Applications of high and low fidelity prototypes in researching intuitive interaction

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Abstract

This paper addresses some of the issues involved in incorporating use of prototypes into a research program. Definitions, merits and uses of both low and high-fidelity prototypes are discussed and then the applications of prototypes in our research program into intuitive interaction are explored. It has previously been established that intuitive interaction is based on past experience, and can be encouraged by designing interfaces that contain familiar features (Blackler, 2006; Blackler, Popovic, & Mahar, 2007b). Two aspects of the research program which are relevant to prototyping are: researching the issues of how intuitive use happens and how it can be better facilitated; and developing ways to help designers include investigations about users and their existing knowledge into their design processes in order to make interfaces more intuitive.

The current and future planned applications of high and low-fidelity prototypes in each of these areas are explored. Then experiences with using high-fidelity touchscreen prototypes for experimental research into intuitive interaction are discussed, including problems with the prototypes, how they were addressed and what we have learned from the process. Next the potential for low-fidelity prototypes to elicit users' tacit knowledge during the design process is explored. This has exciting possibilities due to the link between intuitive interaction and tacit knowledge. Finally, the challenges of developing prototype-based design tools for use by older people are discussed and future directions for using prototypes in our research program are considered.

Keywords

Prototypes; intuitive interaction; experimental methodology; implicit or tacit knowledge

This paper starts with a brief review of relevant literature on prototypes and their uses, including the relative merits of low and high-fidelity prototypes for various purposes and the use of prototypes in research as well as in the design process. It then moves on to discuss the application of prototypes to the work of the author's team in researching intuitive interaction, the potential for low-fidelity prototypes to elicit users' tacit knowledge during the design process, the challenges of developing prototype-based design tools for use by older people, and future directions for using prototypes in our research program.

Prototype Fidelity

Prototypes are often referred to as low or high fidelity. Sauer, Franke, & Ruettinger (2008, p71) define prototype fidelity as follows:

> *The degree to which a model of the system resembles the target system refers to the fidelity of the model. The fidelity of the model (or prototype fidelity) may very considerably, ranging from a low-fidelity simulation of the system (e.g., paper prototype) to a fully operational prototype, which is (almost) identical to the real system.*

Bonner & Van Schaik (2004, p253) use the terms low- and high-level and define a high-fidelity or high-level prototype as one “where all or most of the functionality and often the form of the interface is fully represented”. Rudd, Stern & Isensee (1996) warn that the fidelity of the prototype as a user sees and interacts with it is the determining factor, not how closely its software code or materials align with a finished product. However, they agree with the above definitions, stating that low fidelity prototypes indicate design direction, including visuals, colours, icons and locations of controls, but they do not provide details such as navigation and interaction. In contrast, they state, high-fidelity prototypes are fully interactive; users can interact as though with the real product.

Applications of high and low-fidelity prototypes

Low- and high-fidelity prototypes have different properties and uses. Ehn & Kyng (1991), reporting on the UTOPIA project, state that low-fidelity mock-ups (e.g. paper or cardboard) lend themselves to collaborative modifications. The materials and how to work with them are well known and so all participants can be involved in making changes and suggesting ideas. The changes are also quickly visible to all. Ehn & Kyng (1991) claim that with a high-fidelity computer prototype there is more likelihood of confusion between the prototype and the real thing. With cardboard and similar materials it is easier to distinguish between failures in the design and failures with the prototype.

Rudd et al. (1996) claim that low-fidelity prototypes can have great value in the early design process stage of gathering requirements and analysis. They are useful in providing a broad brush design and various design alternatives can be quickly generated and evaluated. However, they are often crude and so can provide little error checking and are of limited usefulness in usability tests. Therefore, low-fidelity prototyping is suitable for qualitative evaluations but not does not have the detail necessary to allow quantitative decisions (Rudd et al., 1996). On the other hand, high-fidelity prototypes allow issues of navigation and flow to be addressed. Realistic comparisons with alternative designs can be made (Rudd et al., 1996).

Sauer et al. (2008) mention that low-fidelity prototypes have only limited value in identifying usability issues because they may cause different reactions and behaviour from real products. They suggest that paper prototypes are not suitable for collecting efficiency measures, such as time. Similarly, Hall (1999) reports on work that found nearly twice as many problems uncovered with a high-fidelity touchscreen prototype as with a paper prototype, even though they differed only in appearance and tactility, not in functionality. Bonner & Van Schaik (2004) compared effectiveness of high and low-fidelity prototypes in getting participants to evaluate a novel interface against a standard interface. Using paper prototypes, Bonner & Van Schaik (2004) were able to address usability problems as they arose and the design developed incrementally based on results from the testing with paper prototypes. However, they found that high-fidelity prototypes allowed more contextual usability problems to be uncovered. They see a combination of the two during the design process to be the solution.

