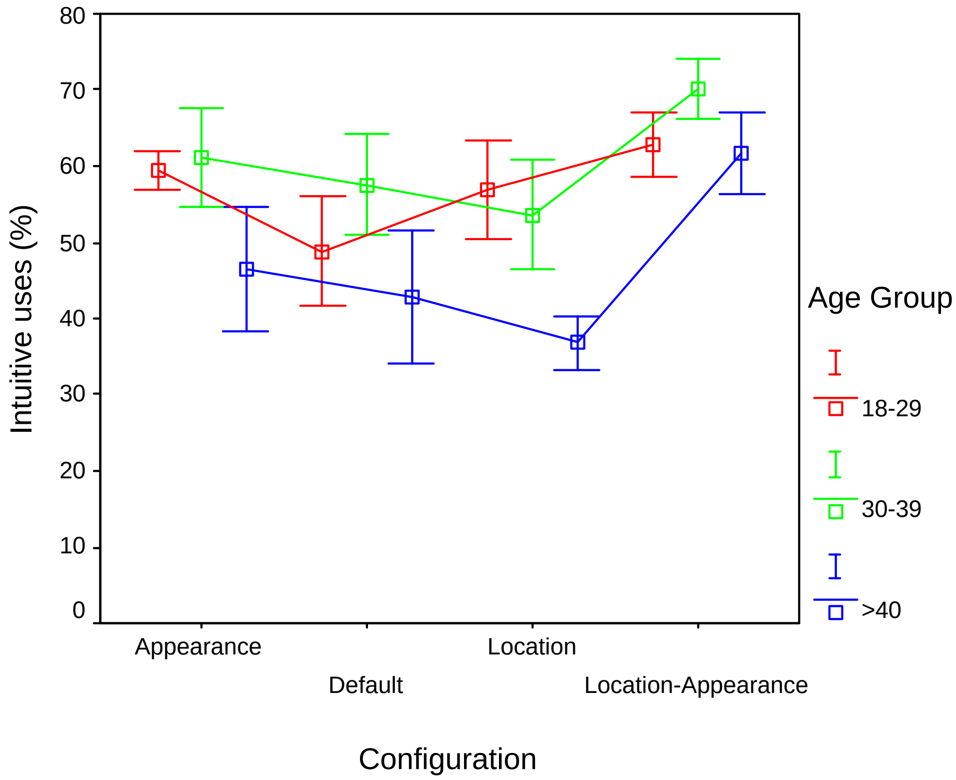


Figure 9.10 Percentage of intuitive uses (correct and correct-but-inappropriate) by configuration and age group

Time spent consulting a manual, the number of times participants received verbal assistance and the total number of times participants received help were analysed for differences between the configurations or age groups using two-way ANOVAs. Levene's test was significant in all cases, $F(11,47) = 17.68$, $p < .0001$, $F(11,47) = 4.38$, $p < .0001$ and $F(11,48) = 4.56$, $p < .0001$ respectively. None of the ANOVAs showed a significant p value less than .025, $F(11,47) = .55$, $p > .05$, $F(11,47) = 3.19$, $p > .025$ and $F(11,48) = 2.81$, $p > .05$ respectively for age group and $F(11,47) = 2.14$, $p > .05$, $F(11,47) = 1.97$, $p > .05$ and $F(11,48) = 1.82$, $p > .05$ respectively for configuration. Therefore, no significant differences exist between these variables and neither age group nor configuration had a significant effect on help received by participants.

The subjective ratings that participants gave during the interviews were compared between the age groups and configurations. Although there were higher mean scores for all familiarity and function ratings for the Appearance and Location–Appearance conditions than for the Default and Location conditions, two-way ANOVAs showed no significant differences. Results for familiarity were, $F(3,48) = 1.65$, $p > .05$ (E^2 = .09, power = .404) and for function, $F(3,48) = 2.67$, $p > .05$ (E^2 = .14, power = .616). However, in these cases at least moderate effect sizes were evident, and power was low to moderate. Thus it is possible that a Type II error occurred in these cases and the effect was masked by the low power. Subsequent research should test this possibility by employing an experiment design with greater power.

A two-way ANOVA revealed that there was a significant main effect for age group in the location ratings, $F(2,48) = 6.22$, $p < .005$. The 30–39 age group rated location significantly higher than the >40 group ($p = .003$). Although there was no significant main effect for configuration in the location rating, $F(3,48) = 2.54$, $p > .05$ (E^2 = .14, power = .59), the Tukey post hoc test revealed a difference between the Default and Location–Appearance groups that was very close to significance ($p = 0.54$). Because the power is low and the effect size moderate here, there is the possibility of a Type II error; an experiment with more power may reveal more.

However, the two-way ANOVA used to assess ratings for appearance really showed some differences. The Levene's test was significant, $F(11,48) = .3.185$, $p < .05$, so again a strict alpha level of $p < .025$ was applied. There was a significant main effect for configuration, $F(3,48) = 10.711$, $p < .0001$. Again, the Tukey test revealed that the differences were between the Appearance and the Default ($p = .001$) and Location ($p = .0001$) groups and also between the Location–Appearance group and the Default ($p = 008$) and Location ($p = .003$) groups. Also there was a significant main effect for age group, $F(2,48) = 5.310$, $p < .025$, and the Tukey post hoc tests showed that both the 18–29 group ($p = .012$) and the 30–39 ($p = .030$) groups were significantly different from the >40 group.

There were also variations in intuitive uses between each feature (Table 9.8). The Location–Appearance design performed the best for the greatest number of features, followed by Appearance, Location and lastly Default. All the new designs showed more intuitive first uses than the default for most of the features. The results for the focus features identified in Chapter 8 are discussed below.

Table 9.8 Percentages of intuitive uses per feature for each group

Feature	Appearance	Default	Location	Location–Appearance
Play	93.33	66.66	86.66	100
Stop	46.66	53.33	46.66	60
Forward/rewind	66.66	71.42	80.00	81.81
4-way	73.33	40.00	53.33	80
VCR on/off	27.27	76.92	78.57	77.77
Enter	66.66	40.00	66.66	66.66
Menu	66.66	26.66	33.33	60
TV on/off	30.76	35.71	33.33	81.81
AV function	15.38	14.28	21.42	20
Remote on	71.42	6.66	0	66.66
Back/ahead	20	0	8.33	16.66
Skip/index	60	0	0	83.33
Scroll arrows	0	0	10	16.66

The back/ahead feature still needs improving but the new design performed much better than the Default design. There were 20 times more intuitive uses for Appearance than for Default, and most people did work it out in the Appearance and Location–Appearance conditions. In the Location and Default conditions many participants tried the back/ahead function, did not understand what it did and did not use it again unless they grew desperate. Generally, participants in the Location and Default conditions were more likely to find and use the home button for navigation than the back/ahead ones.

Back/ahead could have been more clearly designed, but due to some concern about multi-modal use for more advanced features of the remote it was decided not to label the hard buttons with arrows as had originally been planned, but only to try to relate them more clearly to the soft labels. However, the soft label could be changed in only a very limited way, and could not be enlarged at all (as was intended after Experiment 2), so it was not possible to make them much clearer than previously. Although this did improve performance, for the purposes of the experiment (which did not really use the advanced features), arrows on the hard keys could have been used and would very likely have shown a more marked improvement over the default design.

The icon for the AV function was put on both VCR and TV main pages to prevent people (especially novices) from getting lost looking for it; it was re-named “TV/video”, which is a more common label on existing remotes. This seemed to cause much less confusion and, although there were no real differences in intuitive uses between the groups, default still had the lowest percentage. The new design may have contributed to overall faster times as people needed to navigate less. Interestingly, some more expert users still navigated from the VCR panel to the TV panel to find the button, even though they could have accessed it from the VCR panel. The double placement made more difference for those lower TF users who did not really know where to expect it, and who were also more likely to become lost in the navigation process. In consequence, this feature may have contributed to overall faster times in the Location–Appearance condition and, to some extent, the Location condition.

Skip/index was used much more in the Appearance and Location–Appearance conditions, and there were large increases in intuitive uses for Appearance and Location–Appearance designs. The “skip” terminology used in the default design was more similar to CD and DVD players, but people seemed unable to transfer that knowledge to VCRs. However, “index” was associated with VCRs, and those who used it generally had a good idea of what it would do. It was also less likely to become confused with the stop function, which happened with the default device once or twice, and also in Experiment 2. The buttons are also much clearer and the label is next to the button rather than on it, so it is obvious which part to press and what each one does. In the default design people often pressed the centre “button”, which had a label on it, but was not actually a button at all, and ignored the directional buttons.

The Remote-on feature was much clearer in the Appearance and Location–Appearance designs. This made a big difference in intuitive uses and, although it saved only a few seconds at the start, it also had a knock-on effect. People who used back/ahead to turn on (they were the largest physical buttons on the remote, so the most popular choice for the majority of users who did not know the remote had a touch screen) often consequently moved to a page that was not the homepage right at the start, which confused them. They then wasted time getting started and more time navigating during the rest of the experiment, with many never subsequently understanding the navigation hierarchy. The clear labelling in the new design prevented this.

Four-way showed a fairly small improvement in intuitive uses but, based on qualitative data from observation, the new design seemed to make it much easier to use and caused less confusion between 4-way arrows and the +/– labels on volume and channel controls. This confusion had been observed during Experiment 2 and was observed again with the default condition. People tried to use the volume and channel buttons to navigate the on-screen menu as the arrows were not obvious, so they looked for some other way of moving the cursor around the screen. The new design reduced the incidence of this problem and so saved time.

Menu was spotted quickly more often in the new design. The impression from Experiment 2 was that the location was the biggest problem. Location showed some improvements in intuitive uses, but appearance again made the real difference. The larger, clearer button which pointed to “VCR menu” rather just “menu” (and therefore possibly the homepage or another page or menu within the remote) was spotted more quickly when participants were searching for access to the clock-set function and pressed more readily, with less hesitation.

9.3.3 Discussion

All the groups using the new designs performed better than the default group. The participants in the Location–Appearance group were quickest at doing the tasks and achieved significantly higher levels of intuitive uses than the default group. The participants in the Appearance condition were not far behind the Location–Appearance group in terms of time and intuitive uses. Participants in the Location group were the slowest of those using the new designs and had less intuitive uses. These results suggest that the change in appearance of the features had more effect upon these performance measures than the change in location. The significant differences in the subjective ratings for appearance also suggest that appearance was the important factor in expectedness, as the groups with the new Appearance and Location-Appearance designs rated appearance as being more expected than those with the new Location or Default design. Also, younger people found the appearance of the features to be more as they expected. This could be because the appearance was based on contemporary features from similar products, and younger people may have had more experience with contemporary products, whereas older people may be more used to older styles (for example, several mentioned during the interviews that they would have preferred the use of words over symbols).

However, location should not be neglected altogether, as there was some qualitative evidence (through observation) that the correct location could help to decrease search times for individual features. Appearance may have had more effect as it helped to prevent confusion and time wasting on searching for and using the wrong features, which saved more time than just a faster response to a single feature. However, once a person knows what s/he is looking for, putting that feature in a familiar location has been shown to decrease response times (Pearson and van Schaik, 2003; Proctor et al., 1995; Wickens, 1992).

Some of the locations chosen may have been less than ideal. For example, “Enter” was re-located to the bottom right of the screen as it is on a keyboard (as recommended by Wheildon, 1984), but many people expected it to be in the centre of the 4-way, as it is on some digital cameras, remotes and other devices, including the default design. This suggests that people were expecting to see the small device standard and not the computer standard, so transfer between similar products may be easier than transfer between more dissimilar ones. In addition, people may use tactile cues rather than visual ones to locate functions, especially for products such as remote controls or car stereos. The product used for the experiment was a touch-screen device, so did not allow for this possibility.

Notwithstanding, it does appear that the most important factor in the new designs was appearance. Making the appearance familiar seems to be a more successful strategy than making the location familiar. It seems that people can find something familiar in an unexpected place but cannot recognise something unfamiliar even if it is in a familiar place. Generally, research findings show no relationship between users’ subjective ratings of a product and their objectively measured performance in using it. In most cases performance is as important (if not more) than satisfaction (Allen and

Buie, 2002). Perhaps it is not surprising then that most of the subjective ratings do not show the sort of significant differences that are so clear from the observational data. However, the subjective results that are significant back up the empirical evidence that appearance is the most important factor of a feature in terms of making it intuitive to use.

Age had a weaker effect than configuration on intuitive uses, but overall the results seem to suggest that there is an effect, with older people completing tasks more slowly and with a lower percentage of intuitive uses. This relationship may be worth exploring in more depth as older people are becoming the major market in many Western nations.

The new design (Location–Appearance) is not perfect and the experiment has revealed flaws in it. For the sake of the experiment, the back/ahead feature should have had standard browser arrows stuck onto the hard buttons (notwithstanding the multi-functionality of these buttons). The location of the Enter key also could have been kept in the centre of the 4-way, as is standard on many small devices such as cameras, remotes, and phones. However, iteration is inevitable in design (Preece et al., 2002), and in practice several iterations would be tested before the design was finalised. As a test of a first iteration designed to uncover the factors behind intuitive use, the experiment was a success.

9.4 Summary

This chapter has covered the re-design process and method used to incorporate intuitive use into interface design. The interfaces were designed according to principles developed from the previous research. Users were video-recorded doing set tasks with one of the four remote control interfaces. The video data were later analysed using Noldus Observer.

All of the new interfaces were found to be quicker and more intuitive to use than the default interface provided by the manufacturers. The evidence certainly suggests that the work done to make the appearance and location of the features more familiar made the products easier and quicker to use. These findings support those of Experiments 1 and 2, and suggest that relevant past experience is transferable between products (and probably also between contexts), and performance is affected by a person's level of familiarity with similar technologies. Using familiar labels and icons and possibly positions for buttons helps people to use a product quickly and intuitively the first time they encounter it. Appearance (shape, size and labelling of buttons) seems to be the variable that most affects time on task and intuitive uses.

The fact that the Location group was quicker and had more intuitive first uses than the Default group, and the Location–Appearance group was quicker and had more intuitive first uses than the Appearance group suggests that location of features does have some effect, but appearance of features is far more significant. Age is also a factor that affects an individual's performance with a new product, as was suggested by the Experiment 2 results and borne out by more rigorous testing in Experiment 3.

By applying the principles of intuitive interaction, it was possible to increase intuitive uses of the product. Chapter 10 discusses the implications of these findings on a wider scale and provides extended principles and recommendations for designers on applying intuitive interaction to products.

Chapter 10

Discussion and Conclusions

10.0 Introduction

This chapter discusses the implications of the results presented in Chapters 7 to 9 and how they interconnect with the theories discussed in Chapters 1 to 5. This is followed by the outcomes and recommendations, including a set of principles (extended from those applied to the re-design process) and a conceptual tool that will allow designers to apply intuitive interaction during the design process in order to produce better interfaces. Final conclusions are then presented, and contributions to knowledge and future directions are reviewed.

10.1 Discussion

The main findings from the research were that familiarity with similar features allowed people to use features more quickly and intuitively than they used those with which they were unfamiliar. The technology familiarity (TF) scale worked to reflect the level of familiarity with similar features that participants were likely to have. Age also had an effect on how quickly and how intuitively participants could complete tasks. Finally, the appearance of a feature had more effect than its location on how intuitively it was used. Reflecting these results, this discussion falls into three main categories: intuition, intuitive use and prior experience; intuitive use and function, appearance and location; intuitive use and age.

10.1.1 Intuition, Intuitive Use and Prior Experience

The literature revealed that intuition is based on experiential knowledge, and people can use intuitive processing only if they have had previous experience on which they can draw. Intuition is generally non-conscious and so is not verbalisable or recallable, so people using intuitive processing are often unable to explain how they made a decision. Because it is efficient, intuition is also generally faster than conscious forms of cognitive processing. However, researchers agree that while it is often correct, it is not infallible.

