Applied Ergonomics 41 (2010) 72–92

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

Investigating users' intuitive interaction with complex artefacts

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ARTICLE INFO

Article history:
Received 15 December 2006
Accepted 17 April 2009

Keywords:
Intuitive interaction
Intuitive use
Interface design
Observational analysis
Prior experience
Product design

ABSTRACT

This paper examines the role of intuition in the way that people operate unfamiliar devices. 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. Two initial experimental studies 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. A third experiment confirmed that performance is affected by a person's level of familiarity with similar technologies, and also revealed that appearance (shape, size and labelling of features) seems to be the variable that most affects time spent on a task and intuitive uses during that time. Age also seems to have an effect. These results and their implications are discussed.

1. Introduction

In general parlance, in advertising and in academic papers (e.g. Frank and Cushcieri, 1997; Rutter et al., 1997; Thomas and van-Leeuwen, 1999), the terms "intuitive interaction" or "intuitive use" have been commonly used. However, there was previously no agreed definition of intuitive use and no experimental work to establish how it might work. The present authors aimed to de-mystify "intuitive use" or "intuitive interaction" and establish how it could be applied to new products in order to make them easier to use.

In order to achieve this aim it was necessary to base the research on a theoretical foundation which includes an understanding of the nature of intuition itself and how it relates to use of products and interfaces, and to empirically test that understanding in order to see how it can best be applied to design. This paper discusses the definition and operation of intuition. Based on this understanding of intuition, a definition of intuitive use or intuitive interaction is presented. Three experiments investigating intuitive interaction are described and findings and recommendations discussed.

1.1. Intuition

This section will briefly review the literature in relation to the main properties of intuition: prior experience, non-conscious processing, speed, individual differences, and correctness. A much more in-depth discussion can be found in Blackler (2008).

1.1.1. Prior experience

This research is grounded in the underlying assumption that intuition is based on past experience. Much research suggests that intuition relies on experiential knowledge (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). 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 they are not aware that intuition comes from their own experience. Described in this way, intuition does not seem as mysterious as some people may at first assume (Klein, 1998).

Bowers et al. (1990) propose that intuition involves memory and experience in judgement and problem solving; 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 access.

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0003-6870/$ – see front matter
doi:10.1016/j.apergo.2009.04.010

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 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 often not recognised by the general public, and many lay people may assume intuition is instinctive or innate (Cappon, 1994).

The intuitive process integrates the information that one already has with what is perceived by the senses, and new associations between these various pieces of information produce insights, answers, recognition or judgements (Bastick, 2003). Boucouvalas (1997) suggests that intuitive knowing may have different origins, for example the memory or the senses. An optimum intuitive solution will have the most attributes in common between the fewest elements or, in other words, be a good match between stored experience and the current perceived situation (Klein, 1998). Thus, intuition uses a combination of existing knowledge and the perceived situation to rapidly generate answers.

Klein (1993) introduced the Recognition Primed Decision (RPD) model, 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). Because the RPD model is based on decision makers using their existing experience, Klein (1998) sees it as a model of intuition.

Rasmussen (1993) developed the Skill–Rule–Knowledge (SRK) model of task performance. This model 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 elements of tasks but lacking extensive experience will be processing at the rule-based level. 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 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.

Wickens et al. (1998) 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. 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 (Wickens et al., 1998). Klein (1993) also found that analytical strategies were often used by decision makers with less experience.

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 or continuum model of cognition, with intuition somewhere in the middle and analysis and automatic processing at each end.

1.1.2. Non-conscious processing

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 (Baars, 1988; Dorfman et al., 1996). 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 non-conscious 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).

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. 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 rather than reasoning *per se* (Wickens et al., 1998). Bastick (2003) claims that the intuitive process could be non-conscious except for some of the sensations or guiding feelings of which the person must become consciously aware.

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 this passive form of remembering. 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 non-conscious 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 et al. (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.

Bowers (1984) claims that perception and consciousness of stimuli are different, and that it is selective attention that transforms 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) suggests that cues that trigger intuitive processing could be the things that go unappreciated.

Ideas such as implicit knowledge (Reber, 1992) and the noticing threshold (Bowers, 1984) 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, meaning that people may believe that they have never been in a similar situation before. For example, 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. 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.

1.1.3. Speed

Intuition also yields quick results, as it allows people to grasp meaning or significance without relying upon slower, analytical processes (Bastick, 2003; Salk, 1983). Intuition is a highly efficient way of knowing which is fast and accurate. It allows processing of a wide array of information on many levels and provides an instantaneous cue about how to act. The answer is provided despite the fact that a person does not understand all the steps or know fully all the information processed to come up with it (Agor, 1986).

Clark (1997) claims that the speed of non-conscious processes is based on parallelism. 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.

1.1.4. Individual 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). 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 in experimental work (Carroll, 2003).

Woolhouse and Bayne (2000) found 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. 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.

These ideas suggest that people use intuition if they have experience to draw on, but use more analytical processes otherwise. This is important, as designing for intuitive use must rely on users being able to utilise intuition if it is to have any impact.

1.1.5. 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). Intuition is always considered to be subjectively correct, and intuitive perceptions are experienced as true in the same way that sensory data is experienced as true, but where there is an accepted correct answer for comparison, intuition may not always completely agree (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). 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.

1.1.6. Summary

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. Tools, artefacts and other life experiences all contribute to the store of information on which intuition can draw.

Rasmussen (1993) and Wickens et al. (1998) distinguished intuitive, or rule-based, processing from automatic processing. 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). 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).

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 people are with it will influence the type of processing they use. From the understanding explained in this section, a definition of intuition was 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 (Blackler, 2008; Blackler et al., 2002).

1.2. Intuitive interaction

This section will address the previous work on intuitive interaction with products and systems in the realms of product design and human–computer interaction (HCI). The concept of intuitive interaction has been widely mentioned and even applied but never previously addressed in depth. Several authors (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 interaction to new designs. However, none of them describe in sufficient detail exactly how products and systems can be designed to encourage intuitive interaction. Some use the terms but do not define what they mean by intuitive or intuitive use, 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.

However, despite that fact that the term intuitive has been overused and under-explained in the literature, it can be inferred from the descriptions of new designs that are given that most of these authors 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 was 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.

The HCI tradition has tackled intuitive interaction more fully than the product design arena, and Raskin's definition of "intuitive equals familiar" (Raskin, 1994) is possibly the reason for this greater willingness to tackle the issue in HCI in recent years. 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 graphical user interfaces (GUIs) and to recent websites, wearable computers and Virtual Reality (VR) software (Knopfle and Voss, 2000; Lehikoinen and Roykkee, 2001; Perkins et al., 1997; Raisamo and Raiha, 2000; Smith et al., 1982).