On the other hand, Virzi, Sokolov and Karis (1996) found experimentally that the usability problems uncovered using low- and high-fidelity prototypes or actual products were substantially the same. Therefore, contrary to many other authors, Virzi et al. (1996). conclude that the use of low-fidelity prototypes can be effective throughout the product development cycle, not just during the initial stages of design. However, this may depend on the product type, exact level of fidelity and/or the way the prototype is explained to the users as their findings are not compatible with the majority of others.

The literature suggests that both low- and high-fidelity prototypes have their place. Most authors agree that low-fidelity is best for the early stages of trialling ideas and for participatory design and similar activities, whereas high-fidelity prototypes are generally thought to be required for more rigorous testing and to uncover usability problems during the later stages of the design process.

Prototypes and tacit or implicit knowledge

Ehn & Kyng (1991) claim that a prototype allows tacit or implicit knowledge to emerge. Rust suggests that the UTOPIA project prototypes unlocked participants' tacit knowledge and allowed it to be included in the design process. He argues that this knowledge would be inaccessible by other methods and only became explicit in that it was embodied in the design and procedures of the new system (Rust, 2004a, 2004b).

Rudd et al. (1996) agree, saying that users do not know how to articulate their requirements (since much of their relevant knowledge is tacit and not accessible to conscious thought), and verbalising their requirements is not objective. Therefore, users can have a problem in differentiating what the system does, for example, from how it does it. However, a low-fidelity prototype gives them some indication of what is possible and provides a starting point for discussion and criticism

A prototype or other tool which is flexible enough to allow users to explore various options may allow user requirements to be better articulated. The elicitation and application of tacit knowledge through the use of prototypes in intuitive interaction research is an important factor since intuitive interaction relies on application of existing knowledge to new interfaces. The relationship between intuitive interaction and tacit knowledge will be further discussed later.

Prototypes and research

Prototypes are not commonly used for research purposes. Models of parts of interfaces and systems and of existing interfaces and systems have been used in research, especially in Psychology and Human Factors. For example, models for population stereotype research, such as those used by Smith (1981) and Wu (1997), and those reviewed by Loveless (1963). In intuitive interaction research, Hurtienne and Blessing (2007) have also used software-based tools for testing the application of image schemata to intuitive interaction. However, these can all be seen as research tools rather than prototypes. These research tools are not meant to be prototypes, the researchers do not refer to them as prototypes and they and are not intended to look like or work like finished products or interfaces.

Some research work has used prototypes, for example Bonner and Van Schaik (2004) and their novel interfaces, which are aimed at exploring user behaviour rather than at developing one particular consumer product, but are nevertheless prototypes of interfaces rather than tools which allow completion of experiment tasks. Also, prototypes have been used by researchers who are developing new technologies and methods of interaction. For example, Lehikoinen and Roykkee (2001) designed an interaction system for wearable computers (N-fingers). They built a prototype which proved to be successful when compared with the same task using a keyboard during testing. Hummels, Smets and Overbeeke (1998) conducted work using prototypes of early gestural interfaces and Murakami (1995) developed and tested a deformable physical input device which was translated into a CAD drawing on a screen. So bringing prototypes into the research domain is an established if still somewhat unusual method.

Prototypes in the intuitive interaction research program

Prototypes are very relevant to the team's research investigating intuitive interaction. Previous empirical work has established that intuitive interaction is based on past experience, and can be encouraged by designing interfaces that contain familiar features (Blackler, 2006; Blackler, Popovic, & Mahar, 2003a, 2003b, 2004a, 2005). A provisional conceptual tool to guide designers in designing more intuitive interfaces has been developed and tested and is currently being further refined (Blackler, Popovic, & Mahar, 2007a). However, older people use things less intuitively and more slowly than younger ones even when they appear to have equivalent experience (Blackler, 2006; Blackler et al., 2007b). It is not yet established exactly why this is and the team's largest project is therefore focussed on this issue. Both high and low fidelity prototyping is relevant to this research program and prototypes have been used in the following contexts:

1. Researching how intuitive use happens and how it can be better facilitated. So far finished products, re-configurable products and high-fidelity touchscreen prototypes have been used to this end.
2. Developing ways to help designers include investigations into their design processes that will allow them to design interfaces that can be used intuitively. So far there has been some use of low fidelity prototypes during the design process and high-fidelity ones for testing the results of that process.
3. Robust but quick and acceptable ways to assess intuitive use for commercial projects. To date assessment of finished products has been done for commercial projects but the ability to assess prototypes for intuitive interaction will increase the usefulness of this type of research and the likelihood of the ideas generated being applied to the relevant product.