The experiments conducted for this research have supported these views. Intuition was found to be facilitated through past experience, and participants who had relevant past experience with particular features used those features intuitively. Intuition was also found to be faster than conscious reasoning and often correct, but not infallible. The fact that intuition is non-conscious was successfully used, along with other properties such as prior experience, speed, correctness and expectedness, to separate intuitive processing from other types of cognitive processing during the coding process.

In support of the arguments of many authors who claim that intuition and intuitive interaction are based on past experience, all the experiments showed that familiarity with a feature will allow a person to use it more quickly and intuitively. This is the foundational conclusion to come from this research and informs the principles and tools which have been developed for designing for intuitive interaction. Although other authors have developed related theory, and some have touched on the issue of intuitive use, none have empirically tested the nature of intuitive interaction or linked intuitive interaction to the existing theoretical knowledge base as has been done here. Some issues that have implications for intuitive interaction based on past experience need to be discussed in more depth. These are establishing familiarity for various user groups, managing change, categories, mental models and anxiety.

Establishing familiarity for various user groups

Using familiar features is the central tenet of the recommendations (Section 10.2). However, "…making design decisions about familiarity is not always simple" (Rosson and Carroll, 2002, p121). Familiar terms can have multiple meanings. Also, familiarity to one user is not familiarity to others. Even translation may not achieve the same level of familiarity in another language. In order to design a product to facilitate intuitive interaction, designers need to carefully identify the target market for the products and establish what features target users would be familiar with. Metaphors should be selected for their appropriateness to the target market and should be matched to the experiences and capabilities of typical users (Smith, 1998). Many designers believe icons have more universal familiarity than labels as all users live in the same visual world, but even then items can look different. For example, mailbox icons commonly used for email are based on US rural mailbox designs which are not seen in Europe. It takes some careful research to make sure the familiar features chosen are going to be understood by all users. A localisation process may also be necessary for products released internationally.

Spool (2005) favours field studies for identifying the user's current knowledge. Watching potential users in their own environment and working with their normal tools and tasks reveals their knowledge and the upper bounds of it. For identifying target knowledge he recommends usability testing. After a test it is possible to list all the knowledge the user needed to acquire during the test. Spool found during his user testing that groups of users form clusters around the various current knowledge points. This could lead to a way of better defining target users and what they know, but he does not explain exactly how it is done. He does say that design teams can work with users in the middle of the important clusters and this helps them to define personas. Personas were often linked to lifestyle in the past, but here is real and useful link to prior experience that could be used to allow intuitive interaction.

Margolin (1997) also discusses how designers can gain more knowledge about users. He suggests that designers gain such knowledge from their own experiences as users, from communities or subcultures of users (e.g. Internet forums or clubs), and from market research. However, none of these are really enough as they stand at present, and designers do not currently have enough information about people and products to create products that better represent the desire for a satisfying world (Margolin, 1997). Designers do not have enough information to go on when developing new products, and Margolin sees a need for large scale research on the subject of product use.

Preece et al. (2002) argue that it is imperative that representative users from the real target group be consulted, and recommend that designers start with an understanding of how people use similar products, even if the product they are designing has no exact equivalents. When introducing a new product type (their example is the introduction of the mobile phone), it may not be possible to study people using them; but there are predecessor products (e.g. standard phones) that can help to inform designers about users' behaviour with similar products. Preece at al. (2002) mention the need to find out about the tasks users currently perform, their associated goals and the context in which they are performed. They recommend a combination of naturalistic observations of users' existing tasks, questionnaires, interviews, focus groups, user participatory design workshops and studying documentation in order to find out about users' behaviour with similar products and their aspirations for the new one. Of these, observation seems to be the method they most favour; this, they say, gives insights that other techniques cannot, and they emphasise that the day-to-day use of products will differ from the procedures set out in the documentation.

Legacy systems have some advantages here as they may provide some features to draw on. For new-generation product design, it is helpful to understand the typical tasks performed with several of the antecedent products (Smith, 1998). There may be more than one of these if a new device merges tasks previously done with different products. Rohlfs (1998) describes re-design of legacy software applications. He used current and new users' experience with an existing application (or similar products and/or applications) and also their familiarity with the task to be performed, to inform a new design. He converted this sort of information into a current task definition which described how users currently perform the tasks. Understanding how the tasks are currently performed provides an important foundation for the design process. It allows designers to maintain the aspects of current tasks that work well, and to identify which features are well-used and would be suitable to transfer to new interfaces.

It can be an advantage to keep an interface for a new generation product unstructured, because new generation products are often put to completely different uses than those originally envisaged, and an excessively structured interface will limit these new uses (Smith, 1998). This is another advantage of a features approach over a mental models one as designers can use familiar features rather than looking at the whole structure. Some researchers also suggest that metaphors which relate to surface features are the most successful (Bowden, 1997; Klein, 1998; Kolodner, 1993).

There is certainly an opportunity for further research to establish which user groups have familiarity with which types of features. Whatever tools are used, it is clear that establishing the knowledge that users already have is an important step in selecting familiar features to design into a product.

Redundancy is also essential in ensuring that a design is as inclusive as possible. Presenting the same feature in different ways is the classic approach to ensuring that diverse groups can access that feature. Therefore, in addition to identifying a target market and establishing what the users will be familiar with, it is essential that designers use redundant cues to make sure all users in the group are included. This could include using both symbols and words, both visual and auditory cues, or providing two or more different ways of accomplishing a task within a system. Redundancy allows for more inclusiveness and gives users more choice about the way they do things.

Managing change

Technology has the capacity to change the way that tasks are accomplished. Thus, as well as designing for users' existing stereotypes and expectations, designers may have to think about whether these should and/or will change in future and, if so, how these changes should be brought about (Harker and Eason, 1984). Marakas, Johnson and Palmer (2000) state that, while the use of metaphor does provide a starting point for developing an understanding, at some point the descriptive metaphor must be replaced with direct reference to the object itself.

Some people have been concerned that always using familiar features and structures would lead to a loss of originality in interface design (Discuss-interactiondesigners.com, 2004). Raskin (1994) argues that intuitive interfaces could reduce innovation as an intuitive interface cannot be completely new, so intuitiveness could be a negative property for an interface. Hutchins, Hollan and Norman (1986) also raise the issue of restricting innovation by using familiar things in a design. However, there are innovative ways in which users' current knowledge can be applied or transferred. For example, Beltzner (2004) suggests that it is best to design primary interaction paths for beginners, and then add secondary (accelerator) interaction paths that speed up someone's interaction with the product once they become a more advanced user. This allows users with more familiarity with the system to use it more efficiently.

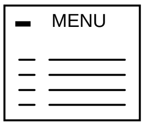
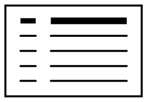
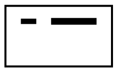
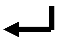
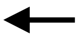
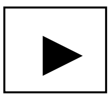
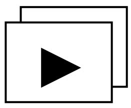
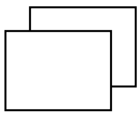
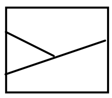
Also, applying existing icons does not mean that a new product cannot be innovative. It may perform new tasks never before envisaged, but in order to make the new tasks easy to understand it would be preferable to transfer some existing feature(s) or metaphors that users can readily identify and use. Features or icons themselves do not make a whole product; the way an object looks, feels and/or functions can still be innovative. Transferring single features rather than having to apply whole mental models allows for more flexibility and more innovative interfaces. In addition, outside of the software realm there are many new devices appearing, many of which are borrowing features and functions from other things (often software). Transferring features from other product types and experiences (which is often necessary with a new product type), and using metaphors, can allow both innovative and intuitive interfaces.

However, when a familiar feature has become outdated and there is valid reason to change it, it is possible to gradually develop people's understanding through incremental changes and the use of metaphor to explain the unfamiliar. This needs to be well managed, or users could be encumbered with inferior and out of date metaphors for years to come, or have new and unfamiliar features, icons or ideas foisted upon them too quickly. Metaphors are catalysts for change; the metaphors of one generation become the well-accepted expressions of the next (Marakas et al., 2000). Some linguistic metaphors have become part of the language and the original vehicles for those metaphors are largely lost (e.g. ring the changes, grist for the mill, keyboard). In many cases this does not matter, but for an interface there may be some instances where it would become counterintuitive. A feature which is familiar because it has been used in the past for the same function may become counterintuitive if a new technology means that the feature no longer conforms to compatibility and mapping principles.

For example, the "desktop" metaphor was very successful in moving desk workers onto GUIs, but is less applicable to younger computer users today who have never used a desk without a computer, and some interaction designers find it very limiting

(Discuss-interactiondesigners.com, 2004). Even the "play" icon and fast-forward and rewind icons which demonstrate some sort of directionality in the way a medium will move are becoming less applicable to new media. Technology may evolve that makes them problematic because of the directionality they show. These ideas have been explored through design to show intuitive evolution of icons (Table 10.1).

Table 10.1 Intuitive evolution of icons

Feature	Current	1st Evolution	2nd Evolution	3rd Evolution
Menu	MENU	MENU 	 	M 
OK/ Confirm/ Enter	OK CONFIRM ENTER	 OK 	 	
Back/ Cancel/ Delete	BACK CANCEL DELETE	 BACK		
Review/ Playback		 	 	
Picture mode				

This work has been produced to demonstrate how some of the common interface commands used in the products investigated (digital camera and universal remote control) can be evolved to allow for more suitable metaphors (Blackler, Popovic, and Mahar, 2005). This has been done in several steps to allow familiarity at each incarnation.

The menu feature has been shown with both an alphanumeric and alternative pictorial stream, leading from the familiar word currently used, through incarnations including the word, and finally to a simple letter or icon based on the previous designs. The feature OK/enter/confirm could progress using the familiar Enter symbol or tick, the tick particularly lending itself to use with touch-screen, stylus and gestural interfaces. Back/cancel can be simplified to the familiar arrow of the internet browser simply by first using the icon and label together, and then removing the label. Review or playback of pictures, based currently on the directionality of obsolete media, may make more sense in the future without the directional arrow. Two possibilities for this progression are shown for digital cameras. The tree symbol was used as it is already a standardised icon for the zoom function of cameras (Crist and Aurelio, 1990). Finally, picture mode on digital cameras is currently still based on the shape of cameras from fifty years ago, which is becoming less familiar and more arbitrary as the years pass. The new icon is similar and familiar enough to allow easy transfer, and it looks more like a digital camera than a traditional 35 mm film camera.

These types of issues have been successfully addressed in the design of new products such as phone cameras and digital cameras. Digital cameras for the first few years retained the form of traditional cameras, even where there was no need for this. Now that users have embraced the concept of digital photography and understand that the digital camera need not look like a traditional camera, new forms are starting to be explored. The first phone cameras required the user to interact with a camera buried within a phone interface that looked like a phone. Fairly quickly these evolved to present the two-fold function more effectively, with one side of the product taking the traditional form of the phone and the other of the digital camera, often rotating to resemble a phone when in portrait position and a camera when in landscape. Some even have a separate shutter button so that the camera operates more like a digital camera and less like a function within a phone.

This work demonstrates that change can be managed by allowing users to apply some knowledge they already have to each new feature, while all the time progressing towards a new design or metaphor for that feature. Although location has less effect on intuitive use than appearance, where it is necessary to change the appearance of an icon, keeping the location consistent with previous or familiar interfaces may allow users to easily adapt to a new icon. Managing change in this way should help to retain intuitiveness of an interface while simultaneously moving users towards a better or more appropriate icon or metaphor.

Categories

The prototype theory of categorisation holds that people employ categories all the time in basic thought, speech and action, and perception. Lakoff (1987) claims that people could not function physically, socially or intellectually without the ability to categorise. He claims that categorisation is a matter of both human experience and imagination. Storing information in categories could be detrimental to transferring knowledge to something new if the new thing is stored in a category different from that of the relevant previous knowledge. For example, in Experiment 3 many people expected the Enter feature to be in the centre of the 4-way as it is on some digital cameras, remotes and other devices, including the default design. It was actually relocated to the bottom right during the re-design, as it would be on a computer keyboard, and as recommended by Whielden (1984). This suggests that people were expecting to see the small device standard and not the computer standard, so transfer between similar products may be easier than transfer between more dissimilar ones.

It is possible that the boundaries of a category blur when a person knows something well and allow him/her to transfer between contexts more easily. Categorisation could be what people do when they are learning something (as Lakoff (1987) emphasises), and when things are already well known, knowledge could become more generally available. Alternatively, when people do not immediately make a connection with something in the same category, they may start to look outside of that category.

Applying connectionist theory (Section 2.2.2) it can be supposed that if more links to a concept exist, then that concept can pass more easily over category boundaries. Links are made by using knowledge and applying it to other things. Therefore, the more well known or familiar something is, the more easily or quickly it should be recognised, understood or used. Connectionism could help to overcome the limitations of categorisation by allowing people to make links between categories. However, the links within categories are presumably always going to be the strongest and most often used. Therefore, using familiar features from the same product types may always be more successful than using features from less strongly related products or experiences. This conclusion is reflected in the conceptual tool described later in this chapter.

Mental models

It was obvious when observing users with lower technology familiarity that they were not building a mental model of the product; they seemed to be unable to learn the structure of the device through using it. However, it appeared that more experienced (higher TF) users were learning the structure of the device through use. Because not all users were able to successfully construct a model, applying a mental models approach or trying to find a mental model that will suit all or even most users does not seem to be suitable. Other authors concur, saying that constructing models for general purpose systems and differing users can be very difficult, and the perfect model does not exist (Fischer, 1991). Models are messy and indistinct (Norman, 1983) and the sheer number of different models a user would need to create over a lifetime, if s/he needed one for each product or system, is daunting (Wickens et al., 1998). In addition, systems that allow the user to decide how to use them are better (and more flexible) than mental model-based systems which try to anticipate what the user wants to do (Richards and Compton, 1998).

If using a mental model approach, it is necessary to establish a reliable way to predict what a mental model might be and how to trigger it. It is very difficult to assess if a person or group of people share a whole model or not (Marchionini (1995) claims that each individual user possesses unique mental models), which would make it difficult to apply them successfully to systems or product design. Some of the authors cited in Chapters 2 to 5 used a mental models approach to applying intuitive use to software, which is not a successful or appropriate approach in all situations, and those who assumed a mental model for the users (e.g. Okoye, 1998) do not convincingly argue that a model can be correctly assumed.

Although Johnson-Laird (1981) proposed that mental models are likely to underlie the perception of objects by providing prototypical information about them – which suggests that models are built from past experience – it would seem unlikely that with the thousands of products people use they should have a separate model for each one. It is more likely that they have a series of overlapping models or that there are familiar features used across many products. The connectionist theory supports this argument; Clark (1997) suggests that a connectionist brain could use methods of overlapping storage so each neuron plays a role in encoding many different things. For this reason, it is the features that the intuitive interaction principles and tools proposed in this thesis depend upon. It is also likely that it would be easier for designers to apply familiar features than to try to apply a whole model.

From the results obtained in this research, it can be suggested that although mental models may have some part to play in intuitive use in some cases, trying to apply them to interface design is too complex. It is likely that intuitive interaction can be designed for, without having to try to apply one specific mental model to a device.

Anxiety

Making an interface intuitive may help users to be less anxious when they encounter it. Several researchers suggest that intuition is linked with low stress and arousal (Hammond, 1993; Laughlin, 1997; Simonton, 1980), so encouraging this type of interaction may make encountering a new product a less stressful experience, especially for users who are nervous of change and are slower to adopt new technologies. Some participants in the experiments commented that they were anxious at first, but when they realised the product features were familiar to them they relaxed more. Using familiar features to make a new product or product type familiar may help new users to feel more comfortable and less anxious than might otherwise be the case, as well as allowing them to use the product more quickly and intuitively.