However, despite the greater depth of understanding in the HCI fields, no authors had previously 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. This paper reports on research that empirically establishes how intuitive interaction and familiarity are related and how the different aspects of an interface design can affect intuitive interaction.

Based on the understanding of intuition explained above, and the available literature on intuitive use, the definition formulated for intuitive interaction for the purposes of this research was:

Intuitive use of products involves utilising knowledge gained through other experience(s). Therefore, products that people use intuitively are those with features they have encountered before. Intuitive interaction is fast and generally non-conscious, so people may be unable to explain how they made decisions during intuitive interaction (Blackler, 2008; Blackler et al., 2002; Blackler et al., 2003a,b, 2004a,b, 2005, 2007).

The authors could have abandoned the use of the word intuitive or intuition and instead talked only about prior knowledge or transfer of experience. However, the phrases "intuitive use" and "intuitive interaction" would have continued to be used and misunderstood. Also, intuitive interaction adds a further dimension than simple knowledge transfer or prior experience – that of non-conscious or implicit knowledge. This is important in designing for intuitive use as it is not always simple to elicit users' implicit knowledge about interface features. Therefore, the research was specifically based on the foundation of this understanding of intuition and intuitive interaction. Intuitive interaction research is now becoming an emerging field (e.g. Hurtienne and Blessing, 2007; Hurtienne and Israel, 2007; Marsh and Setchi, 2008; Mohs et al., 2006; O'Brien et al., 2008a,b).

1.2.1. Intuitive use heuristics

The understanding of intuitive interaction described here was used in this research as the basis of a coding scheme for determining which feature uses were intuitive during three experiments. Noldus Observer software was used to code the video footage and concurrent verbal protocol. The coding scheme and analysis have been reported in depth elsewhere (Blackler, 2008, 2004b), but the coding system is summarised here for clarity. The dependant variables common to all the experiments were time on tasks, number or percentage of intuitive uses and intuitive first uses, and subjective measures of familiarity of product features.

Time on task is relevant as intuitive processing is faster than more conscious types of processing (Agor, 1986; Bastick, 2003; Salk, 1983), so participants interacting intuitively with the product should complete tasks more quickly. However, it could not be assumed that completing the task quickly was always the same as completing it intuitively; a measure of intuition or intuitive uses was also needed. Number or percentage of intuitive uses and intuitive first uses are problematic variables to measure, but are also the most direct way the authors have found of quantifying intuitive interactions. The main indicators of intuitive uses that were employed to make the decisions about types of use during the coding process are explained below.

1.2.1.1. Evidence of conscious reasoning. Since intuitive processing does not involve conscious reasoning or analysis (Agor, 1986; Bastick, 1982, 2003; 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. Often, participants processing intuitively did not verbalise the details of their reasoning. They briefly verbalised a whole subtask rather than all the steps involved; or they started to press a button and then stopped to explain what they were about to do; or performed the function and then explained it afterwards. Their verbalisation was not in time with their actions if they were processing unconsciously while trying to verbalise consciously. Table 1 shows examples of an intuitive use and a reasoning use of the four-way navigation feature on a universal remote control (Experiment 2), with times for each use shown. Both were correct uses on the first encounter of this function. 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.

Table 1
Intuitive and reasoning uses.

Reasoning 21 s	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 s	Aha! OK here we go and I want to go to clock set. OK.

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

1.2.1.3. 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). 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.

1.2.1.4. Latency. When users were able to correctly locate and use a feature reasonably quickly, it could be coded as intuitive. 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 feature with no more than five seconds latency, and often much less, commonly one or two seconds.

1.2.1.5. Relevant past experience. Participants would sometimes mention that a feature was similar to one at home, or that they had seen a feature before, showing evidence of their existing knowledge.

"Intuitive use" codes were applied cautiously, and only when the use showed two or more of these characteristics. Any uses about which there was doubt were not coded as "intuitive". All recordings were double-checked.

1.2.2. Correctness of use

Correct uses were those that entailed the correct action for the feature and for the task or subtask. Correct-but-inappropriate uses involved a correct use of a feature which was not correct for the task or subtask. Incorrect uses were wrong for both the feature and the task or subtask. 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 feature or 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.

2. Experiment 1

Experiment 1 was undertaken to investigate the hypothesis that intuitive interaction is based on past experience. It was designed to investigate whether past experience of product features increased the speed and/or intuitiveness with which people could use those features, and whether interface knowledge could be transferred from known products to new ones.

2.1. Method

2.1.1. Participants and experiment design

A between-groups, matched-subjects experiment design was used. Twenty Queensland University of Technology staff members were recruited from a pool of volunteers. None of the participants had previously encountered the digital camera used in the experiment, and participants received no payment.

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 so that there was a realistic distribution of gender and age throughout the four experimental groups. This information was collected at the recruitment stage using a simple survey instrument. Dependant variables were time to complete tasks and percentage of intuitive uses, particularly intuitive first uses.

2.1.2. Apparatus and measures

The Fuji 4700 zoom digital camera was chosen for this experiment as it had a mix of features, some unique to this model and others familiar to some users as they had been employed in other cameras, other digital cameras, and other products.

The experiment took place at the People and Systems laboratory at Queensland University of Technology with a constant level of artificial light, and the recording equipment was positioned in the same way for each participant. Two digital video cameras were used to record the participants' interaction with the camera. As per Bocker and Suwita (1999) and Vermeeren (1999), one was trained on the participants' hands, and the other recorded torso and facial expressions (Fig. 1). 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. These images were synchronously mixed and recorded to produce one MPEG file that showed both scenes.

The technology familiarity (TF) questionnaire (example in Appendix A) 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 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 score for each participant (example in Appendix B). More exposure to, and knowledge of, the 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. Since technology familiarity

Fig. 1. Laboratory set-up during experiments.

score was an untested variable at this stage, it was not used as the IV for Experiment 1.

A structured interview was also used. During the interview, participants gave ratings (from 1 to 6) for familiarity of each of the features they had used.

2.1.3. Procedure

Participants were first welcomed to the laboratory and given an information package to read and a consent form to sign. Then all the equipment to be used and the tasks to be performed were explained clearly using a pre-determined script. Intuition has been shown to be vulnerable to anxiety (Bastick, 1982, 2003; Laughlin, 1997). Thus a calm environment was provided and participants were encouraged to relax and not to worry about the experiment or their performance.

The participants were asked to complete two operations, each of which consisted of a number of tasks:

- Use the camera to take a photograph in auto-focus mode using the zoom function;
- 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.