In the following sections, the current and future planned applications of high and low fidelity prototypes to this research will be discussed.

High fidelity prototypes in Intuitive Interaction Research

A set of principles and a conceptual tool for designing for intuitive interaction have been developed, based on previous experimental work. This tool has been tested with designers. The first test with one designer led to some alterations (Blackler, Popovic, & Mahar, 2006). A refined version of the tool was then tested by seven groups of postgraduate designers undertaking a re-design project. This process and student feedback on the tool has been reported by (Blackler et al., 2007a)

One of the best designs to result from this process was a microwave. The original product (Figure 1) worked in a similar way to most domestic microwave ovens. The new design (Figure 2) addressed all the main usability problems the students identified with the original product and offered an innovative solution soundly based on the principles and tool for intuitive interaction.

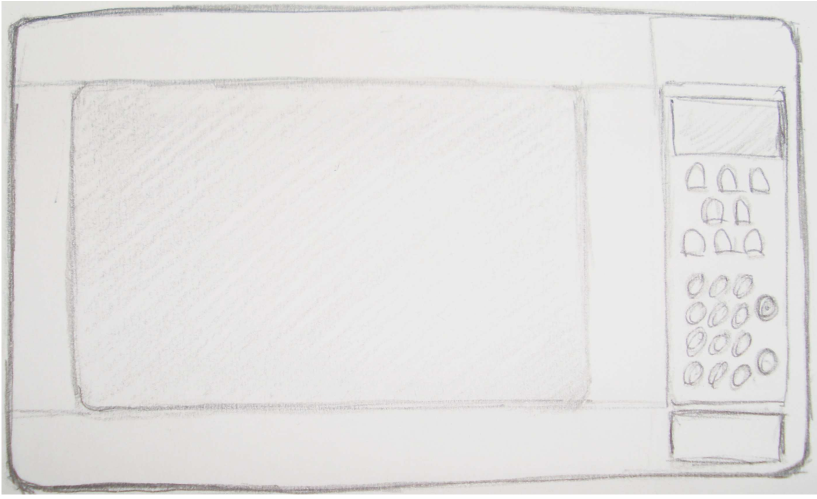

Figure 1: Original microwave design

Figure 2. New microwave design

The design is discussed in depth elsewhere (Blackler et al., 2007a), but here it is important to note that the new design produced using the refined tool applied features familiar from other products to the microwave, for example the menu interface (Figure 3) was similar to an ATM as the great majority of microwaves users the students interviewed were familiar with ATMs.

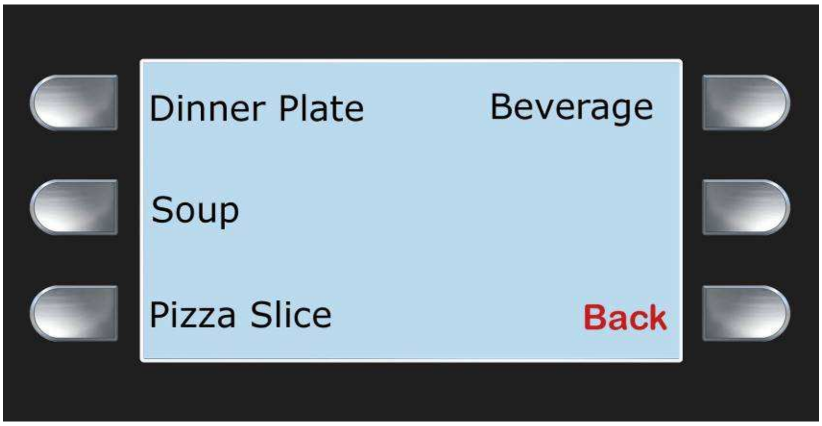

Figure 3: Example sub-menu

The students' observations using low fidelity paper prototypes suggested that the new design was more intuitive to use than the original, and they felt that using our tool was a major factor in the increased usability of the product. However, to collect the very precise measures needed to establish intuitive usability, one of which is time (Blackler, Popovic, & Mahar, 2004b), higher-fidelity prototypes were required (Bonner & Van Schaik, 2004; Hall, 1999; Rudd et al., 1996; Sauer et al., 2008).