10.1.2 Intuitive Use and Function, Appearance and Location

The three factors function, appearance and location were investigated in all three experiments through subjective feedback from participants. It was found that this was not offering adequate and definite data for the more complex product (remote control), so Experiment 3 was designed to investigate the factors more empirically. Experiment 3 (Chapter 9) demonstrated that intuitive use is enabled more by the appearance of features than by their location. Making the appearance of features such as buttons and icons familiar by using familiar symbols and icons, accepted conventions for labelling and naming, and also by sizing buttons as users might expect, will allow people to use an interface intuitively. This has implications for the design of interfaces as it seems more important to concentrate on getting the appearance right, rather than the location. Appearance is also more multi-faceted – comprising shape, size, colour and labelling – whereas location comprises only location within local components and (for complex products) global systems. Since appearance is more complex as well as more important for intuitive interaction, it is justified as a priority over location.

In the case of the remote control, appearance was in most cases based on a standard and many other audiovisual (AV) products use similar icons. Reasonable consistency in the appearance of these features between various remotes and other audiovisual devices has allowed users to have more exposure to, and therefore more familiarity with, the appearance than the location. Location, on the other hand, has not been standardised on these types of products, or between product types, and location of features on remote controls is generally different from location of the same features on the corresponding products. Location is more difficult to standardise between disparate product types because of the many different potential forms and functions of products (although in theory it should be possible to standardise it to some extent within types, such as remote controls). This means that audiovisual symbols would have more standardised appearances than standardised locations. It is hypothesised that this is the case with many product types, and that appearance is generally more standardised than location, so appearance will likely remain the most important factor in intuitive interaction.

However, location should not be neglected altogether as there was some qualitative evidence (through observation) that the correct location could help to decrease search times for individual features. Once a person knows what s/he is looking for, putting that feature in a familiar location has been shown to increase response times (Pearson and van Schaik, 2003). Appearance may have had more effect as it helped to prevent confusion and time wasting on searching for and using the wrong features, which saved more time than just a faster response to a single feature.

More standardisation of location on products (similar to the standardisation of location of various key features of software) may make location more important and products more intuitive to use. Some products do have standard positions for some functions; for example, mobile phone power buttons are almost exclusively located on the top face or the very top of the front face, which makes them easy to find. More features located consistently in this way would allow location to play a more important role in intuitive interaction.

One of the limitations of this research was that it was not possible to test the function of the various features for intuitive interaction because the mediating products already had functions assigned to the features. However, it could be assumed that function is the most important of the three factors as, without being familiar with the function of a feature, users would not have any idea what to do with it. Therefore, it can be recommended that functions required on a product and the way in which those functions work need to be based on familiar processes that users have seen before. Further work is needed to confirm these assumptions with a more flexible product mediator, or even with software. Meanwhile, the three factors have been applied to a conceptual tool which designers can use to make interfaces more intuitive (Section 10.2.3).

10.1.3 Intuitive Use and Age

Well known factors of aging such as speed of reaction times and cognitive processing could be responsible for the slower times of older people. However, it does seem that a relationship, although not so strong as the technology familiarity relationship, exists between age and intuitive uses. Therefore it seems likely that there are other factors as well as symptoms of aging playing a part. There does seem to be some difference in the way that people of different ages can utilise their prior experience to intuitively use a new product. This could come about because an older person who may be familiar with the same technology as a younger one and have the same TF score has learned about that technology at a later stage in life and therefore it has been harder to learn, or they have known about it for a proportionally shorter time.

Weiss (2002) states that “teenagers are likely to pick up new technology quickly … Older people are also less adaptable to new interaction mechanisms” (p74). He does not explain why, but one possible explanation is that children and teenagers are at the right age to learn new things and their brains are more receptive to laying down this information. Older adults may still have their mental models based around the interaction techniques they learned in their youth, which are now obsolete, and it is known that older people need to make more effort in order to learn new things (Howard and Howard, 1997). The decision to use standardised symbols and contemporary products as comparisons may have excluded older users from some of the benefits of the re-design. In Experiment 2 some of them showed better performance with words than with symbols, so increasing redundancy by providing both words and symbols could be helpful for older people who are less familiar with contemporary symbols.

Damasio (1994) hypothesises that the critical and formative set of somatic markers that respond to certain stimuli is formed in childhood and adolescence. Accrual of somatically marked stimuli continues throughout life, but the formative ones are there from early on. This may suggest that the things people can use the most intuitively are those that follow somatic markers established in their youth. Those formative markers may be the ones that people refer back to throughout life. In a primitive lifestyle this would make age an advantage; an older person would have more experience to compensate for loss of strength and other factors of aging. However, now that the environment with which people interact has started to change so much during each lifetime, people need to continually keep making new somatic markers and new links to experiences to replace the formative ones. This could be one factor that affects the performance of older people as compared to younger ones who are still able to use their formative markers. According to connectionist theories, the connections required for these long held markers are reinforced by constant use and so would be very strongly preferred.

Mescellany (2002) claims that younger people (particularly children and teenagers) are simply more motivated than older people to use new technologies, especially those that allow them to communicate with their friends. Norman (2002) agrees, putting forward three possible reasons for the differences. Firstly, adults are more hesitant and afraid they might break something, whereas children experiment much more, and therefore learn more. Secondly, children spend more time at it. Most adults give up after a short time because they are less motivated. This is essentially the same argument as that put forward by Mescellany. Also, Norman claims that children are not yet “burned out”. Many of the things they use are new to them, so are a novelty.

However, the results obtained here show people in their twenties and thirties achieving significantly faster times and more intuitive uses than people over forty. People in their twenties and thirties are unlikely to be behaving in the way children do in their approach to new technology. Therefore, while some of their ideas are no doubt valid, it does seem that there is more to this issue than Norman and Mescellany suggest. Further work focussed more specifically on intuitive interaction and aging is needed to determine the exact cause of these differences.

10.2 Outcomes and Recommendations

This section offers ideas about how intuitive interaction can be applied within the design process. The recommendations are based around the principles and conceptual tool that have been developed.

10.2.1 The Principles

The following principles have been extended from the preliminary principles used as part of the re-design process (Chapter 9), where they worked successfully in enabling a design to be produced that was more intuitive to use. They can be recommended as guidelines to help designers make an interface which is intuitive to use. Designers should use the principles when designing products and interfaces.

Principle 1: use familiar features from the same domain

Make function, appearance and location familiar for features that are already known. Use familiar symbols and/or words, put them in a familiar or expected position and make the function comparable with similar functions users have seen before. Principle 1 involves inserting existing features or labels or icons that users have seen before in similar products that perform the same function. This is the simplest level of applying intuitive interaction and uses features transferred from similar contexts. For example, the Play and related functions for the re-designed remote control (Figure 9.2) were simply familiar icons designed for a new interface. The simplest application of Principle 1 would be through real or physical affordances (Norman, 2004b), or body reflectors (Bush, 1989), which people can understand immediately, simply because they reflect their ingrained experience of embodiment in the world.

Principle 2: transfer familiar things from other domains

Make it obvious what less well-known functions will do by using familiar things to demonstrate their function. Again use familiar function, appearance and location. Principle 2 sometimes requires the use of metaphor to make something that is completely new familiar by relating it to something already existing. This principle requires transfer of features from differing domains (either different types of products or technologies or things from the physical world transferred to the virtual world). Some of the emerging technologies mentioned in Chapter 1 (e.g. gestural interfaces, ubiquitous computing) may require application of this principle as there is nothing similar enough to some of these interfaces to allow application of Principle 1. The desktop metaphor was a good example of this sort of metaphor successfully applied (Perkins et al., 1997; Smith et al., 1982). Also, the re-designed back/ahead function (Figure 9.2) was re-designed according to this principle, taking a feature commonly used on mobile phones for a slightly different purpose and applying it to a new product type.

Principles 1 and 2 involve applying external consistency. Weiss (2002) argues that external consistency can be an effective tool to increase ease of use but warns that it could hinder good design when migrating a user interface from platform to platform. Designers should retain terminology and processes from PC applications and use them for smaller devices only when they are equally appropriate for the smaller screen (Weiss, 2002). Familiar things should not be indiscriminately applied when they are not suitable for a new platform or hardware.

Principle 3: redundancy and internal consistency

Redundancy is essential in ensuring that as many users as possible can use an interface intuitively. This involves tactics like using visual and audible feedback, including labels as well as symbols or icons, and providing different ways of doing things so that both novices and experts, and older and younger users, can use the same interface easily and efficiently. If one user is familiar with a word, another may be familiar with the corresponding symbol; or one user may be used to one way of navigating a device and another may prefer an alternative way. Providing as many options as possible will enable more people to use the interface intuitively. Redundancy is a basic and well known principle of interface design and applying it will help to make an intuitive interface accessible and also flexible for more people.

Increase the consistency within the interface so that function, appearance and location of features are consistent between different parts of the design and on every page, screen, part and/or mode. Keeping internal consistency allows users to apply the same knowledge and metaphors to all parts of the interface (Kellogg, 1989). Principle 3 is demonstrated by the power symbols applied to the new remote control interface. In the default design the power icon was different in function, location and appearance for each device; on the full re-design (Location–Appearance) it was consistent (Figures 9.1 and 9.2).

The only author to have offered anything similar to these principles is Spool (2005). Spool uses the terms *current* and *target* knowledge to refer to the knowledge that users already had and the knowledge they would need in order to use a product respectively. He presents with two principles for intuitive use. Firstly, a designer can design so that both the current knowledge point and the target knowledge point are identical. Here the user already knows everything s/he needs to use the interface because the designer has applied familiar features. This idea is similar to Principle 1.

Secondly, the designer can design so that current and target knowledge points are separate, but the user is unaware of this as the design is bridging the gap. The user is being trained in a way that seems natural. This is similar to Principle 2 where metaphor is used to transfer knowledge from one domain or product to another. However, Spool's (2005) work has not yet been developed any further or tested empirically. He has offered definitions based on his experience with user testing and his categorisations have similarities with those developed here, but his ideas are less rigorously based and do not offer tools by which designers can apply intuitive interaction.

10.2.2 Continuum of Intuitive Interaction

It is likely that intuition operates as part of a continuum between highly controlled and completely automatic processes (Isen and Diamond, 1989; Logan, 1985). Further, it seems likely that there is a continuum of intuitive interaction (Figure 10.1). The continuum starts from the simplest form of intuitive interaction; body reflectors (Bush, 1989), or physical affordances (Norman, 2004b), which are based on embodied knowledge learned so early that it seems almost innate. At a more complex level, intuitive interaction employs population stereotypes which are engrained from an early age, and at the next level again can work through similar features from the same or differing domains. At its most complex, intuitive interaction requires the application of metaphor, used to explain a completely new concept or function.

Figure 10.1 links the various theories that have been discussed throughout this thesis and places them on the continuum in the context of intuitive interaction.

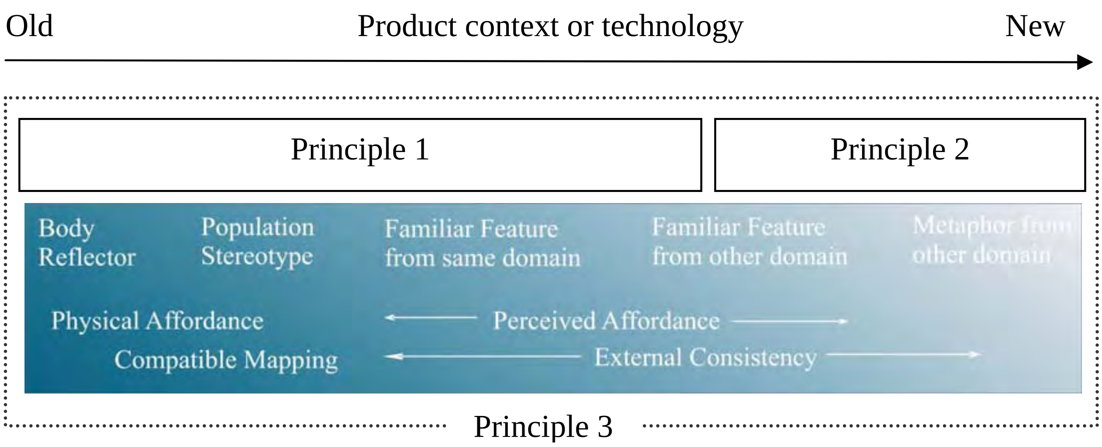


Figure 10.1 The intuitive interaction continuum as it relates to the three principles for intuitive interaction.

Body reflectors

The continuum starts from the simplest form of intuitive interaction; body reflectors (Bush, 1989), which are based on embodied knowledge learned so early that it seems almost innate. Bush (1989) describes body reflectors as products or parts that resemble or mirror the body because they come into close contact with it. Examples include headsets, glasses, shoes, gloves and combs. He claims that humans are pre-disposed to perceive body images for evolutionary reasons. Therefore, designs which use body images should be more readily perceivable. Bush claims that it is not necessary to be familiar with a body reflector in order to ascertain its relation to a person; these forms are self evident in relation to people. Any person would be able to make the association whether familiar with similar things or not. This idea has also been discussed by Norman (2004b) in relation to physical, or real, affordances.

Population stereotypes

At a more complex level, intuitive interaction employs population stereotypes which are engrained from an early age. Humans have assimilated a large number of arbitrary, unnatural mappings from products that were not designed to be usable but that they use easily because they have learned to use them from a young age (Norman 1988, 1993). Population stereotypes derive largely from experience of cultural conventions.

Familiar features

At the next level again intuitive interaction can work through similar features from the same or differing domains. There is general consensus about the importance of designing artefacts that relate to users' prior knowledge and familiarity, particularly in HCI, but with growing force also in design. The experiments conducted by these authors were based on the differentiation of familiar and unfamiliar features, applied from both similar and differing domains. All these experiments showed that familiarity with a feature will allow a person to use it more quickly and intuitively. This is the foundational conclusion to come from this research and informs the principles and models which have been developed for designing for intuitive interaction. It is envisaged that familiar features from the same and different domains would be the main mechanism for designers to use in order to apply intuitive interaction.

Metaphor

At its most complex, intuitive interaction requires the application of metaphor, used to explain a completely new concept or function. Metaphor involves retrieval of useful analogies from memory and mapping of the elements of a known situation, the source, and a new situation, the target (Holyoak, 1991; Lakoff, 1987). Metaphors are grounded in experience and understood only in relation to experience (Lakoff and Johnson, 1981, p202). Intuition is enabled by this sort of transfer. (Rasmussen, 1986). Metaphor allows people to transfer knowledge between domains. When a person has relevant experience in a different domain, metaphors could be used to relate that knowledge to a new situation.

Affordances

Norman (2004b) has talked about perceived and real affordances. Physical objects have real affordances, like grasping, that are perceptually obvious and do not have to be learned. A physical object like a door handle affords actions because it uses constraints; its physical properties constrain what can be done with it. However, a virtual object like an icon button invites pushing or clicking because a user has learned initially that that is what it does. User interfaces that are screen-based do not have real affordances; they have perceived affordances, which are essentially learned conventions. This is a useful distinction – between "real" physical affordances that do not require learning beyond experience of being in the human body, and perceived affordances which are based on prior experience with similar things. Norman's (2004b) perceived affordance has therefore been placed on the continuum as being equivalent to familiar features from the same domain, whereas the physical affordance is seen as equivalent to body reflectors.

Compatibility

Stimulus-response compatibility relates to the relationships of controls and the object they are controlling. It is important because a system with a greater degree of compatibility will result in faster learning and response times, fewer errors and a lower mental workload (Wickens, 1987; Wu, 1997). Responses are faster when the structural features of stimulus and response sets correspond and the S-R mappings can be characterised by rules (Proctor et al., 1995; Wickens, 1992; Barker and Schaik, 2000; Norman, 1993). These simple rules (Wickens, 1992) seem to be drawn from population stereotypes to map the set of stimuli to the set of responses. The fewer rules have to be utilised, the faster the response time.

Ravden and Johnson (1989) also relate compatibility to similarity of the interface with other familiar systems and with users' expectations and mental models of the system. This highlights the fact that mappings are learned conventions and rely on past experience. Hence, compatible mappings have been equated with population stereotypes on the continuum. Population stereotypes and compatible mapping have a similar level of intuitive interaction; they are completely ingrained cultural norms that are widely but fairly unconsciously known by the majority of a population.