Participants were asked to think aloud (concurrent verbal protocol) while they performed these tasks. The manual for the camera was available only on request, and participants were asked to try to work out the operations for themselves, as 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. Immediately after the completion of the operations, the technology familiarity questionnaire was completed and the structured interview conducted.

2.2. Results

Statistically significant results are shown with p values (alpha levels) as $>$ or $<$ multiples of .01 or .05. Non-significant results are shown as n.s. Power and effect size are included only where relevant. All error bars are standard error of the mean $\times 1$.

Fig. 2 presents time to complete the operations as a function of level of expertise. These data suggested that no strong relationship exists between time and the IV level of expertise, and a one-way ANOVA revealed no significant differences between the times of the participants in the four groups, $F(16) = 1.033$, n.s. However, the power is low for this analysis (.23) and the effect size relatively high ($E^2 = .16$), 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.

Fig. 3 presents the relationship between time to complete the operations and the technology familiarity score, and shows the strong negative correlation between these two variables, $r(18) = -0.69$, $p < .01$. The IV level of expertise of each participant is also shown.[1]

There was a strong positive correlation between the percentage of intuitive first uses (correct and correct-but-inappropriate) throughout the operations and the technology familiarity score, $r(18) = 0.643$, $p < .01$. 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 (Fig. 4).

The total percentage of intuitive uses of the features (correct and correct-but-inappropriate) was compared with the familiarity ratings 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 Fig. 5.

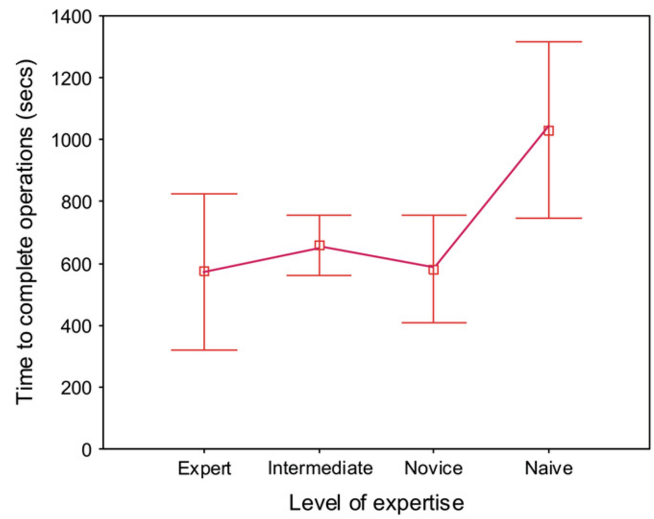


Fig. 2. Time to complete operations plotted against level of expertise.

2.3. 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 included features that had been transferred from other digital products. Expert digital cameras users 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

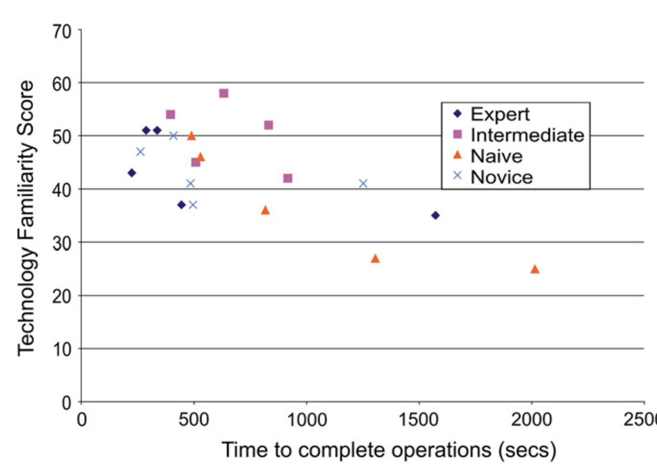


Fig. 3. Time to complete operations plotted against technology familiarity score.

[1] This data set was also tested after removal of the outlier evident at 1995 s in Fig. 3 and the result was still a significant negative correlation, $r(17) = -0.56$, $p < .05$.

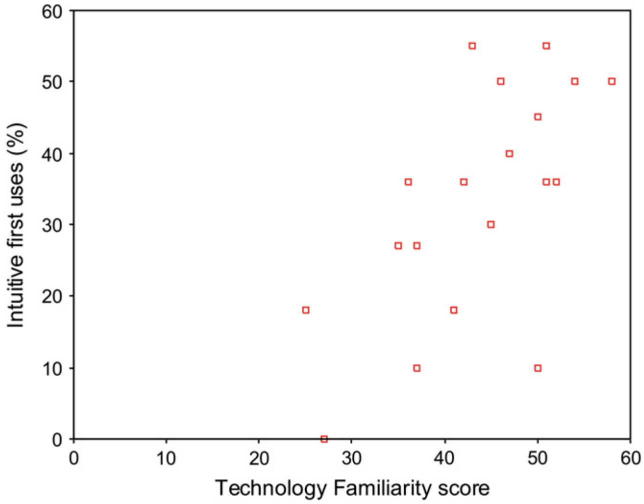


Fig. 4. Technology familiarity score plotted against percentage of intuitive first uses (correct and correct-but-inappropriate).

shown in the strong negative correlation between time and technology familiarity score, and suggests that level of expertise is not an appropriate IV for this type of experiment. TF is a better indicator of transferable past experience.

The intuitive first uses results are particularly important as, in these cases, 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 past experience of similar features, 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.

3. Experiment 2

This experiment was designed to test the findings of Experiment 1 with a larger sample of participants and a different type of product (a universal remote control). It also aimed to gain an understanding of the features of the remote control used in the experiment, in order to re-design it for Experiment 3. Experiment 2 was based on the same method as Experiment 1.

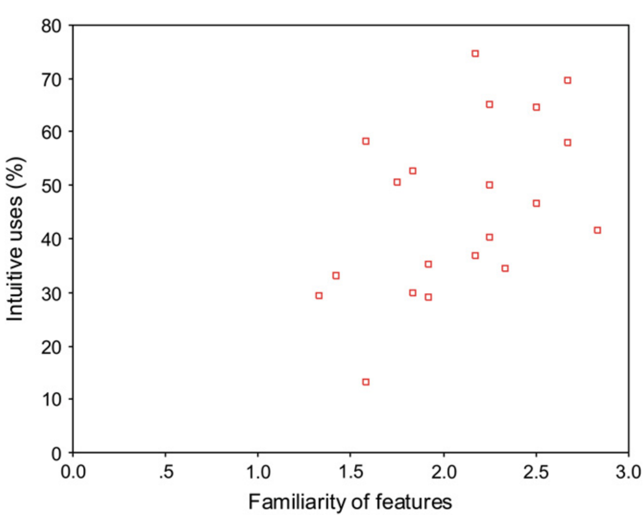


Fig. 5. Mean familiarity of features plotted against mean percentage of intuitive uses of features (correct and correct-but-inappropriate).