An experiment was devised to test whether or not the new microwave is actually more intuitive than the original design, aiming to establish whether the tool is effective, as well as to discover more about intuitive interaction and ageing. Participants were split into two microwave groups - old and new design - and also into three age groups. Age groups were evenly distributed within microwave groups. The experiment involved participants doing set tasks with one or other of the microwave interfaces while delivering concurrent (talk aloud) protocol. They were timed and recorded and the time and audio visual data were analysed later.

Full experimental results will be discussed elsewhere; this paper focuses on the uses of prototypes, and this section will describe the process of creating the high fidelity prototypes for the experiment.

Prototype Development

The new and original interfaces were both prototyped. Since one of the microwaves was a student design and not a fully working model, both of the microwave interfaces were mocked-up to be used on a touchscreen, so that they would be equivalent to each other. Bonner & Van Schaik (2004) followed a similar method – their participants were asked to evaluate a novel interface against a standard (existing) interface, both presented in the form of prototypes.

Hall (1999) found high-fidelity touchscreen prototypes to be effective, and our touchscreen prototypes were relatively high fidelity, although there were some significant differences between them and a real microwave, which created some challenges. The prototypes were problematic in several ways, and strategies were implemented to overcome these problems. These will be discussed below. Possible approaches to better addressing these issues for future experiments will also be explored.

Use of inappropriate software to create and program the prototypes

Ehn & Kyng (1991) and Rudd et al (1996) warn that computer supported prototypes rely on people in the design team being skilled programmers. Rudd et al. (1996) mention that at that time high-fidelity software prototypes were often built with Small Talk or Visual Basic, while

Bonner & Van Schaik (2004) made theirs using Macromedia Director. Mainly due to limitations of the team at the time, these prototypes were made on MS PowerPoint, importing the jpegs created by the student designers and adding multiple hyperlinks. A quick trial of using Visual Basic was conducted but it does not provide much flexibility for graphical components unless advanced features are used as it is aimed at developing Windows interfaces (Gould & Schaefer, n.d.). It was therefore deemed impractical as the team member with Visual Basic skills had time constraints.

The process was frustrating because of the limitations of PowerPoint, which was not intended for this type of use. Each possible action required a new slide. To provide all outcomes possible with a real microwave would require a very large and graphics-heavy PowerPoint file, which would take a long time to create and could cause the program to crash. Therefore "vertical prototypes" were developed – high-fidelity prototypes of a subset of the functions (Rudd et al., 1996), albeit in this case a large subset. No pages were created for some of the features not under test (e.g. setting the time on the clock), and participants that tried to use them were simply told that that particular button would not do anything. Count-downs for cooking and timing were set in 10 second increments and it was not possible to enter every time into the dial or keypad – just those asked for in the set tasks and those that were likely to be commonly used by mistake. As well as allowing the prototype to function, this approach saved time – actually waiting for 3:30 minutes to cook a virtual meal during the experiment would be a waste of everyone's time.

Positioning of hyperlinks on the interfaces required a lot of precision. It was found that once testing started with real people rather then those who were familiar with the interfaces and the way they were created, adjustments had to be made so that the links were more precisely placed. The dial on the new microwave was particularly problematic in these instances. Due to this some of the earlier data had to be scrapped as the first few participants ended up linked to incorrect pages during the experiment.

Finally, a macro was written to force the cursor to be always visible to allow the PowerPoint shows to function on the touchscreen. Otherwise, if the application timed-out, the cursor would disappear and when a participant touched the screen again it would not be registered.

Considering the limitations, PowerPoint did do the job once all the issues had been addressed, and it is interesting to note that none of the 40 participants commented on the use of PowerPoint even though they all saw the well-known interface of the program during the introduction to the experiment. Once the PowerPoint show was started the prototypes appeared to be credible for them.

Sizing of the interfaces

Using a 19" touchscreen, the prototypes were approximately half size, which led to issues with the ability of participants to easily see and use the controls. The control panel on the old microwave and the dial on the new one were increased in size so that they were proportionally bigger than the rest of the microwave. Therefore, the experiment was a more realistic test of the interfaces. This is illustrated in Figure 4. Note the proportional difference in size of the dial compared to Figure 2.