External consistency

Consistency is assumed to enhance the possibility that the user can transfer skills from one system to another, which makes new systems easier to use (Nielsen, 1989; Preece et al., 2002; Thimbleby, 1991). It improves users' productivity because they can predict what a system will do in a given situation and can rely on a few rules to govern their use of the system (Nielsen, 1989).

External consistency is the consistency of a system with things outside it; for example, metaphors, user knowledge, the work domain and other systems (Kellogg, 1987). Both principles 1 and 2 involve applying external consistency. It can be seen as equivalent to applying familiar features or applying metaphors (Kellogg, 1987).

Figure 10.1 also demonstrates how the principles relate to the continuum of intuitive interaction. Principle 1 relates to the simpler end of the continuum, where body reflectors, population stereotypes or familiar things from the same domain are applied. Principle 2 relates to transferring things from other domains, including the use of metaphor. Principle 3, internal consistency and redundancy (represented by the dotted line), needs to be considered at all times and so it surrounds the other principles.

It is suggested that as the newness or unfamiliarity of a product increases, so too does the complexity of the designing required to make the interface intuitive to use. Very innovative products (or those based on very new technologies that have no established conventions) may require the application of features from other domains or metaphors, whereas familiar technologies or features can utilise familiar things from similar products, or even standard stereotypes and body reflectors.

Looking at this continuum, it may seem to make sense to say that as one moves along to the right, more technology familiarity would be required to use the interface. However, if the design is done well, and if tools and principles suggested here are used, it should be possible to design an interface at any of these levels which people with differing levels of technology familiarity could use intuitively. For example, a metaphor or familiar feature from another domain may be more familiar to some than a feature from the same domain – depending on their experience with the various domains. Therefore, the continuum corresponds to the complexity or recency of the product or technology but not the level of technology familiarity required to use it.

10.2.3 Conceptual Tool for Applying Intuitive Interaction

Figure 10.2 shows how the principles could be applied during the design process. The continuum is juxtaposed with an iterative spiral, which represents a design process which has a variety of entry and exit points.

As discussed in Section 10.1.1, before starting design, the designers need to establish who the users are and what they are already familiar with so that they know what features or metaphors would be suitable to apply.

Designers then need to go through the spiral twice. Firstly the structure or form of the system or product needs to be established. This would involve primarily establishing the various functions that need to be included in the interface or product, as until the functions are established nothing else can be done. Following that, overall appearance (look and feel or form) can be established, and finally, location of global features within the structure. Once this first stage is completed the spiral is entered a second time for the detailed design of each feature.

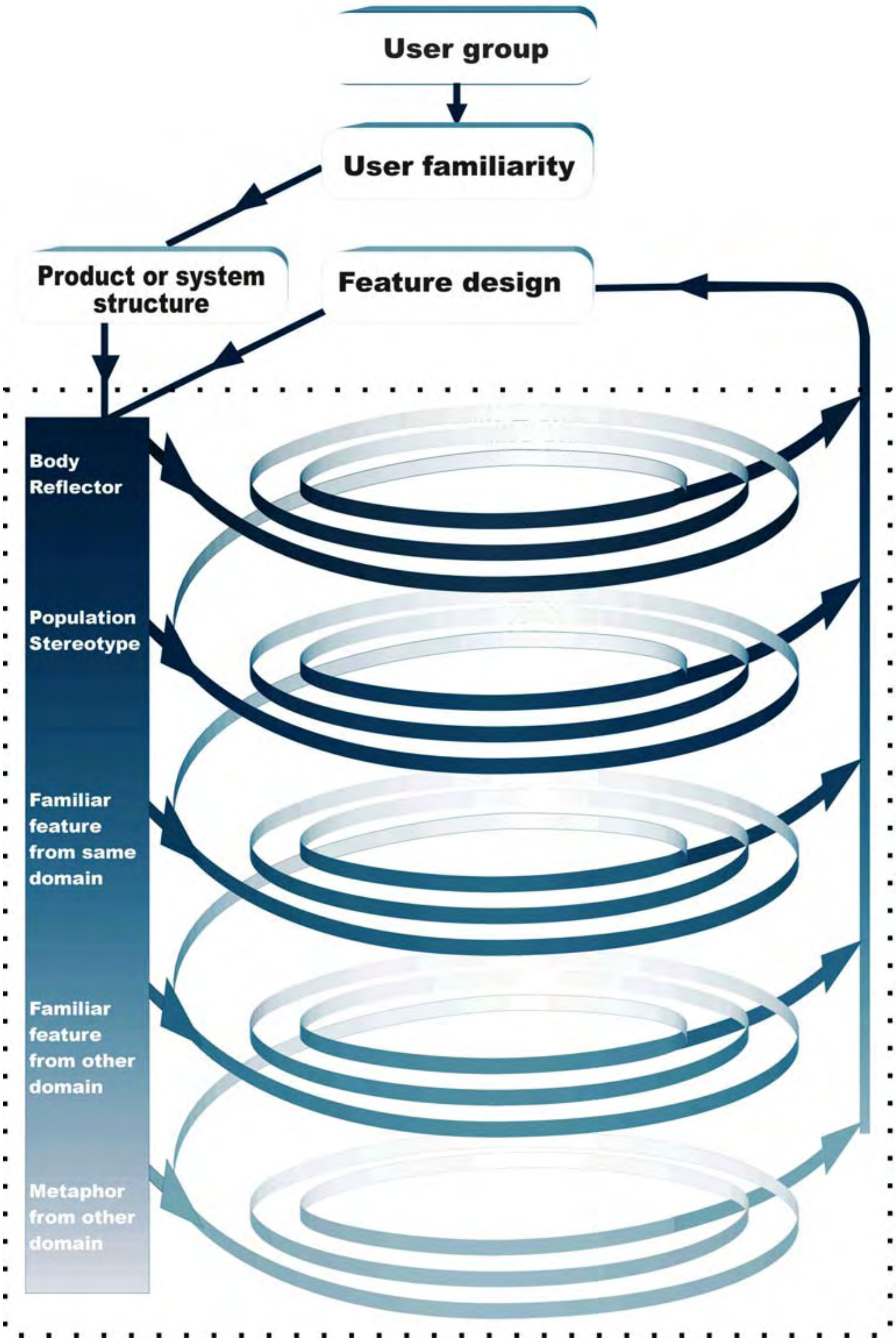


Figure 10.2 Conceptual tool for applying intuitive interaction during the design process

Each loop of the spiral has three layers. These layers represent the function, appearance and location (Figure 10.3). They are placed like this so that function is tackled first, then appearance and finally location. The factors are addressed in this order as that is the order of priority that has been established through this research (Section 10.1.2).

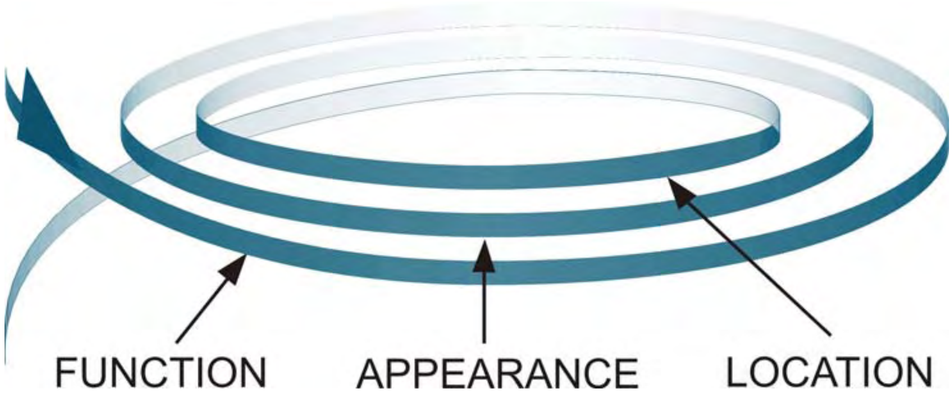


Figure 10.3. Detail of the three loops within each spiral.

The conceptual tool has been designed so that one can enter the spiral at a suitable point and leave it when necessary. As designers work down the spiral, they can establish the earliest point at which a familiar thing can be applied to that feature. For a simple interface, this may be a body reflector for a handle or a population stereotype for direction of a scale. For more complex interfaces, it would involve applying familiar features from similar or extra domain products. For very new technology which has none of its own conventions, a metaphor which relates to something that is familiar to the users would need to be applied. The spiral should be exited at the point at which a suitable level is found.

However, it is also possible to enter the spiral further down if appropriate, especially after designers have worked through the first few features and have established where on the continuum they are working. Figure 10.4 shows an example of a designer entering the spiral near the top (applying population stereotype). Figure 10.5 shows an example of a designer, entering at the halfway point but then not finding suitable familiar features to apply, and needing to progress to the metaphor level.

Consistency and redundancy are represented as a dotted line surrounding the spiral, as also shown in Figure 10.1. They should be considered at all times during the design process in order for design for intuitive interaction to be effective. Applying a similar type of familiarity to each factor of each feature is part of remaining consistent. This could mean that if the function of the feature requires a metaphor, that metaphor is also applied to the appearance and location of that feature, so that the metaphor remains consistent.

Once the entire form or structure of the product and the design of all the features have been taken through this process, an appropriate level of familiarity based on things that target users already know will have been applied consistently throughout the design. According to all the conclusions reached though this research, working through this process should mean that the resulting product is intuitive to use.

This tool has undergone pilot testing since it was developed. A paper discussing this process and the results to come from it (Blackler, Popovic, and Mahar, in Press) can be found in Appendix H.

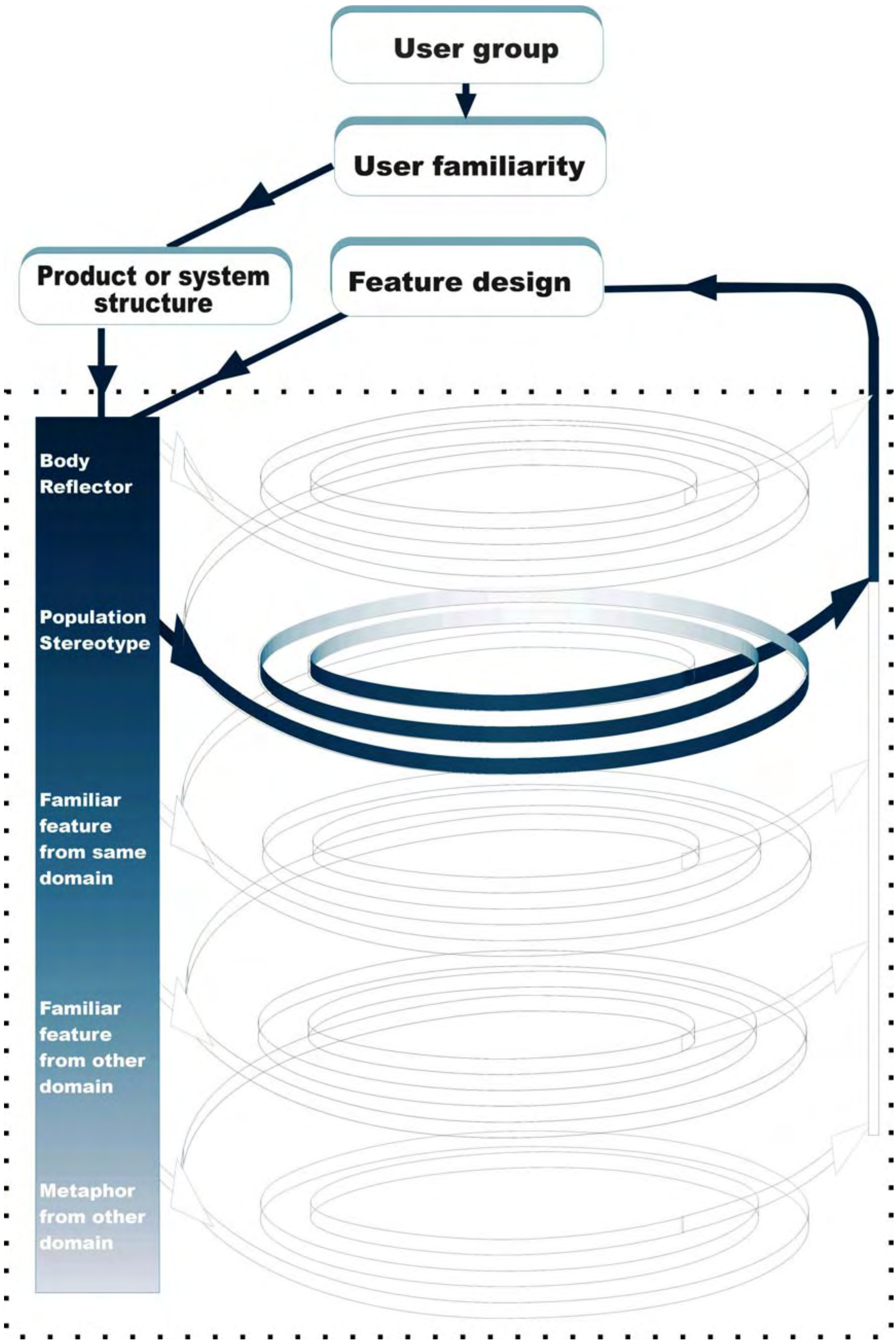


Figure 10.4 Working at the second level on the continuum.

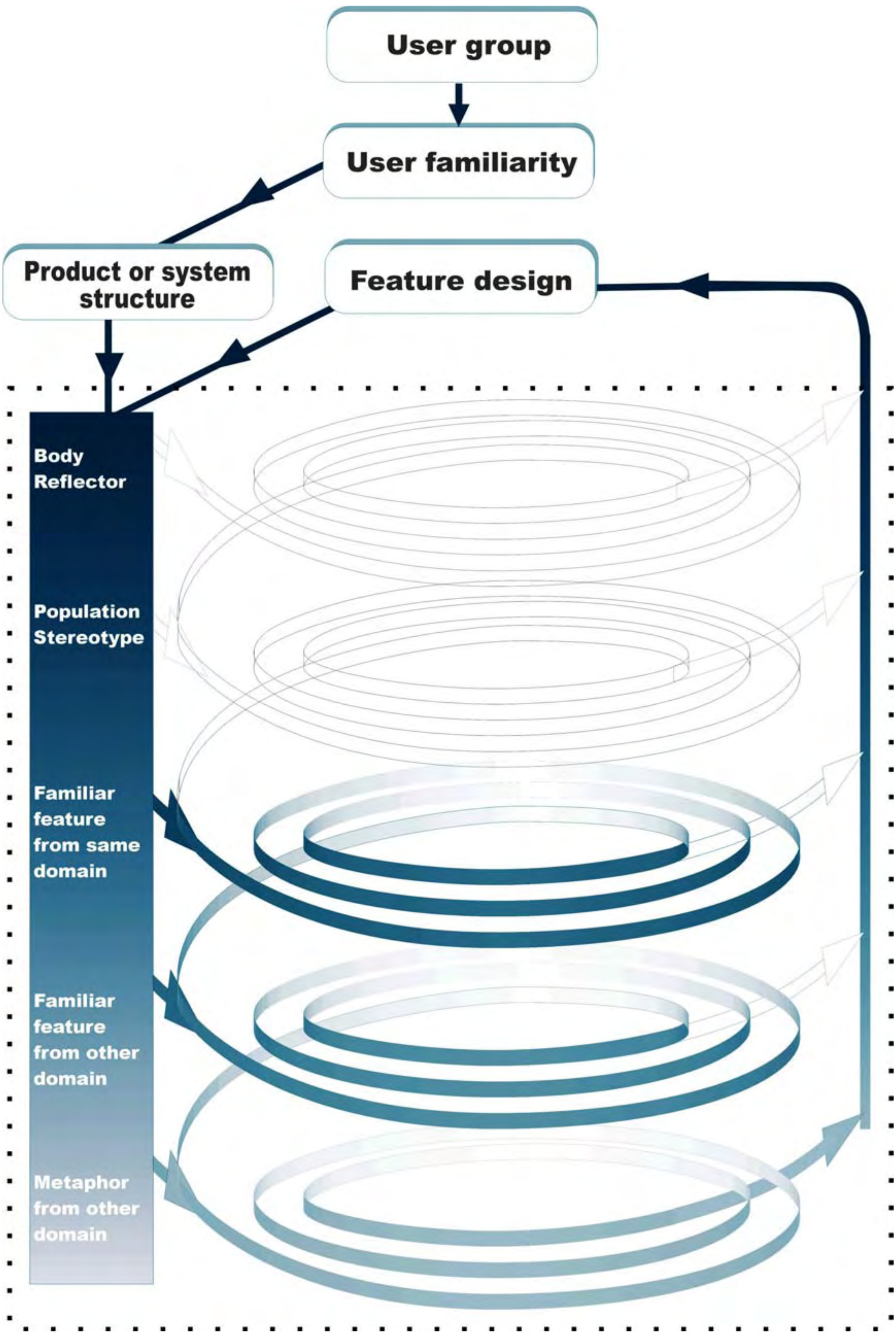


Figure 10.5 Working from the halfway point to the bottom of the continuum

10.3 Conclusions and Contributions to Knowledge

The concept of intuitive interaction has been mentioned and even applied in the past but never really addressed in depth. Although no other author has described in sufficient detail exactly how products and systems can be designed to encourage intuitive interaction, intuitive interaction has, in most cases, been related to familiarity. This research goes further in empirically establishing that intuitive interaction and familiarity are related and how the different aspects of an interface design can affect intuitive interaction.