3.1. Method

3.1.1. Participants and experiment design

Technology familiarity was the independent variable used to group the participants for Experiment 2. This experiment was a between-groups matched-subjects design, and thirty QUT staff in three groups (high, medium and low level of technology familiarity) were recruited from a pool of volunteers. TF score was used as the IV for Experiment 2 as it had proven useful and more accurate for this purpose than the traditional categories used for Experiment 1. The Dependant Variables used were similar to those employed in Experiment 1; time to complete tasks and number of intuitive uses, particularly intuitive first uses. Individual differences were controlled by choosing a cross-section of the volunteers in terms of age, level of education and gender for each group. None of the participants had encountered the remote control used in the tests before the experiment began, and they received no payment.

3.1.2. Apparatus and measures

The Marantz RC5000i universal touch screen remote control (Fig. 6) was programmed to control a Panasonic NV SD 220 VCR and NEC Chromovision TV. The operations were designed to utilise seventeen of the features of the product, 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.

As per Experiment 1, two digital video cameras were used to record the activity.

The technology familiarity questionnaire (Appendix A) was used as a recruitment tool for this experiment. It was adapted from the one used for Experiment 1 to include products with features similar to the remote rather than 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 B.

3.1.3. Procedure

The procedures for the experiment and interview were the same as for Experiment 1, with some exceptions. Firstly, the technology familiarity questionnaire was completed as a part of recruitment rather than part of the follow-up interview. Secondly, the remote control was the mediating product instead of the camera, and the operations were therefore different:

Fig. 6. Remote control default interface on VCR main screen.

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

At the start of each experiment, the remote control was 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 pre-recorded program.

3.2. Results

There were no significant differences in the time to complete the tasks based on level of education, $F(3, 26) = .84$, n.s. ($E^2 = .088$, power = .206), or gender, $t(28) = .55$, n.s. ($E^2 = .011$, power = .083). Level of education also had no significant effect on intuitive uses, $F(3, 26) = 2.03$, n.s. ($E^2 = .19$, power = .46). A t test revealed that gender also had no significant effect on number of intuitive first uses, $t(28) = 1.59$, n.s. 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 had some effect on time and/or intuitive uses.

Fig. 7 presents the relationship between time to complete the operations and the technology familiarity group. Levene's test showed that homogeneity was breached, $F(2, 27) = 10.22$, $p < .0001$. Therefore, in accordance with Keppel (1991), a strict alpha level of .025 was adopted. The ANOVA showed a significant difference in time to complete tasks, $F(2, 27) = 5.77$, $p < .01$. According to the Tukey HSD test, this difference was between the high technology familiarity and low technology familiarity groups ($p < .01$). Therefore, participants who had a higher level of technology familiarity were quicker at doing the tasks.

For time to complete operations for each age group, Levene's test showed a breach of homogeneity, $F(3, 26) = 8.73$, $p < .0001$, so the alpha level of 0.25 was again 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 Fig. 8. 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 ($p < .05$).

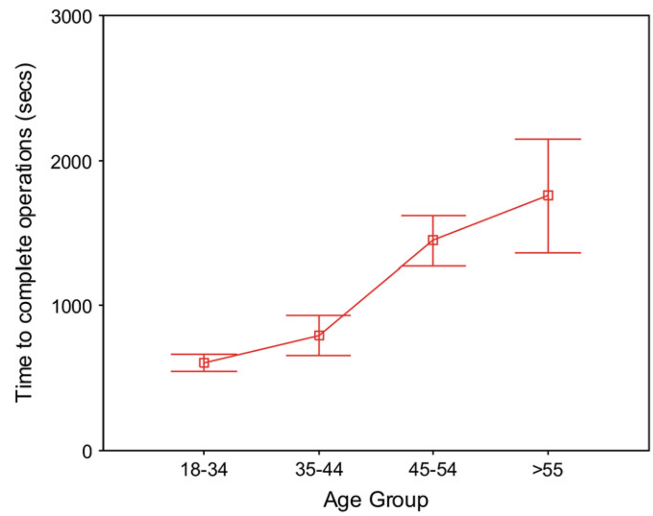


Fig. 8. Time to complete operations by age group.

A one-way ANOVA revealed that TF group had a significant effect on the number of intuitive first uses (correct or correct-but-inappropriate), $F(2, 27) = 8.58$, $p < .001$ (Fig. 9), 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. A one-way ANOVA showed that age group significantly affected the number of intuitive first uses, $F(3, 26) = 8.62$, $p < .0001$ (Fig. 10), with the Tukey post hoc test showing the significant difference between the 18–34 groups and both the 45–54 group ($p < .005$) and the >55 group ($p < .005$).

The percentage of intuitive uses of the features was compared with the familiarity of the features, as rated by participants during the interviews. It was found that the mean familiarity of the features correlated strongly and positively with the mean of the

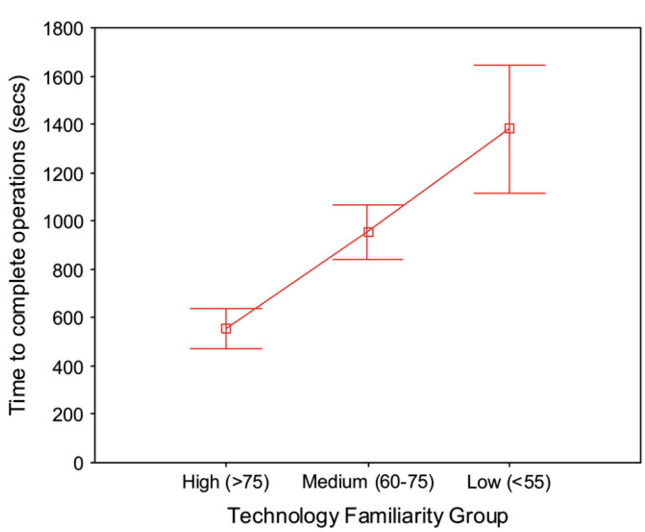


Fig. 7. Time to complete operations for each technology familiarity group.