Intuition is based on past experience and is generally non-conscious and fast. Intuitive interaction is based on past experience, which can be transferred between different products or systems to allow people to use a new product intuitively if they have used similar features previously. Intuitive interaction can be seen as a continuum ranging from the simplest physical affordances through to complex metaphors. Designers can facilitate intuitive interaction with products by using the conceptual tool that has been developed to employ features that are familiar to the target users in their interfaces.

This conclusion supplies confirmation for the existing theory that suggests intuition itself relies on past experience. However, more specifically, this work has built on that theory to establish firm conclusions about intuitive interaction. Other researchers have suggested the idea that intuitive interaction is based on familiarity with similar things, but none have carried out experimentation to empirically test it.

The appearance of a feature is more important for intuitive use than its location. This suggests that the cues which people store in memory about a product's features depend more on how the feature looks than where on the product it is placed. It seems likely that appearance is easier to transfer between products than location, as feature appearance tends to be more standardised than location on a wide variety of products. Location of features was shown to be much less important than appearance, although qualitative data and traditional stimulus response work suggest that location should make some difference to the speed of sub-tasks. No other author has successfully applied intuitive interaction to the detail design of an interface in this way. This allows designers to prioritise on those factors of the interface design that require more attention.

Older people take longer to complete tasks and are less likely to use features intuitively the first time they encounter them. There may be several reasons for this, and more research is needed to establish which is the most likely. Although it is known that older people are slower at some tasks, the fact that they are also using products less intuitively could shed new light on the true reasons behind the problems they experience. Because the baby boomer generation is such a major market force and is now starting to age, it is important to develop this research further in order to come up with solutions that will assist older people to use new technologies.

An understanding of intuitive interaction and tools to help apply it will allow designers to make interfaces that are easier to use, addressing the research problem discussed in Chapter 1. The aim of this research was to provide designers with principles and tools which they can use during the design process in order to make their products more intuitive to use. From the conclusions above, three principles that designers can directly apply to their designs have been developed. These principles recommend that a designer should use familiar features as much as possible, apply familiar metaphors to things that are novel and keep products internally consistent.

A continuum to locate intuitive interaction principles within those of other theories and guidelines has been provided and a conceptual tool has been developed to guide designers through the process of applying intuitive interaction to products. No clear guidelines, principles or tools specifically and explicitly to help designers apply intuitive interaction have been produced in the past. This work may be particularly important for the design of those interfaces that are based on new technologies or formats and so have no established conventions, or for those with a lot of one off or occasional users.

Further, this research has contributed to new methods in three ways. The first of these is the development of a method of measuring technology familiarity (Appendices B and C). This measure provides an index that correlates with performance on products relevant to the familiar technology. This could be applied to further work on intuitive interaction, and various other areas of human centred design and usability research.

The second contribution to new methods is the detailed use of video observation software to make decisions about the type of cognitive processing a participant is using during an experiment (detailed in Section 6.5.3). These data, along with more empirical data traditionally used in user testing (such as time to complete tasks), was used to draw conclusions about whether or not a participant was using the features of the product intuitively. This could be applied to further work on intuitive interaction, or intuition itself, and may also be valuable for other psychological research which looks at cognitive processes.

The third contribution to new methods is the successful use of the three factors of function, location and appearance to unravel the way in which users experience problems with an interface. These factors have been applied to simple rating scales and used to gain feedback after the user has completed tasks with the product. For simple products where users can easily distinguish the function, location and appearance from each other, these work very successfully at bringing out which factors of each feature could be potentially problematic. For more complex products, where these factors can become more ambiguous, they showed some measure of success but were less clear. The factors have also been applied to experiment design to investigate the differences between the factors more empirically. This method could be successfully applied to user centred design research and also to usability testing. It could help designers or researchers to understand more clearly the problems that users may be experiencing with an interface during a user test.

10.4 Future Directions

As mentioned above, age and its relationship with intuitive use is an area that warrants further study. It would be helpful to see how this relationship can be explained and to establish what designers can do to help older people to use things more intuitively. One way to do this could be to design an experiment that will allow older users to refer to features that would have been familiar to them earlier in their lives, and see whether they are able to use them more intuitively than more contemporary features. Using a touch screen and a more traditional, physical interface as mediators could work well here.

It would be interesting to discover if the principles and tools developed here (which worked well in the university setting) could be easily applied to design practice, and to investigate how the recommended approach might alter the design process and the acceptance of the product by consumers. This could be investigated by asking designers in practice to use the conceptual tool that has been developed and to investigate whether it helps them to create more intuitive interaction. This testing has been piloted (Appendix H).

The location of features was shown through Experiment 3 to be much less important than appearance, and the way in which appearance and location of features are varied to different extents in existing interfaces would seem to explain this. However, qualitative data and work on response times (e.g. Pearson and van Schaik, 2003) would suggest that location does make some difference to the speed of sub-tasks. Eye tracking studies may reveal more about intuitive search behaviour of users.

The function of features is assumed to be the foundation of interface design, ideally needing to be tackled before either location or appearance. However, it was not possible to investigate the function of features in depth because of the functions already assigned to the features of the mediating products. Function could be investigated with experiments similar to those reported here, using software to simulate various familiar and unfamiliar functions for features.

As discussed in Section 1.3.2, it was not possible to investigate the effect of colour and the stereotypes related to it as part of this research due to the limitations of the products used. Software or reconfigurable colour touch-screen-based devices (similar to the remote control) could be used to mediate this kind of investigation.

The application of these principles to other areas of design, such as software, would be a useful contribution. There are many overlaps and shared metaphors between digital devices and computer software so similar principles should be applicable.

Detailed methods to establish which features are familiar to particular user groups need to be developed so that these principles can be applied successfully to all types of artefacts for many groups of users. The technology familiarity questionnaire developed as part of this research could be applied or adapted to this purpose. As mentioned in Section 5.6, there is also a dearth of research into stereotypes for new and digital products, and this research has highlighted the need for that to be addressed.

As has been demonstrated, there is potential for further work in this area. However, this research has put in place a set of principles and conceptual tools that designers can work from in order to make interfaces intuitive to use. This will allow designers to provide interfaces which facilitate easier and simpler transitions to new products, systems and product types. This work has also established a foundation for the study of intuitive interaction, and gives future researchers in this area a solid basis from which to work.

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Appendix A

Recruitment questionnaire from Experiment 1

QUESTIONNAIRE FOR VOLUNTEERS

Thank you for volunteering to participate in my experiment. The purpose of this questionnaire is to sort the volunteers into groups according to their level of experience with digital cameras. Each group will also have a similar distribution of age groups and gender among its members. When I have sorted people into the groups, I will contact you to arrange a convenient time for you to participate in the experiment.

Answer each question by circling or underlining the appropriate answer

1. **Name** ____

2. **Email contact and/or phone number**

   ____

3. **Age group**

   Under 25 25-35 35-45 45-55 55+

4. **Gender**

   Male Female

5. **How often do you use a digital camera?**

   At least once a week

   At least once a month

   Once every few months

   I have only used one once or twice

   I have never used one

Thank you for your time.

Appendix B

Representative example of technology familiarity questionnaire (from Experiment 2)

User Technology Familiarity Questionnaire

Thank you for volunteering to assist with my experiment.

This questionnaire is intended to give me more information about volunteers so that I can sort them into appropriate groups for the experiment.

The first section requires personal information that will allow me to get a good cross-section of the community as participants. These participants should then be representative of the population as a whole.

The second section (pages 2 and 3) is intended to show how familiar you are with various types of complex electronic products. It will allow me to assess how much experience you have had with products similar to the remote control to be used in the experiment. Therefore, I will be able to group participants according to their level of experience with these types of products and their features.

All information will be treated confidentially.

*Please answer **all** questions and return all three pages to me via email at a.blackler@qut.edu.au or to level 5, D Block, Gardens Point. If at any time you are unsure about a question, please contact me via email or call me on 3864 4334 or 0410 736494 to clarify your query.*

Thank you for your time

Thea Blackler

SECTION ONE

6. **Name** ____

7. **Email contact and/or phone number**

____

8. **highest academic qualification (I need a good cross-section)**

____

4. **Age group**

Under 25 25-34 35-44 45-54 55+

5. **Gender**

Male Female

SECTION TWO

Please note

- *A **universal** remote control is a single handheld device that can be taught to control many different appliances.*
- *"Other" appliances with remotes may include air conditioning, DVD, satellite TV, digital TV, etc*
- *Other devices employing touchscreens may include photocopiers, ATMs, information points, etc*

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

6. How often do you use the following products? (if you have never used a product of the type, please tick never)

Product	every day	several times a week	once or twice a week	every few weeks	every few months	Only ever used it once or twice	never
Marantz RC5000i universal remote control							
Other ***universal*** remote controls **Which brands?……….. ……………………..**							
Standard remote controls for TV							
Standard remote controls for VCR							
Standard remote controls for stereo							
Remote controls for other appliances **Which ones?...……….. ………………………….. …………………………..**							
Mobile phone							
Stereo, car stereo or personal stereo ***without*** remote							
Personal digital organiser or Palm.							
Web browser (eg Netscape or Internet Explorer)							
Windows or similar							
Other devices with touchscreens **Which ones?......**							

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

7. When using versions of these products (below), how many of the features on the product do you use? (if you do not use a product of the type please tick none)

Product	All of the features (you read the manual to check them)	As many features as you can figure out without manual	Just enough features to get by with	Your limited knowledge of the features limits your use of the product	None of the features – you do not use this product
Marantz RC5000i universal remote control					
Other ***universal*** remote controls **Which brands?…………. ……………………….**					
Standard remote controls for TV					
Standard remote controls for VCR					
Standard remote controls for stereo					
Remote controls for other appliances **Which ones?…………… …………………………… ……………………………**					
Mobile phone					
Stereo, car stereo or personal stereo ***without*** remote					
Personal digital organiser or Palm.					
Web browser (eg Netscape or Internet Explorer)					
Windows or similar					
Other devices with touchscreens **Which ones?……………. ……………………………. …………………………….**					

Appendix C

Example of technology familiarity questionnaire (from Experiment 2) showing scoring system

User Technology Familiarity Questionnaire scoring example sheet

How often do you use the following products? (if you have never used a product of the type, please tick never)

Product	every day	several times a week	once or twice a week	every few weeks	every few months	Only ever used it once or twice	never
Marantz RC5000i universal remote control							✓
Other ***universal*** remote controls **Which brands?…..** **…Sony…………………...**			✓				
Standard remote controls for TV		✓					
Standard remote controls for VCR				✓			
Standard remote controls for stereo				✓			
Remote controls for other appliances **Which ones?...………..** **…DVD……………………..**		✓					
Mobile phone	✓						
Stereo, car stereo or personal stereo ***without*** remote		✓					
Personal digital organiser or Palm.					✓		
Web browser (eg Netscape or Internet Explorer)	✓						
Windows or similar	✓						
Other devices with touchscreens **Which ones?........... …**							✓
Score for each entry	6	5	4	3	2	1	0
Total for column	*18*	*15*	*4*	*6*	*2*	*0*	*0*
Total for this question	*45*						

When using versions of these products (below), how many of the features on the product do you use? (if you do not use a product of the type please tick none)

Product	All of the features (you read the manual to check them)	As many features as you can figure out without manual	Just enough features to get by with	Your limited knowledge of the features limits your use of the product	None of the features – you do not use this product
Marantz RC5000i universal remote control					✓
Other ***universal*** remote controls **Which brands?………...** **…Sony…………………..….**		✓			
Standard remote controls for TV		✓			
Standard remote controls for VCR		✓			
Standard remote controls for stereo			✓		
Remote controls for other appliances **Which ones?…DVD………** **………………………………**			✓		
Mobile phone		✓			
Stereo, car stereo or personal stereo ***without*** remote		✓			
Personal digital organiser or Palm.				✓	
Web browser (eg Netscape or Internet Explorer)		✓			
Windows or similar		✓			
Other devices with touchscreens **Which ones?……………** **……………………………**					✓
Score for each entry	4	3	2	1	0
Total for column	*0*	*21*	*4*	*1*	*0*
Total for this question	*26*				
Grand total (=TF score)	*71*				

Appendix D

Representative example of interview profroma (from Experiment 2)

Follow up Interview

Control	Familiar?	Where from? Ie, what product or experience?	1 - 6
Remote on			
TV on/off			
VCR on/off			
Navigable windows or screens			
Back and Ahead			
Home			
Touch screen/soft keys			
Play			
Stop			
Pause			
Fwd and Rwd			
Skip/index back and forward			
Number pads			
Navigation between devices			
Volume / channel			
AV function			
Mute			

Did you feel at all anxious during the test? **Y** **N**

Why?