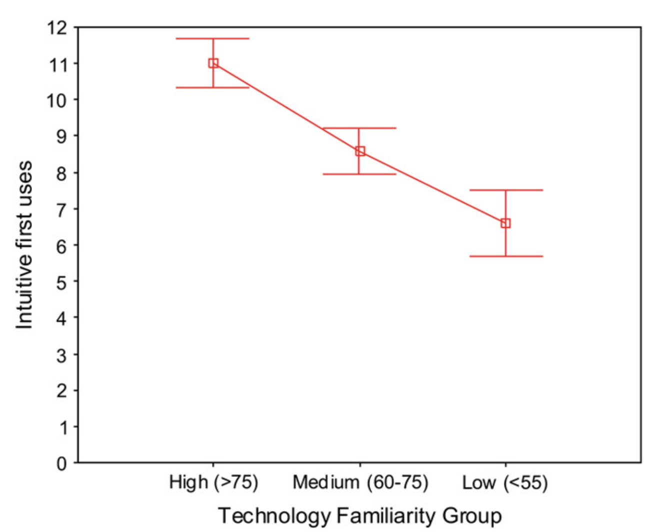


Fig. 9. Intuitive first uses (correct and correct-but-inappropriate) by technology familiarity group.

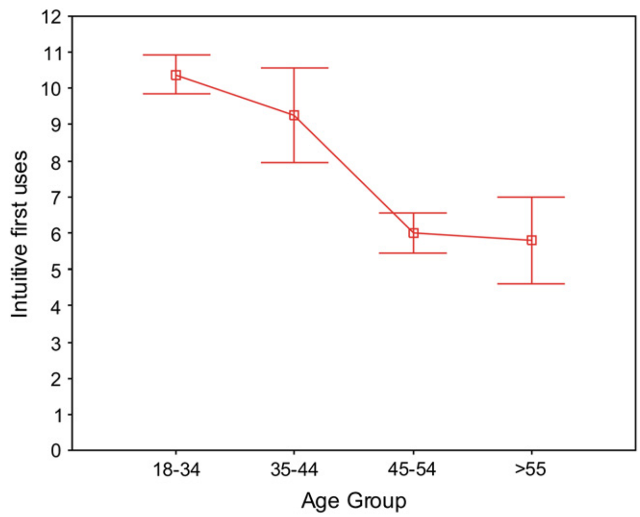


Fig. 10. Intuitive first uses (correct and correct-but-inappropriate) by age group.

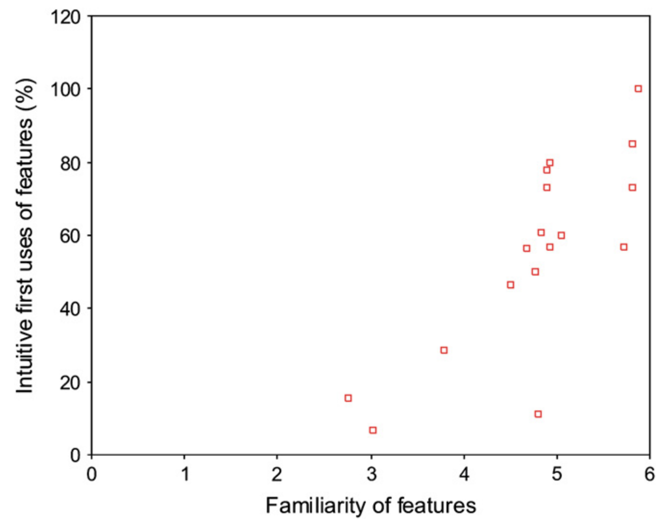


Fig. 12. Intuitive first uses of features (correct and correct-but-inappropriate) by familiarity of features.

percentage of intuitive uses of the features (correct and correct-but-inappropriate), $r(15) = .698$, $p < .05$ (Fig. 11). Mean familiarity of features and intuitive uses of features (correct only) did not correlate significantly, $r(15) = .38$, n.s. However, the correlation is moderate so it is possible that this result was not significant due to low power.

The percentage of intuitive first uses of features (correct and correct-but-inappropriate) also correlated strongly and positively with familiarity, $r(15) = .80$, $p < .0001$ (Fig. 12), as did the percentage of intuitive first uses of features (correct only), $r(14) = .75$, $p < .001$.

3.3. Discussion

The relationships between time, TF score and intuitive uses of the features supported the findings of Experiment 1. People use their previous experience with similar features in order to use new features intuitively. 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.

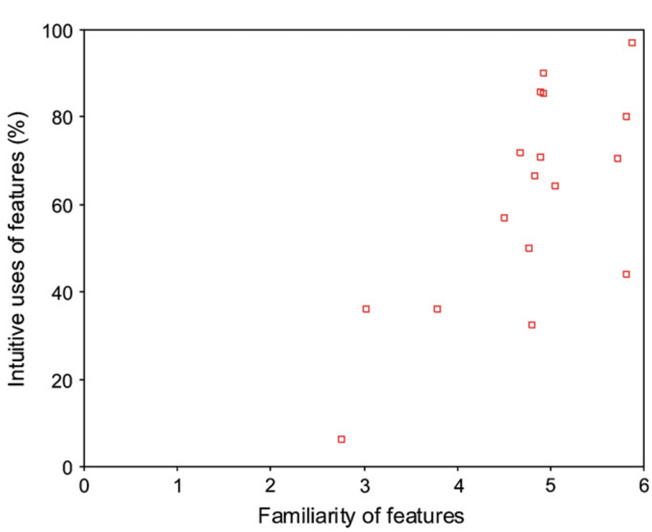


Fig. 11. Mean familiarity of features plotted against mean percentage of intuitive uses of features (correct and correct-but-inappropriate).

The detailed data on the features obtained from this experiment enabled the re-design of the remote control in a systematic way that was aimed at increasing the intuitiveness of the product. Further discussion of the usability and re-design issues that were revealed by this experiment can be found in Blackler et al. (2003a). The relationship between age and intuitive uses and time on task is an interesting one and needed further clarification. This issue was addressed in Experiment 3.

4. Re-design

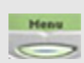
Experiments 1 and 2 revealed that prior knowledge of features of a digital camera and a universal remote control allowed participants to use those features quickly and intuitively. However, neither of the first two experiments revealed which factors of the features (function, location or appearance) had the most influence on intuitive interaction. Since function was pre-determined by the product, Experiment 3 was designed to establish whether the location or appearance of a feature was the dominant factor in intuitive use. It was also intended to investigate more closely the relationship between age and intuitive interaction.

4.1. Principles of intuitive interaction

The following preliminary principles were developed, based on Experiments 1 and 2:

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 to demonstrate their function.
3. Increase consistency so that function, location and appearance of features are consistent between different parts of the design (in this case between controls for different AV devices) and on every screen, mode and/or part.

Table 2
Specified features for remote control re-design.

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	 
4-way	Designer's choice	
VCR on/off	CEI/IEC 60417-2	
Enter Menu	Designer's choice Label as VCR menu Exact style designer's choice	
TV on/off	CEI/IEC 60417-2	
AV function	Label as TV/Video Exact style designer's choice	
Remote on	Label as "Touch screen to start" or similar Exact style designer's choice	
Back/ahead	Label Back and → as Internet Browsers Mark hard keys as mobile phones	
Skip/index	ISO/IEC 18035	 

4.2. Interface design process

Eighteen postgraduate industrial designers were asked to re-design the remote control interface according to the preliminary principles. The researcher developed a brief, specifying the icons to be used for particular features (Table 2), and students were given copies of the specified icons in enlarged format. Before starting the design process, the students attended a presentation explaining the research and previous findings. They also undertook the operations used for Experiment 2 in order to gain experience at using the remote control.

The icons provided to the designers 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 would 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 feature appearances and locations were most common and therefore 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.

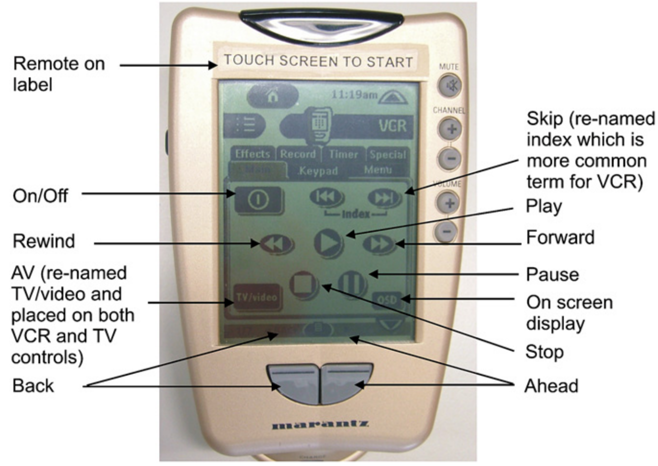


Fig. 13. Location–Appearance interface on VCR main screen.

The main VCR screen of the chosen interface design is shown in Fig. 13. This can be compared to the same screen on the default interface (Fig. 6). It can be seen that both appearance and location of the features have been changed in accordance with Table 2. Four interfaces were required for Experiment 3 (Table 3). The chosen interface design (Fig. 13) was used as the Location–Appearance interface and was also adapted into the Location and Appearance interfaces. The Location interface used the re-designed locations for the features with the default appearances, while the Appearance interface used the re-designed appearances with the default locations.

The software used to produce the interfaces from the individual bitmaps provided by the student was the Marantz RC5000 setup package version 2.3 (available through Marantz and designed for the purpose of re-configuring the remote). This package was the only one that could be used to assemble the bitmap images of the buttons onto the screens and download each interface into the device.

5. Experiment 3

Experiment 3 had two objectives: testing the three new interfaces against the default interface 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; and further investigating the links between age, time on tasks and intuitive uses.

Table 3
Interface designs for Experiment 3.

Interface	Explanation
Default	Default interface used in Experiment 2
Location	New location for features, default appearance
Appearance	New appearance for features, default location
Location–Appearance	New appearance and location.

Table 4
Experimental groups for Experiment 3.

Interface	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

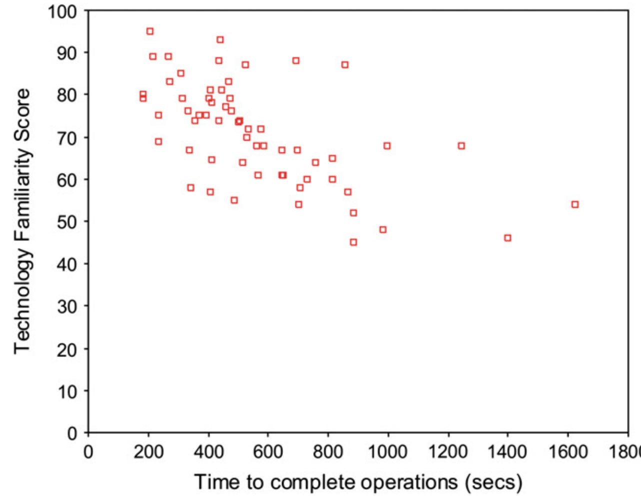


Fig. 14. Time to complete operations by technology familiarity score.

5.1. Method

5.1.1. Participants and experiment design

Participants were recruited from a pool of volunteers from university staff and students and employees of three local companies. 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 4×3 matched-subjects between-groups design was chosen to yield adequate power (Table 4). The IV interface had four conditions: Appearance, Default, Location and Location–Appearance. The IV age group had three conditions: 18–29, 30–39 and >40.

5.1.2. Apparatus and measures

As in the previous two experiments, the dependant variables were time to complete operations and intuitive uses. The products and equipment used in this experiment were identical to those used in Experiment 2, except that the remote used the four different interfaces instead of just the default one. This was a matched-subjects design and in order to balance the groups, potential participants were asked to fill in a technology familiarity questionnaire, which included general demographic questions, when they volunteered. Therefore, all groups had an equivalent representation of gender, level of education and TF score. The TF 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 (Appendix A). However, volunteers were asked for their exact age rather than age group in order for the age variable to be investigated more thoroughly.

5.1.3. Procedure

Apart from some minor differences (reported below), the procedure followed for the experiments and interviews was identical to that for Experiment 2. The participants were asked to complete the same three operations as those set in Experiment 2. As previously, participants were delivering concurrent protocol during the operations.

The first difference was that each interface 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. Stick on labels for “remote on” and “back/ahead” features (Fig. 13) were also added for the Appearance and Location–Appearance interfaces. Secondly, one video camera was focussed close-up on the participants' hands as they operated the remote, and 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. This was done to allow for easier coding of the clock-set task.

5.2. Results

The assumptions upon which Experiment 3 was based were drawn from the findings of Experiments 1 and 2. The assumptions were that those with a higher technology familiarity score would perform the tasks more quickly and intuitively than those with

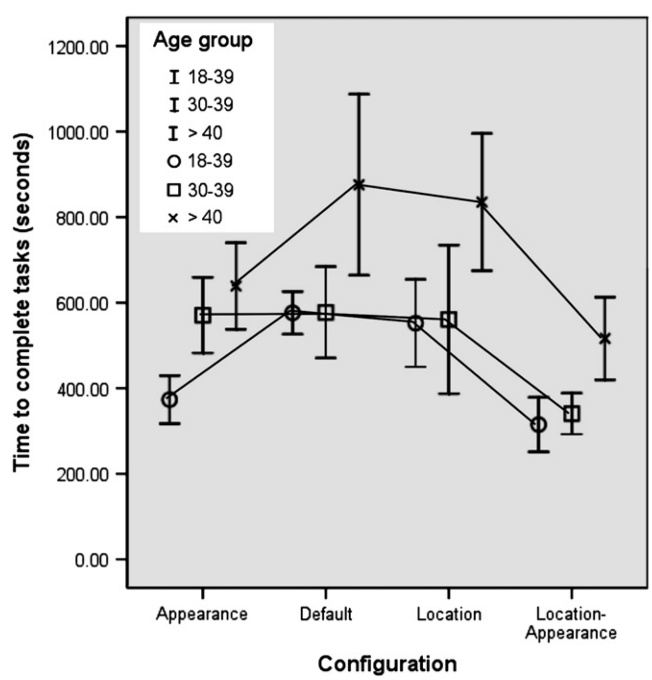


Fig. 15. Time to complete operations by interface and age group.

lower scores, and that there would be no significant differences in performance due to gender or level of education.