- monitoring equipment
- presence of experimenter
- using remote
- other

Please mark the following features on the scale to show how to compared with your expectations:

Remote On function

Did not work as you would expect — worked as you would expect

1 2 3 4 5 6

Was not located where you would expect — was located where you would expect

1 2 3 4 5 6

Appearance was not as you would expect — appearance was as you would expect

1 2 3 4 5 6

Navigable windows or screens

Did not work as you would expect worked as you would expect

1 2 3 4 5 6

Was not located where you would expect was located where you would expect

1 2 3 4 5 6

Appearance was not as you would expect appearance was as you would expect

1 2 3 4 5 6

Back and ahead

Did not work as you would expect worked as you would expect

1 2 3 4 5 6

Was not located where you would expect was located where you would expect

1 2 3 4 5 6

Appearance was not as you would expect appearance was as you would expect

1 2 3 4 5 6

TV on/off

Did not work as you would expect worked as you would expect

1 2 3 4 5 6

Was not located where you would expect was located where you would expect

1 2 3 4 5 6

Appearance was not as you would expect appearance was as you would expect

1 2 3 4 5 6

Touch screen

Did not work as you would expect				worked as you would expect	
1	2	3	4	5	6
Was not located where you would expect				was located where you would expect	
1	2	3	4	5	6
Appearance was not as you would expect				appearance was as you would expect	
1	2	3	4	5	6

Play

Did not work as you would expect				worked as you would expect	
1	2	3	4	5	6
Was not located where you would expect				was located where you would expect	
1	2	3	4	5	6
Appearance was not as you would expect				appearance was as you would expect	
1	2	3	4	5	6

Stop

Did not work as you would expect				worked as you would expect	
1	2	3	4	5	6
Was not located where you would expect				was located where you would expect	
1	2	3	4	5	6
Appearance was not as you would expect				appearance was as you would expect	
1	2	3	4	5	6

Fast Forward and rewind

Did not work as you would expect					worked as you would expect
1	2	3	4	5	6
Was not located where you would expect					was located where you would expect
1	2	3	4	5	6
Appearance was not as you would expect					appearance was as you would expect
1	2	3	4	5	6

Skip/index

Did not work as you would expect					worked as you would expect
1	2	3	4	5	6
Was not located where you would expect					was located where you would expect
1	2	3	4	5	6
Appearance was not as you would expect					appearance was as you would expect
1	2	3	4	5	6

VCR on/off

Did not work as you would expect					worked as you would expect
1	2	3	4	5	6
Was not located where you would expect					was located where you would expect
1	2	3	4	5	6
Appearance was not as you would expect					appearance was as you would expect
1	2	3	4	5	6

4 way

Did not work as you would expect worked as you would expect

1 2 3 4 5 6

Was not located where you would expect was located where you would expect

1 2 3 4 5 6

Appearance was not as you would expect appearance was as you would expect

1 2 3 4 5 6

Volume / channel

Did not work as you would expect worked as you would expect

1 2 3 4 5 6

Was not located where you would expect was located where you would expect

1 2 3 4 5 6

Appearance was not as you would expect appearance was as you would expect

1 2 3 4 5 6

AV function

Did not work as you would expect worked as you would expect

1 2 3 4 5 6

Was not located where you would expect was located where you would expect

1 2 3 4 5 6

Appearance was not as you would expect appearance was as you would expect

1 2 3 4 5 6

Menu

Did not work as you would expect	worked as you would expect

1	2	3	4	5	6

Was not located where you would expect	was located where you would expect

1	2	3	4	5	6

Appearance was not as you would expect	appearance was as you would expect

1	2	3	4	5	6

Number pads

Did not work as you would expect	worked as you would expect

1	2	3	4	5	6

Was not located where you would expect	was located where you would expect

1	2	3	4	5	6

Appearance was not as you would expect	appearance was as you would expect

1	2	3	4	5	6

Navigation between devices

Did not work as you would expect	worked as you would expect

1	2	3	4	5	6

Was not located where you would expect	was located where you would expect

1	2	3	4	5	6

Appearance was not as you would expect	appearance was as you would expect

1	2	3	4	5	6

Home function

Did not work as you would expect				worked as you would expect	
1	2	3	4	5	6
Was not located where you would expect				was located where you would expect	
1	2	3	4	5	6
Appearance was not as you would expect				appearance was as you would expect	
1	2	3	4	5	6

Are there any parts, features or things that you found particularly difficult to use or contrary to your expectations and that you think should be changed?

Thank you

Appendix E

Representative example of information package and consent form
(from Experiment 2)

Contact Information: Thea Blackler
School of Design and Built Environment
D Block, Gardens Point Campus
Phone 07 3864 4334
Mobile 0410 736494

Project Title: Intuitive Use of Products

This project is being conducted as part of my PhD studies at Queensland University of Technology. This study is designed to investigate the issue of whether or not it is possible to design products to be intuitive to use. The main conclusion reached through the literature review and first round of experiments is that intuitive use of things would appear to be experiential. In other words, things that humans use intuitively are those that they have used before. Therefore, the issue being investigated is how it may be possible to use design to help users transfer the intuitive knowledge gained from familiar products to new products.

Project Objectives:

- To investigate how the use of products becomes intuitive.
- To identify functional features of products that target user groups would find intuitive to use.
- To establish how intuitive procedural knowledge can be transferred from a known scenario to one involving new products.

What you are being asked to do:

You will be asked to complete specified tasks with the product that I am investigating. You will be filmed undertaking the tasks and afterwards asked about different features and controls of the product that you have been using. It is not possible to participate in the project without being recorded, but only members of the research team will have access to the recordings.

Selection of participants:

Participants are recruited to ensure that a balanced number of people with low, medium and high levels of experience with similar products undertake the experiment. This is to allow for comparison between the groups.

Expected outcomes of the research:

I hope to develop a conceptual model to be used during the design process to assist in designing products so that their use is intuitive.

This would be supported by relevant examples and results are expected to be published in scholarly journals. If you would like to have copies of published papers or feedback about the results of the research when data has been analysed, please contact Thea Blackler (contact details at top).

Benefits of the research:

Products are often difficult to use correctly and are frequently misused for a variety of reasons. While there are no direct and immediate benefits for you as a participant agreeing to take part in this research, the research is expected to benefit the wider community of consumers by providing suggestions to designers about how they can make their products more intuitive to use.

Confidentiality:

Your confidentiality will be protected at all times. Your name will not be used to identify you in any document or published paper, and only the research team and myself will have direct access to the collected data, which will be kept in a secure location.

Voluntary Participation:

Your participation in the project is entirely voluntary. If you decide to withdraw from the study, you will not be penalised or judged in any way. You may discontinue participation at any time without any comment.

Please contact Thea Blackler (details at top) for any further details about this project, or if you have any questions.

If you have any concerns or complaints about the ethical conduct of this project, you should contact the Secretary of the University Human research Ethics Committee on 07 3864 2902.

Contact Information: Thea Blackler
School of Design and Built Environment
D Block, Gardens Point Campus
Phone 07 3864 4334
Mobile 0410 736494

Project Title: Intuitive Use of Products

Statement of consent:

I have read and understood the information provided, and have had any questions answered to my satisfaction.

I understand that I can contact the researcher if I have any additional questions.

I understand that I can withdraw from the study at any time, without comment or penalty.

I understand that I can contact the Secretary of the University Human research Ethics Committee on 3864 2902 if I have any concerns about the ethical conduct of a project.

I understand that participation in this project involves being recorded, and that it is not possible to participate in the project without being recorded. I understand that only members of the research team will have access to the recordings and they will be stored in a secure location.

I 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. *

I agree to participate in this project.

Name____________________________

Signature_________________________

Date________

*Please delete this paragraph if you do not consent to have images of yourself used

Appendix F

Representative example of experiment script (from Experiments 2 and 3)

SCRIPT FOR EXPERIMENTS

Hello, _____________ , I'm Thea.

Thank you for agreeing to participate.

Now could you please read through the information package?

Do you have any questions you would like to ask about the project or the experiments we are doing here today?

Answer questions as appropriate

Could you please read and sign the consent form if you are still happy to participate?

Answer questions as appropriate.

I just want to take a moment to explain all the equipment that is here.

We have two video cameras that will be used to film you using the product.

There is an audio tape recorder to make a clear recording of what you say, onto a standard tape format that is easier to transcribe than video.

Set up equipment and get participant seated comfortably with the video cameras positioned correctly

Do you have any questions about any of the equipment?

Answer questions as appropriate

This is the product that I am using for the tests. It is a universal remote control.

Please do only the tasks I will set you during the experiment. If you would like to look at the remote more closely you are welcome to do so after the test.

While you are performing the tasks, please talk aloud about what you are doing with the remote so I can record your thoughts about how you use the product.

While remaining sitting where you are, please could you use this remote to perform the following tasks.

There is a written copy of the tasks here so you do not have to remember all the instructions now.

READ OPERATION ONE

READ OPERATION TWO

The manuals for the remote, TV and video are in the room, but I am trying to investigate how people will be able to work out the product on their own, so please only ask for the manual when you have already tried all the ways you can think of to do a task yourself.

Above all please remember that the product is being tested, not you. Try to relax.

Any questions?

Answer questions as appropriate

OK please wait while I start all the monitoring equipment.

Set tape recorder and video cameras to record.

OK please pick up the remote and start the first task now.

Appendix G

Brief for re-design of remote control interface

Brief for redesign of remote control interface

Principles for intuitive design developed from Experiment 2:

1. Use familiar symbols and/or words for well-known functions
2. Make it obvious what less well-known functions will do by using familiar things to demonstrate their function
3. Increase the consistency between devices and features
4. Make buttons larger and clearer with maximum space between them.

Based on Experiment 2, there are several features that appear to be preforming badly and therefore those to focus on are:

1. Back and ahead
2. Navigation
3. AV function
4. Skip/index
5. Remote on

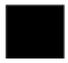
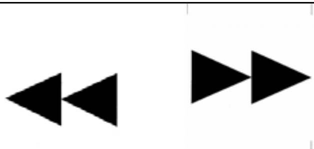
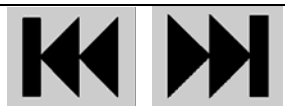
Use the standard icons provided

Go through the experimental tasks (used for Experiment 2) and answer the questionnaire on function, location and appearance to get a better understanding of the problems with the features.

All designs must be suitable for application to the product. Therefore, they must be:

- Appropriate size to fit the panels
- Greyscale

Do not add new commands
Produce final design with each feature as a separate bitmap.

Feature	Reference for design	Illustration
Play	CEI/IEC 60417-2 ISO/IEC 18035	
Stop	ISO/IEC 18035	
Forward /Rewind	CEI/IEC 60417-2 ISO/IEC 18035	
Four way	Designers choice	
VCR on/off	CEI/IEC 60417-2	
Enter	Designers choice	
Menu	Label as VCR menu Exact style designers choice	
TV on/off	CEI/IEC 60417-2	
AV function	Label as TV/Video Exact style designers choice	
Remote on	Label as “Touch screen to start” or similar Exact style designers choice	
Back/ahead	Label Back and → as Internet Browsers Mark on hard keys as mobile phones	
Skip/index	ISO/IEC 18035	

Appendix H

Paper to be presented at the Design Research Society International “Wonderground” conference in November 2006, Lisbon.

Applying Intuitive Interaction: Towards Intuitive Interaction Design Methodology

Abstract

Intuitive interaction involves utilising knowledge gained through other products or experience(s). Therefore, products that people use intuitively are those with features they have encountered before. This position has been supported by experimental studies. The findings suggest that relevant past experience is transferable between products, and probably also between contexts, and performance is affected by a person's level of familiarity with similar technologies. Appearance (shape, size and labelling of features) seems to be the variable that most affects intuitive uses. Using familiar labels and icons and possibly positions for buttons helps people to use a product quickly and intuitively the first time they encounter it.

This paper offers an overview of this work, which has become the basis for an emerging design methodology for intuitive interaction. The principles and conceptual tool that have been developed are explained and an initial trial of the tool is also described and the findings discussed.

Keywords

intuitive interaction, design methods, human factors and ergonomics, industrial design, human centred design

1.0 Introduction

The role of intuition in the way that people learn to operate unfamiliar devices, and the importance of this for designers, has been examined by these authors. Intuition is a type of cognitive processing that is often non-conscious and utilises stored experiential knowledge. Intuitive interaction involves the use of knowledge gained from other products and/or experiences (Blackler, Popovic, and Mahar, 2002; Blackler, Popovic, and Mahar, 2003a, b, 2004, 2005). Therefore, products that people use intuitively are those with features they have encountered before.

This position was supported by two initial experimental studies, which found that prior exposure to products employing similar features helped participants to complete set tasks more quickly and intuitively, and that familiar features were intuitively used more often than unfamiliar ones.

The definition of a feature, as the term is used here, is a function of a product that is discrete from others, has its own function, location and appearance and can be designed as a separate entity. A shutter button on a camera, a print icon on software or an earpiece on a stereo are all examples of features. Technology Familiarity was an important variable in this work. It was determined using a questionnaire which asked participants how often they used certain products that had similar features to the product they would use during the experiments, and how much of the functionality of each product they utilised. Participants who had a higher level of Technology Familiarity were able to use significantly more of the features intuitively the first time they encountered them, and were significantly quicker at doing the tasks. Those who were less familiar with relevant technologies required more assistance (Blackler et al., 2003a, b).

A third experiment was designed to test four different interface designs on a universal remote control in order to establish which of two variables – a feature's appearance or its location – was more important in making a design intuitive to use. As with the previous experiments, the findings of this experiment suggested that performance is affected by a person's Technology Familiarity. Also, the results showed that appearance (shape, size and labelling of buttons) seems to be the variable that most affects time spent on a task and intuitive uses. This suggests that the cues that people store in memory about a product's features depend on how the features look, rather than where on the product they are placed (Blackler et al., 2004, 2005). It was also found that older people were significantly slower at completing the tasks and had significantly fewer intuitive uses (Blackler, 2005).

Previously, no-one has empirically tested the nature of intuitive interaction or linked intuitive interaction to the existing theoretical knowledge base. Three principles of intuitive interaction were developed, and a conceptual tool was devised to guide designers in their planning for intuitive interaction. Designers can apply these in order to make interfaces intuitive to use, and thus help users to adapt more easily to new products and product types. The principles and the tool are discussed in detail below.

2.0 Principles of Intuitive Interaction

The following principles were extended from those used as part of the re-design process (Blackler et al., 2003a). They can be recommended as guidelines to help designers make an interface which is intuitive to use. Designers should use the principles when designing products and interfaces.

2.1 Principle 1: Use familiar features from the same domain

Make function, appearance and location familiar for features that are already known. Use familiar symbols and/or words, put them in a familiar or expected position and make the function comparable with similar functions users have seen before. Principle 1 involves inserting existing features or labels or icons that users have seen before in similar products that perform the same function. This is the simplest level of applying intuitive interaction and uses features transferred from similar contexts.

2.2 Principle 2: Transfer familiar things from other domains

Make it obvious what less well-known functions will do by using familiar things as metaphors to demonstrate their function. Again use familiar function, appearance and location. Principle 2 requires the use of metaphor to make something that is completely new familiar by relating it to something already existing. This principle requires transfer of features from differing domains (either different types of products or technologies or things from the physical world transferred to the virtual world). Emerging technologies like gestural interfaces and ubiquitous computing may require application of this principle as there is nothing similar enough to some of these interfaces to allow application of Principle 1. The desktop metaphor was a good example of this sort of metaphor successfully applied (Perkins, Keller, and Ludolph, 1997; Smith, Irby, Kimball, and Verplank, 1982).

2.3 Principle 3: Redundancy and internal consistency

Redundancy is essential in ensuring that as many users as possible can use an interface intuitively. This involves tactics like using visual and audible feedback, including written labels as well as symbols or icons, and providing different ways of doing things so that both novices and experts, and older and younger users, can use the same interface easily and efficiently. If one user is familiar with a word, another may be familiar with the corresponding symbol; or one user may be used to one way of navigating a device and another may prefer an alternative way. Providing as many options as possible will enable more people to use the interface intuitively. Redundancy is a basic and well known principle of interface design and applying it will help to make an intuitive interface accessible and also flexible for more people.

Increase the consistency within the interface so that function, appearance and location of features are consistent between different parts of the design and on every page, screen, part and/or mode. Internal consistency is consistency within a system between its various parts. Keeping internal consistency allows users to apply the same knowledge and metaphors throughout the interface (Kellogg, 1989).

The only author to have offered anything similar to these principles is Spool (2005). Spool used the terms *current* and *target* knowledge to refer to the knowledge that users already had and the knowledge they would need in order to use a product respectively. He came up with two principles for intuitive use. Firstly, a designer can design so that both the current knowledge point and the target knowledge point are identical. Here the user already knows everything s/he needs to use the interface because the designer has applied familiar features. This idea is similar to Principle 1. Secondly, the designer can design so that current and target knowledge points are separate, but the user is unaware of this as the design is bridging the gap. The user is being trained in a way that seems natural. This is similar to Principle 2 where metaphor is used to transfer knowledge from one domain or product to another.

However, Spool’s (2005) work has not yet been developed any further or tested empirically. He has offered definitions based on his experience with user testing and his categorisations have similarities with those developed here, but his ideas are less rigorously based and do not offer tools by which designers can apply intuitive interaction.

2.4 Continuum of Intuitive Interaction

It seems likely that there is a continuum of intuitive interaction. Such a continuum was developed based on this research. Figure 1 places the various levels of interaction on the continuum in the context of intuitive interaction.

It is suggested that as the newness or unfamiliarity of a product increases, so too does the complexity of the designing required to make the interface intuitive to use. Very innovative products (or those based on very new technologies that have no established conventions) may require the application of features from other domains or metaphors, whereas familiar technologies or features can utilise familiar things from similar products, or even standard stereotypes and body reflectors. These are the terms used by these authors and they are shown at the top of the continuum box. Other theories and terms (shown below) can also be seen as equivalent to the terms used here. All of these terms, and how they link to each other, are discussed in detail below.