There was a significant negative correlation between technology familiarity score and time to complete operations, $r(58) = -.57$, $p < .0001$, and a significant positive correlation between technology familiarity 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 Fig. 14. 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, $t(59) = .72$, $p < .05$. 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 four interfaces can be seen as valid.

Time to complete operations showed variation between the groups (Fig. 15). A two-way ANOVA revealed that interface had a significant main effect on time to complete tasks, $F(3, 48) = 3.801$, $p < .05$. 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, revealing that participants using the Location–Appearance interface were significantly faster than those using both the Location and Default interfaces.

Age group also had a significant main effect on time to complete operations, $F(2, 48) = 5.627$, $p < .01$. The significant difference between age groups indicates that age is a predictor of the time taken to do the tasks, with the Tukey post hoc test revealing that both the younger groups completed the operations significantly faster than the oldest one. There was no interaction between age and interface, $F(6, 48) < 1$, n.s.

The percentage of intuitive first uses (correct only) showed a significant main effect between the interfaces, $F(3, 48) = 5.584$, $p < .005$. All the new interfaces had a higher percentage of intuitive first uses (correct only) 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) (Fig. 16). Again a Tukey HSD post hoc test was used to explore the significant main effect. Intuitive first uses (correct only) were significantly higher for the Location–Appearance group than the Location ($p < .05$) and Default ($p < .005$) groups.

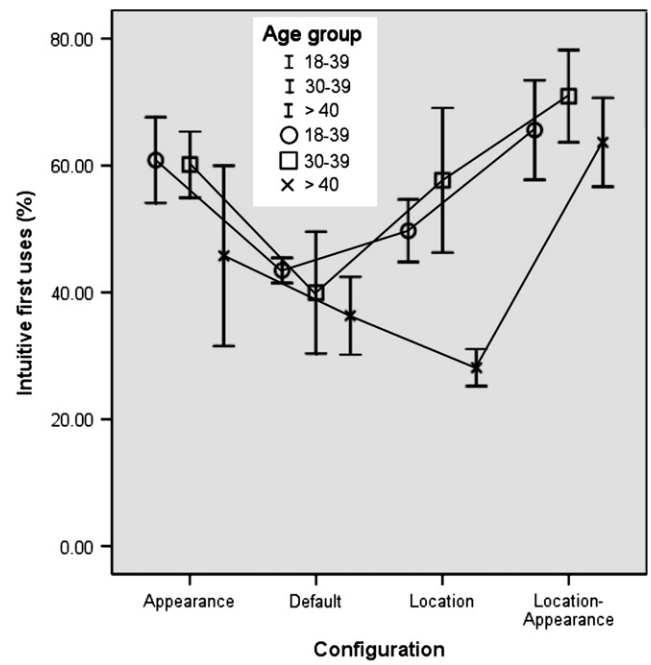


Fig. 17. Percentage of intuitive first uses (correct and correct-but-inappropriate) by interface and age group.

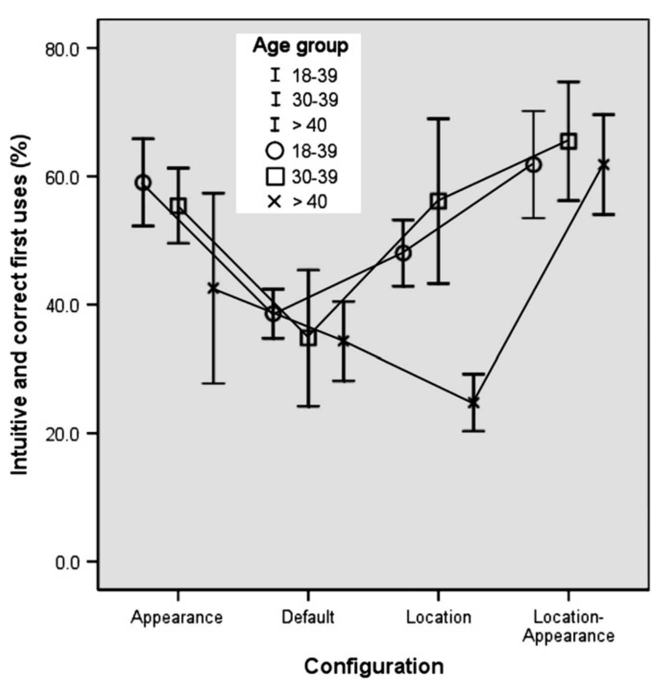


Fig. 16. Percentage of intuitive first uses (correct only) by interface and age group.

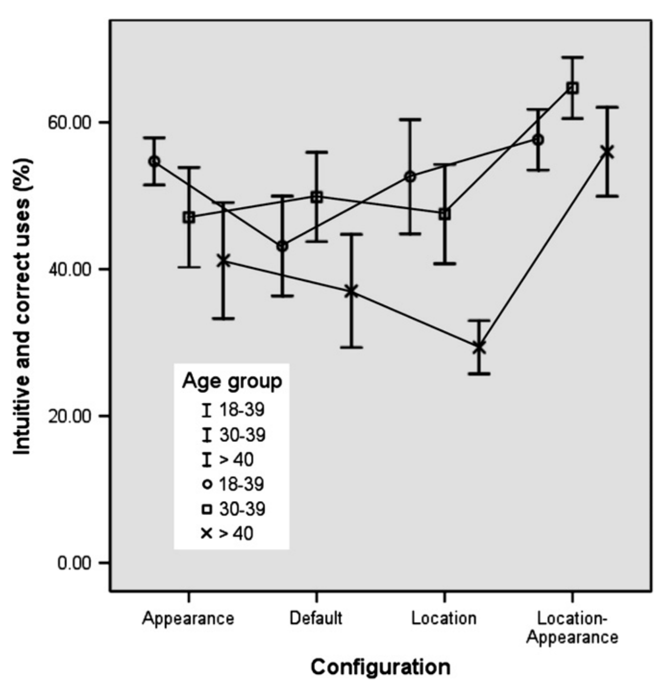


Fig. 18. Percentage of intuitive uses (correct only) by interface and age group.