Old   Product context or technology   New

Figure 1. The intuitive interaction continuum including positions of other interaction theories

2.4.1 Body Reflectors

The continuum starts from the simplest form of intuitive interaction; body reflectors (Bush, 1989), which are based on embodied knowledge learned so early that it seems almost innate. Bush (1989) describes body reflectors as products or parts that resemble or mirror the body because they come into close contact with it. Examples include headsets, glasses, shoes, gloves and combs. He claims that humans are pre-disposed to perceive body images for evolutionary reasons. Therefore, designs which use body images should be more readily perceivable. Bush claims that it is not necessary to be familiar with a body reflector in order to ascertain its relation to a person; these forms are self evident in relation to people. Any person would be able to make the association whether familiar with similar things or not. This idea has also been discussed by Norman (2004b) in relation to physical, or real, affordances. The simplest application of Principle 1 would be through real or physical affordances (Norman, 2004b), or body reflectors (Bush, 1989), which people can understand immediately, simply because they reflect their ingrained experience of embodiment in the world (Clark, 1997; Varela, Thompson, and Rosch, 1991).

2.4.2 Population Stereotypes

At a more complex level, intuitive interaction employs population stereotypes which are engrained from an early age. Humans have assimilated a large number of arbitrary, unnatural mappings from products that were not designed to be usable but that they use easily because they have learned to use them from a young age (Norman 1988, 1993). These are called population stereotypes. Population stereotypes derive largely from experience of cultural conventions.

They are just customs, but Smith (1981) claims that "expectations based on customary usage can be strongly compelling" (p306). Strong stereotypes are less vulnerable to stress, change of body position and use of the non-preferred hand (Loveless, 1963). When population stereotypes were conformed to, Asfour, Omachonu, Diaz and Abdel-Moty (1991) found that reaction or decision time was shorter, the first control movement the operator made was more likely to be correct, the operator could use the control faster and with greater precision and learn to use the control more rapidly.

Population stereotypes have been studied since the 1950s (Smith, 1981). However, Simpson and Chan (1988) claim that many issues remained unresolved, and many recommendations are still based on work done during the 1950s. A lot has changed since then in terms of the population itself and the mediating products that produce the stereotypes, so the existing work is by no means unequivocal (Simpson and Chan, 1988). Some stereotypes may not be transferable to modern digital interfaces, but many others will.

2.4.3 Familiar Features

At the next level again intuitive interaction can work through similar features from the same or differing domains. There is general consensus about the importance of designing artefacts that relate to users' prior knowledge and familiarity, particularly in HCI, but with growing force also in design. The experiments conducted by these authors were based on the differentiation of familiar and unfamiliar features, applied from both similar and differing domains. All these experiments showed that familiarity with a feature will allow a person to use it more quickly and intuitively (Blackler et al., 2002; Blackler et al., 2003a, b, 2004, 2005). This is the foundational conclusion to come from this research and informs the principles and models which have been developed for designing for intuitive interaction. It is envisaged that familiar features from the same and different domains would be the main mechanism for designers to use in order to apply intuitive interaction.

2.4.4 Metaphor

At its most complex, intuitive interaction requires the application of metaphor, used to explain a completely new concept or function. Metaphor involves retrieval of useful analogies from memory and mapping of the elements of a known situation, the source, and a new situation, the target (Holyoak, 1991; Lakoff, 1987). Metaphors are grounded in experience and understood only in relation to experience (Lakoff and Johnson, 1981, p202). Each experience or vicarious experience can serve as a metaphor or analogue (Klein, 1998). Intuition is enabled by this sort of transfer. Using metaphor, a problem is transferred "…to a level where immediate intuition from experience is available" (Rasmussen, 1986, p123). Metaphor allows people to transfer knowledge between domains. When a person has relevant experience in a different domain, metaphors could be used to relate that knowledge to a new situation.

2.4.5 Affordances

Norman (1988) asserts that the thoughtful use of affordances and constraints in designs allows users to determine the proper course of action, even in a novel situation. Affordances have been much popularised and have been used to describe both physical and virtual interface objects (Preece, Rogers, and Sharp, 2002). Norman (2004a) admits that by popularising the use of the term affordance in the design community he deviated from Gibson's (1977) original definition. For example, he has generalised the term to include emotional, social, and cultural affordances.

However, Norman (2004b) has tried to clarify the situation by talking about perceived and real affordances. Physical objects have real affordances, like grasping, that are perceptually obvious and do not have to be learned. A physical object like a door handle affords actions because it uses constraints; its physical properties constrain what can be done with it in relation to the person and the environment. However, a virtual object like an icon button invites pushing or clicking because a user has learned initially that that is what it does. User interfaces that are screen-based do not have real affordances; they have perceived affordances, which are essentially learned conventions.

This is a useful distinction – between “real” physical affordances that do not require learning beyond experience of being in the human body, and perceived affordances which are based on prior experience with similar things. Norman’s (2004b) perceived affordance has therefore been placed on the continuum as being equivalent to familiar features from the same domain.

It seems likely that physical affordances which are based on basic constraints that are dictated by the human body can indeed be picked up directly by anyone with a normal physique, and could be archetypical. They are related to the body and what can be done with it, and the experience required to use them is limited to experience gained through being embodied in the world; there is no cultural knowledge or even experience with similar things necessarily required here. The physical affordance (Norman, 2004b) is therefore seen as being equivalent to a body reflector (Bush, 1989): a very basic and easy to perceive fit with a part of the body, which people know and understand because of their lifelong experience of embodiment.

2.4.6 Compatible Mappings

It has been recommended that designers should exploit natural mappings, which are the basis of stimulus-response compatibility (Norman, 1988; Wickens, 1992; Wickens, Gordon, and Liu, 1998).

Stimulus-response compatibility relates to the relationships of controls and the object they are controlling. It is important because a system with a greater degree of compatibility will result in faster learning and response times, fewer errors and a lower mental workload (Wickens, 1987; Wu, 1997). Responses are faster when the structural features of stimulus and response sets correspond and the S-R mappings can be characterised by rules (Proctor, Lu, Wang and Dutta, 1995; Wickens, 1992; Barker and Schaik, 2000; Norman, 1993). These simple rules (Wickens, 1992) seem to be drawn from population stereotypes to map the set of stimuli to the set of responses. The fewer rules have to be utilised, the faster the response time.

Movement compatibility defines the set of expectancies that an operator has about how a display will respond to a control activity and is largely based on the principle of the moving part (Roscoe, 1968, cited in Wickens et al., 1998), which states that movement should be analogous to the mental model of the displayed variable (Wickens, 1992). Ravden and Johnson (1989) also relate compatibility to similarity of the interface with other familiar systems and with users’ expectations and mental models of the system. This highlights the fact that mappings are learned conventions and rely on past experience. Hence compatible mappings have been equated with population stereotypes on the continuum. Population stereotypes and compatible mapping have a similar level of intuitive interaction; they are completely ingrained cultural norms that are widely but fairly unconsciously known by the majority of a population.

2.4.7 External Consistency

Consistency is assumed to enhance the possibility that the user can transfer skills from one system to another, which makes new systems easier to use (Nielsen, 1989; Preece et al., 2002; Thimbleby, 1991). It improves users' productivity because they can predict what a system will do in a given situation and can rely on a few rules to govern their use of the system (Nielsen, 1989).

Nielsen (1989) argues that the consistency of a device with users' expectations is important, whether those expectations have come from a similar system or something different. Koritzinsky (1989) states that a consistent interface would be predictable, habit-forming, transferable and natural (consistent with the user's understanding). The main point of consistency is to establish a behaviour pattern; similar physical actions in similar situations can establish habits and teach the end user what to expect (Koritzinsky, 1989).

External consistency is the consistency of a system with things outside it; for example, metaphors, user knowledge, the work domain and other systems (Kellogg, 1987). Both principles 1 and 2 involve applying external consistency. It can be seen as equivalent to applying familiar features or applying metaphors (Kellogg, 1987).

2.4.8 The Continuum and the Principles

Figure 2 demonstrates how the principles relate to the continuum of intuitive interaction. Principle 1 relates to the simpler end of the continuum, where body reflectors, population stereotypes or familiar things from the same domain are applied. Principles 2 relates to transferring things from other domains, including the use of metaphor. Principle 3, internal consistency and redundancy (represented by the dotted line), needs to be considered at all times and so it surrounds the other principles.

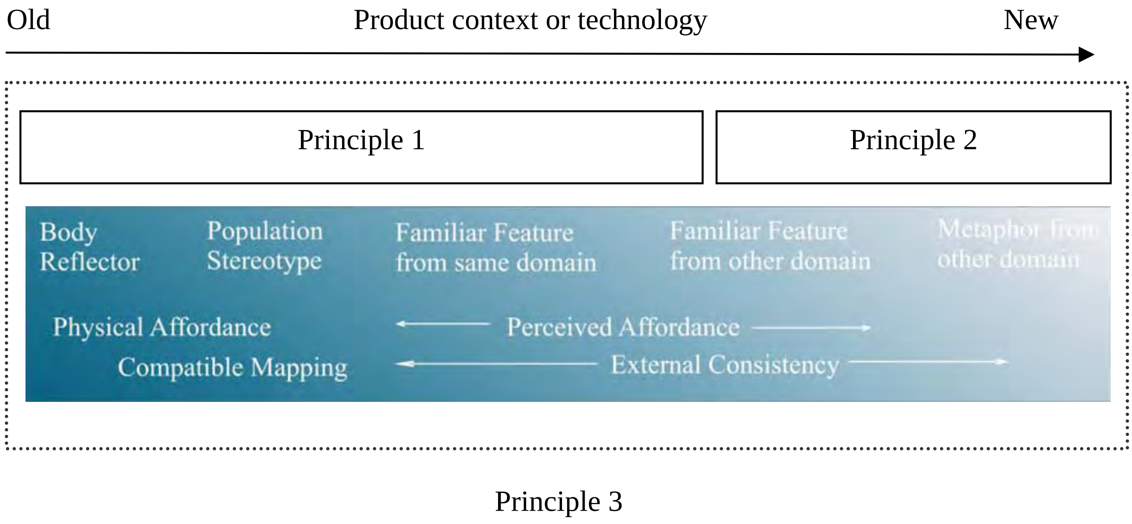


Figure 2. The intuitive interaction continuum as it relates to the principles

2.4.9 The Continuum and Technology Familiarity

Looking at this continuum, it may seem to make sense to say that as one moves along to the right, more Technology Familiarity would be required to use the interface. However, if the principles and tool suggested here are used, it should be possible to design an interface at any of these levels which people with differing levels of Technology Familiarity could use intuitively. For example, a metaphor or familiar feature from another domain may be more familiar to some than a feature from the same domain – depending on their experience with the various domains. Therefore, the continuum represents the complexity or recency of the product or technology but not the level of technology familiarity required to use it.

3.0 Conceptual Tool for Applying Intuitive Interaction

Figure 3 shows how the principles could be applied during the design process. The continuum (in a vertical orientation) is juxtaposed with an iterative spiral, which represents a design process which has a variety of entry and exit points. The spiral is based around the three "factors" of function, appearance and location (Figure 4).

Consistency and redundancy are represented as a dotted line surrounding the spiral, as also shown in Figure 2. They should be considered at all times during the design process in order for design for intuitive interaction to be effective. Applying a similar type of familiarity to each factor of each feature is part of remaining consistent. This could mean that if the function of the feature requires a metaphor, that metaphor is also applied to the appearance and location of that feature, so that the metaphor remains consistent.

Before starting design, the designers need to establish who the users are and what they are already familiar with so that they know what stereotypes, features or metaphors would be suitable to apply. Designers then need to go through the spiral twice. Firstly the structure or form of the system or product needs to be established. This would involve primarily establishing the various functions that need to be included in the interface or product, as until the functions are established nothing else can be done. Following that, overall appearance (look and feel or form) can be established, and finally, location of global features within the structure. Once this first stage is completed the spiral is entered a second time for the detailed design of each feature.

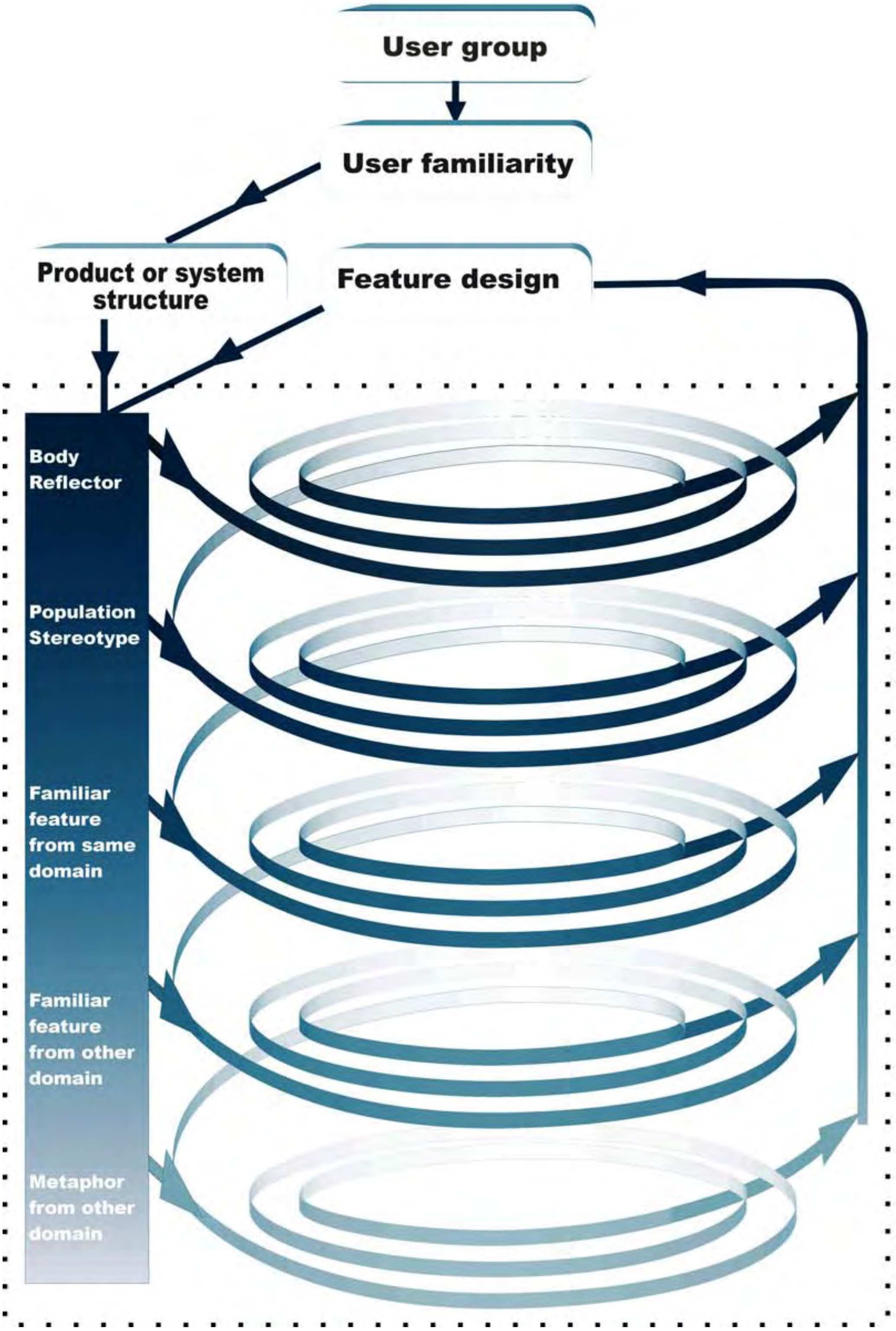


Figure 3. Conceptual tool for applying intuitive interaction during the design process

Each loop of the spiral has three layers. These layers represent the factors function, appearance and location (Figure 4). They are placed like this so that function is tackled first, then appearance and finally location. The factors are addressed in this order as that is the order of priority that has been established through this research. Appearance had more effect on intuitive interaction than location (Blackler et al., 2005), so appearance needs to be addressed before location. However, appearance and location cannot be determined for a feature that has no associated function, so function needs to be determined first.