A two-way ANOVA revealed that the percentage of intuitive first uses (correct only) did not show any significant variance according to age group, $F(2, 48) = 2.403$, n.s. ($E^2 = .09$, power = .46). However, there is a moderate effect here, and it is possible that the low power is masking an effect.

The percentage of intuitive first uses (correct and correct-but-inappropriate) showed similar results (Fig. 17). Levene's test for homogeneity was significant, $F(11, 48) = 2.608$, $p < .05$, so again a strict alpha level of .025 was adopted. Interface had a significant effect on this variable, $F(3, 48) = 6.896$, $p < .001$. A Tukey HSD test showed that the significant difference was between the Location–Appearance group and both the Default ($p < .001$) and Location ($p < .01$) groups. Age group did not have a significant effect, $F(2, 48) = 3.523$, $p = n.s.$ ($E^2 = .13$, 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.

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

The subjective ratings that participants gave during the interviews were compared between the age groups and interfaces. Although there were higher mean scores for all familiarity ratings for the Appearance and Location–Appearance conditions than for the Default and Location conditions, two-way ANOVAs showed no significant differences, $F(3, 48) = 1.65$, n.s. ($E^2 = .09$, power = .404). However, at least moderate effect sizes were evident, and power was low to moderate. Thus it is possible that a Type II error occurred and the effect was masked by the low power.

5.3. Discussion

All the groups using the new interfaces 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 interfaces 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. Age had a weaker effect than interface on intuitive uses, but overall the results seem to suggest that there is an effect, with older people having a lower percentage of intuitive uses. Older people also completed the tasks more slowly.

6. Implications

The main findings from the research were that familiarity with similar features allowed people to use new interfaces more quickly and intuitively than they used those with unfamiliar features. The technology familiarity scale worked to quantify the level of familiarity with similar features that participants had. Increasing 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 is organised into three main subsections: intuition, intuitive use and prior experience; intuitive use and appearance and location; intuitive use and age.

6.1. Intuition, intuitive use and prior experience

Based on extensive literature review, it was stated in Section 1 that intuition and intuitive interaction are based on past experience, that intuition is generally correct, and that it is fast and non-conscious. The experiments reported here have supported these views. Intuitive interaction was found to be facilitated through past experience, and participants who had relevant past experience with particular features used those features intuitively. Intuitive uses were also found to be faster than conscious reasoning uses and often correct, but not infallible. Understanding of properties of intuition, such as non-conscious processing, prior experience, speed, correctness and expectedness, was successfully used to separate intuitive processing from other types of cognitive processing during the coding process.

All the experiments showed that familiarity with a feature allows 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 (Blackler, 2008; Blackler and Hurtienne, 2007; Blackler et al., 2006).

6.2. Intuitive use and appearance and location

Experiment 3 demonstrated that intuitive use is enabled more by the appearance of features than by their location. Making the appearance of features familiar by using familiar symbols and icons, accepted conventions for labelling and naming, and also by sizing and shaping 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 some cases based on an international 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 product forms. This means that audiovisual features 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. 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 simply 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). Notwithstanding, it does appear that the most important factor in the new interfaces was appearance. 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.

More standardisation of location on products (similar to the standardisation of location of various key features of software) may make location more important. 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.

6.3. Intuitive use and age

This research showed that older people used products more slowly and less intuitively. Other researchers have reported similar results, with age having an impact on time and error rates for tasks with a digital camera, microwaves and a car (Langdon et al., 2007; Lewis et al., 2008). Well-known factors of ageing such as speed of reaction times and cognitive processing could be responsible for the slower times of older people. However, Experiments 2 and 3 also suggest a previously unexplored relationship between age and intuitive uses, so it seems likely that there are other factors at work. Prior experience is important for older adults interacting with new technologies, and is known to affect older adults' performance with new technologies (Fisk et al., 2004; Rudinger et al., 1994). Older people obviously have more overall experience than younger ones, but it is likely that there is some difference in the way that people of different ages can utilise their prior experience to intuitively use a new product. Possible reasons for this are discussed below

Older people who do have relevant experience with similar devices have gained that experience only recently, and therefore it has been difficult to learn and retain. Young people learn more easily (Baracat and Marquie, 1994; Howard and Howard, 1997; Kok et al., 1994). Fluid abilities, including decision making, working memory and attention, play a role in acquisition and transformation of information. Age-related cognitive decline is most conspicuous for fluid functions, whereas crystallised abilities are more resistant to ageing (Kok et al., 1994).

Crystallised abilities are associated with previously acquired skills and depend strongly on experience. They are activated mainly when information stored in long term memory is used (Kok et al., 1994). Cremer (1994) defines crystallised abilities as passive use of available knowledge and learned skills. This is similar to the definition of intuition in Section 1.1.5 – using existing knowledge and experience largely non-consciously. Older people can use skills and experience to compensate for physical limitations (Rabbitt and Carmichael, 1994). However, there is a need to address how experience and skills may be used to compensate for the decline in fluid cognitive abilities in complex, real-life task conditions (Kok et al., 1994).

The experience that older people have may not be relevant to contemporary tasks or technology, and their crystallised knowledge may be based on skills and knowledge acquired when younger. The decision to use standardised symbols and contemporary products to develop the symbols and icons used in the interfaces for Experiment 3 may have excluded older users from some of the benefits of the re-design. In Experiment 2 some older people 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.

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 quickly 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 in this paper 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.

Therefore, the authors have underway a large project funded by the Australian Research Council (ARC) to address this issue. It may be tempting to think that, as the population continues to age, people who are experienced with these technologies will also age and the problem will resolve itself. However, technology is very dynamic, and it is likely that there will always be a disparity between the experience of older adults and the new devices of the day (Fisk et al., 2004), which makes this research essential.

7. Conclusion

It was found that intuitive interaction does depend on past experience with similar features, and it is affected by age. Appearance of a feature is more important than location for facilitating intuitive interaction. Principles for designing for intuitive interaction have been developed, extended from the preliminary principles used as part of the re-design process, where they worked successfully in enabling an interface to be produced that was more intuitive to use. A conceptual tool to guide designers through the design process for intuitive interaction has also been produced (Blackler, 2008; Blackler and Hurtienne, 2007; Blackler et al., 2006). Further work on refining this tool and also investigating the link between age and intuitive use is underway (Blackler, 2008).

This research is significant as it has established a foundation for the study of intuitive interaction, and provided future researchers in this area a solid basis from which to work. There is much potential for further work in this area, some of which is currently underway. There is also potential for the transfer of the knowledge gained to other domains such as management or education.

Appendix A

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

1. Name ____

2. Email contact and/or phone number

____

3. highestac ademic 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 touch screens 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 th etype, 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 B

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*				

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