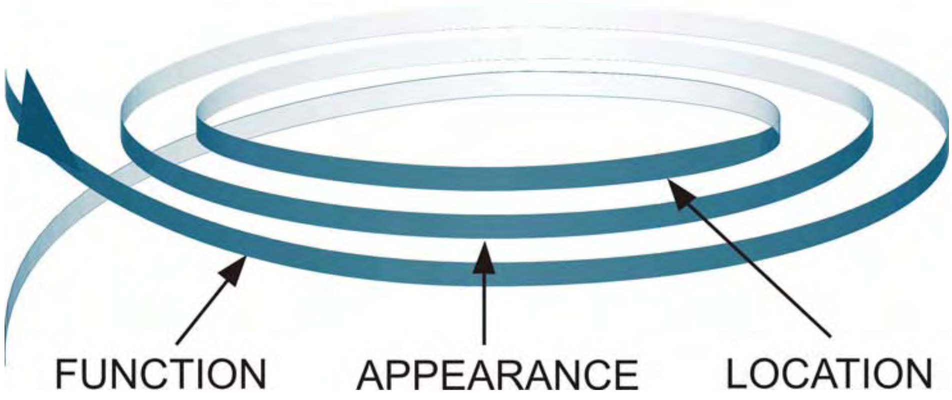


Figure 4. Detail of the three loops within each spiral.

The conceptual tool has been designed so that one can enter the spiral at a suitable point and leave it when necessary. As designers work down the spiral, they can establish the earliest point at which a familiar thing can be applied to that feature. For a simple interface, this may be a body reflector for a handle or a population stereotype for direction of a scale. For more complex interfaces, it would involve applying familiar features from similar or extra-domain products. For very new technology which has none of its own conventions, a metaphor which relates to something that is familiar to the users would need to be applied. The spiral should be exited at the point at which a suitable level is found.

However, it is also possible to enter the spiral further down if appropriate, especially after designers have worked through the first few features and have established where on the continuum they are working. Figure 5 shows an example of a designer entering and working on the continuum near the top (applying population stereotype). Figure 6 shows an example of a designer entering at the halfway point but then not finding suitable familiar features to apply, and needing to progress to the metaphor level.

Once the entire form or structure of the product and the design of all the features has been taken through this process, an appropriate level of familiarity based on things that target users already know will have been applied consistently throughout the design. According to all the conclusions reached though this research, working through this process should mean that the resulting product is intuitive to use.

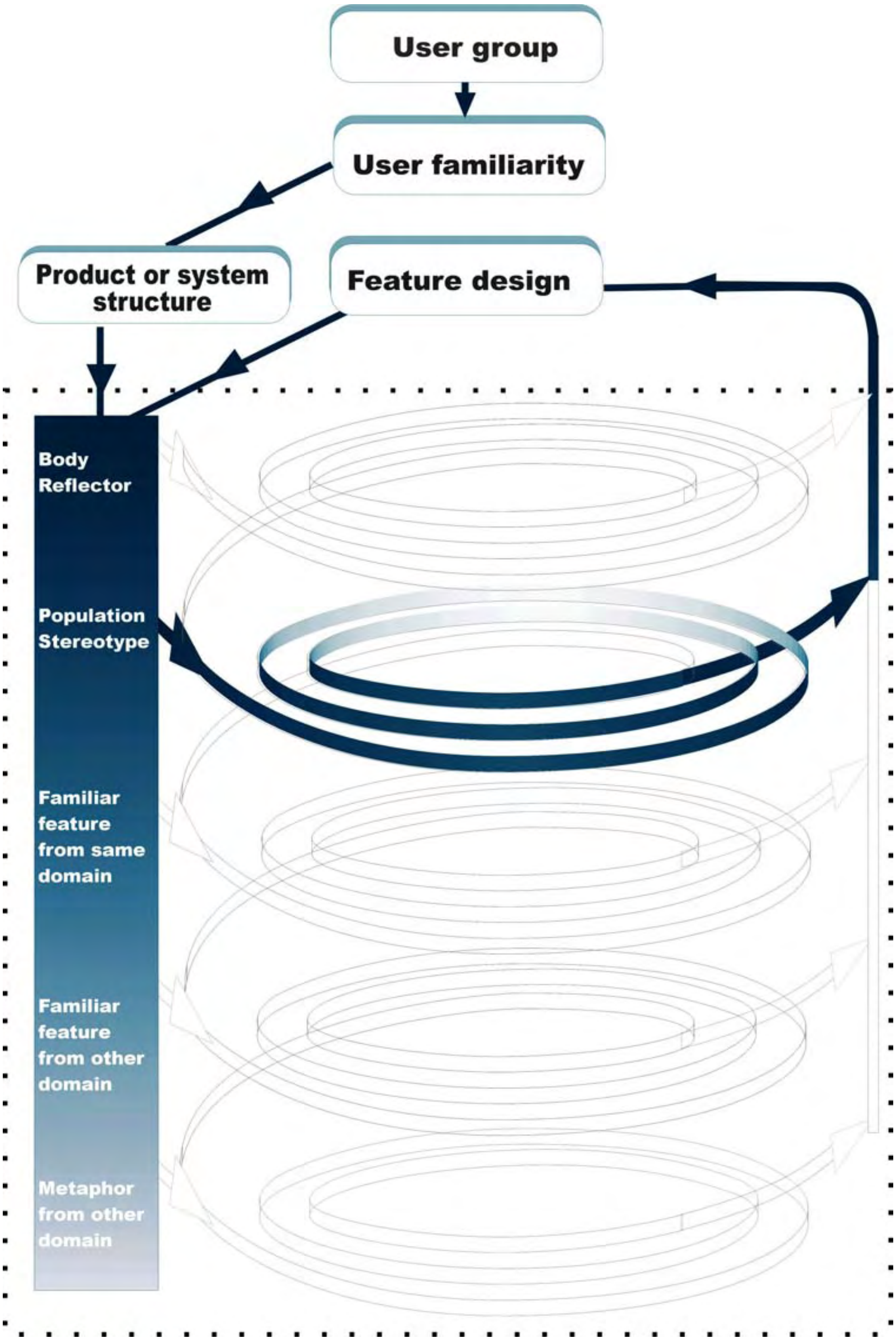


Figure 5. Working at the second level on the continuum

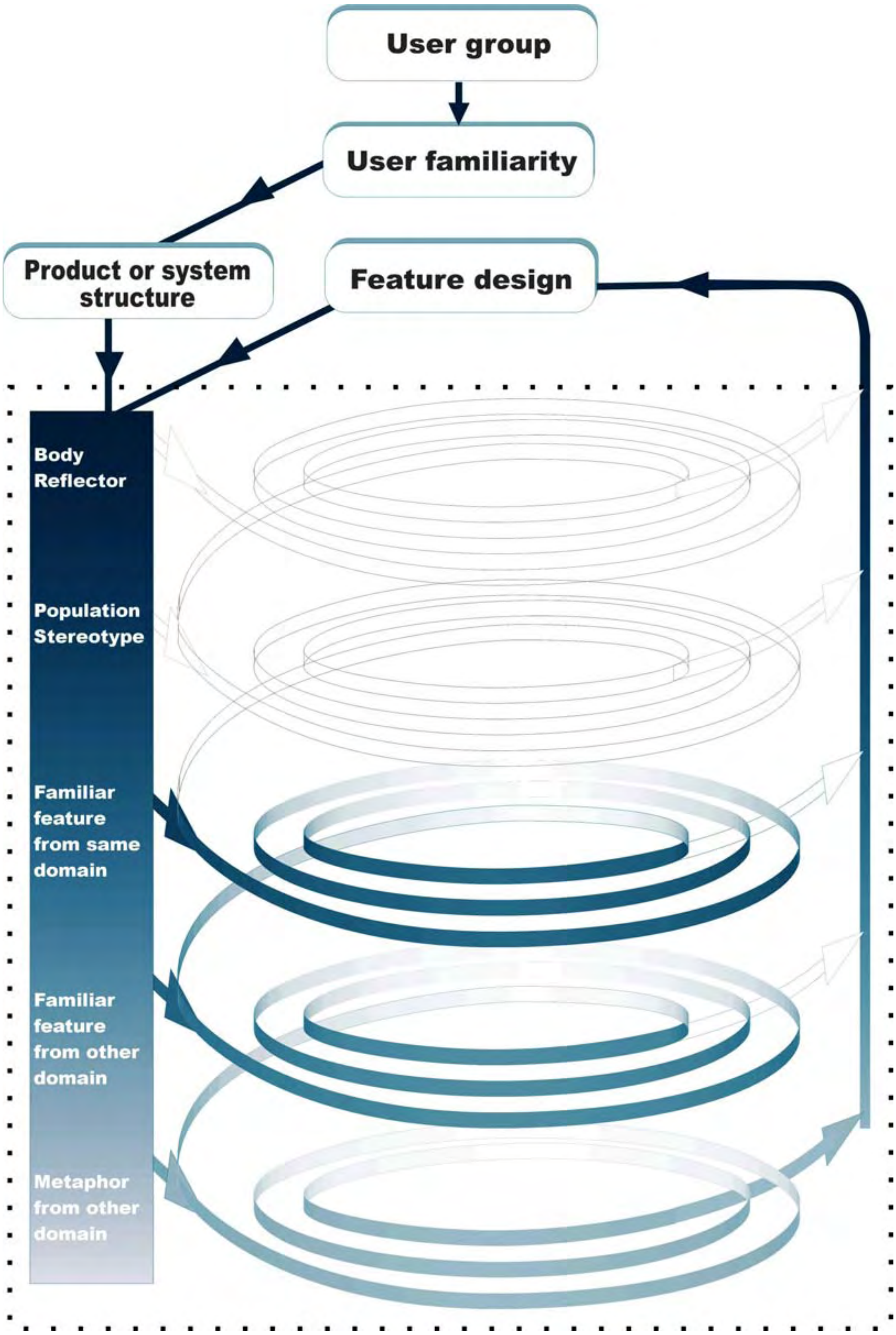


Figure 6 Working from the halfway point to the bottom of the continuum

4.0 Conceptual Tool Trial

The conceptual tool developed was trialled by asking a designer to apply it while designing a consumer product. He was asked to use the conceptual tool developed during the Intuitive Interaction research to design a digital camera, designing the form and the interaction of the camera, including menu functions, and using the model to look at function, appearance and location of each aspect in detail. He was also asked to evaluate the tool.
The designer found that the tool forced him to spend a great deal more time researching and analysing the intended users. He found this frustrating at first, but with some persistence began to see its benefits. He stated that usually he would have gone straight to researching the field of information based on the product he was designing but the model encouraged him to gain an understanding of information related to other products that the user group would already be experienced with. The designer believed that this adjustment to his research method allowed a minor breakthrough to be achieved for digital camera design. By looking at the other products that the intended user group interacts with, he was to include key aspects of products they would already be familiar with (in this case, mobile phones and existing digital cameras), and include them in the design to enable it to be used more intuitively. This is something that he did not believe he could have done if he had followed his usual design process.

However, he felt that the significance of the research component was not conveyed by the tool in its current form. The research component takes up only a very small portion of the page when viewed in comparison with the five levels for feature design, which does not accurately portray the importance of these two initial steps. He suggested that these two steps be adjusted so that they have greater presence on the page, and perhaps even extrapolated so that they give a more detailed description of what processes may be involved.

This suggests that research may need to be done in order to establish reliable ways of discovering what types of features are likely to be familiar to particular market segments. The top section of the model may then need to be adapted accordingly.

4.1 Establishing Familiarity for Various User Groups

As the trial demonstrated, "…making design decisions about familiarity is not always simple" (Rosson and Carroll, 2002, p121). Familiar terms can have multiple meanings. Also, familiarity to one user is not familiarity to others. Even translation may not achieve the same level of familiarity in another language. In order to design a product to facilitate intuitive interaction, designers need to carefully identify the target market for the products and establish what features target users would be familiar with. Metaphors should be selected for their appropriateness to the target market and should be matched to the experiences and capabilities of typical users (Smith, 1998). Many designers believe icons have more universal familiarity than labels as all users live in the same visual world, but even then items can look different. For example, mailbox icons commonly used for email are based on US rural mailbox designs which are not seen in Europe. It takes some careful research to make sure the familiar features chosen are going to be understood by all users. A localisation process may also be necessary for products released internationally.

The designer who trialled the tool found market research suggesting that many new digital camera users are first becoming used to the idea of digital photography through using camera phones, and then buying digital cameras because they desire better picture resolution (PC Magazine, 2005). He then used a detailed product review to investigate existing digital cameras and mobile phones in order to establish the function, location and appearance of each feature relevant to digital camera design. However, this was a project conducted with limited time and budget and other methods may be more reliable and applicable in commercial projects.

Spool (2005) favours field studies for identifying the user's current knowledge. Watching potential users in their own environment and working with their normal tools and tasks reveals their knowledge and the upper bounds of it. For identifying target knowledge he recommends usability testing. After a test it is possible to list all the knowledge the user needed to acquire during the test. Spool found during his user testing that groups of users form clusters around the various current knowledge points. This could lead to a way of better defining target users and what they know, but he does not explain exactly how it is done. He does say that design teams can work with users in the middle of the important clusters and this helps them to define personas. Personas were often linked to lifestyle in the past, but here is real and useful link to prior experience that could be used to allow intuitive interaction.

Margolin (1997) also discusses how designers can gain more knowledge about users. He suggests that designers gain such knowledge from their own experiences as users, from communities or subcultures of users (e.g. Internet forums or clubs), and from market research. However, none of these are really enough as they stand at present, and designers do not currently have enough information about people and products to create products that better represent the desire for a satisfying world (Margolin, 1997). Designers do not have enough information to go on when developing new products, and Margolin sees a need for large scale research on the subject of product use.

Preece et al. (2002) argue that it is imperative that representative users from the real target group be consulted, and recommend that designers start with an understanding of how people use similar products, even if the product they are designing has no exact equivalents. When introducing a new product type (their example is the introduction of the mobile phone), it may not be possible to study people using them; but there are predecessor products (e.g. standard phones) that can help to inform designers about users' behaviour with similar products. Preece at al. (2002) mention the need to find out about the tasks users currently perform, their associated goals and the context in which they are performed. They recommend a combination of naturalistic observations of users' existing tasks, questionnaires, interviews, focus groups, user participatory design workshops and studying documentation in order to find out about users' behaviour with similar products and their aspirations for the new one. Of these, observation seems to be the method they most favour; this, they say, gives insights that other techniques cannot, and they emphasise that the day-to-day use of products will differ from the procedures set out in the documentation.

Legacy systems have some advantages here as they may provide some features to draw on. For new-generation product design, it is helpful to understand the typical tasks performed with several of the antecedent products (Smith, 1998). There may be more than one of these if a new device merges tasks previously done with different products. Rohlfs (1998) describes re-design of legacy software applications. He uses current and new users' experience with an existing application (or similar products and/or applications) and also their familiarity with the task to be performed, to inform a new design. He converts this sort of information into a current task definition which describes how users currently perform the tasks. Understanding how the tasks are currently performed provides an important foundation for the design process. It allows designers to maintain the aspects of current tasks that work well, and to identify which features are well-used and would be suitable to transfer to new interfaces.

There is certainly an opportunity for further research to establish which user groups have familiarity with which types of features. Whatever tools are used, it is clear that establishing the knowledge that users already have is an important step in selecting familiar features to design into a product.

5.0 Conclusion

This paper has provided an overview of the extensive research into intuitive interaction, presented a proposed tool for applying intuitive interaction to the design process and also revealed some early results from the trialling of that tool. Intuitive interaction has been shown to be based on familiarity with similar features in an interface, and the tool developed has been used in a trial situation to facilitate the design of product features which are intuitive in their function, appearance and location. This work is moving towards a more fully developed design methodology for intuitive interaction. With this aim, future work will concentrate on more extensive testing of the tool, and developing further tools to assist designers in gaining better understanding of what users are familiar with.

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