Figure 4. New microwave prototype in use

2D representation of 3D features

One of the major problems was the two dimensional representation and use of features which in the real world would be three dimensional The new design was particularly problematic as it involved the three dimensional dial. This problem was addressed through five strategies:

- The dial was developed with a reference point on it and participants had to touch next to the line in the direction they wanted the dial to move (one touch of the dial in the appropriate location changed the time up or down by 10 seconds). Unfortunately, it was not possible to get it to scroll around like an IPOD scroll wheel. A training task with a safe interface (Figure 5) was developed (also on PowerPoint) to familiarise participants with using the 3D features such as dials and doors on a 2D interface. It was also a practice with the touchscreen for those who may be unfamiliar with them. The experimenter talked the participants through this training task to make sure they understood how each part worked. The safe task was designed to introduce participants to equivalent types of interaction to overcome the 2D/3D issue but without giving them clues about how the microwave interfaces might operate. Therefore, it had a dial that looked different and showed relevant numbers differently, a letter rather than number pad and the screen was in a different location.

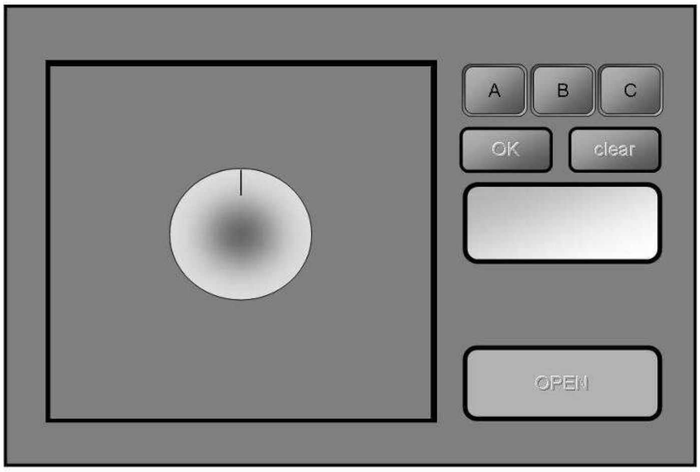

Figure 5. Safe interface

- 3D cardboard models were used as accessories to the touchscreen prototypes (Figures 6 and 7). These included details such as relief buttons and a moving dial. They were shown to the participants at the start of the experiment and they were asked to handle the feature so that they could understand what each one would actually feel like. Participants were encouraged to refer to these models throughout the experiment.

Figure 6. Cardboard model of old microwave

Figure 7. Cardboard model of new microwave

- Labelled pictures were provided to each participant as further support (Appendix A). Sauer et al. (2008) found that enhanced labelling decreased the detrimental effects of lower fidelity. Ehn & Kyng (1991) describe the "borderland" of mixed cardboard and computer (low and high fidelity) prototypes. The use of cardboard models and labelled diagrams to support the touchscreen prototypes suggests that the borderland has been entered here.
- The touchscreen beep was turned on so that each time participants touched the screen they received some feedback to try to replace the tactile feedback they would get from a real 3D interface. Participants were told that this would happen and the reason for it.
- The times in the results were adapted to allow for differences between the 2D dial on the touchscreen and a real 3D dial. This was to prevent any unrealistic difference in the times taken to do the tasks on the old and new microwave interfaces, as entering the time into the keypad took no more time than on a real microwave, but using the touchscreen dial was slower than using a real dial. The time it would take to turn a real dial was calculated using averaged times to do equivalent tasks with a variety of real 3D dials similar to the one on the new microwave design.

Representations of LCD display panels on touchscreens

Both microwave interfaces had LCD display panels on them. Participants sometimes assumed that these were touchscreens, especially if they had begun to feel stressed or confused. The fact that the prototype operated on a touchscreen seemed to encourage them to think that the microwaves would also work by touchscreen, even though they both had clear buttons. This happened even when participants had already correctly used the buttons previously, and it seems likely that if the prototypes were not on the touchscreen this problem would have been less prevalent. Ehn & Kyng (1991, p193) warn that in computer-supported prototypes; "The closer the two "roles" get, and the less familiar the computer is, the more careful one had to be in avoiding attributing the wrong aspects of the mock-up…to the future product.." This seems to be what happened in this case.

Lessons learned and future plans

The prototype development was a success after a lot of effort, and as a result the experiment was able to be conducted in a rigorous way. However, for the future several lessons have been learned from this exercise:

- More appropriate software should be used (e.g. Flash or Visual Basic). More skill sets have been added to the team since these prototypes were prepared. Training for initial team members or outsourcing of this service is also being considered.
- Consideration of development of prototyping capabilities so that it is possible to test 3D electronic/software enabled interfaces. Possibilities here include combinations of software and hardware and 2D and 3D prototypes, re-entering the "borderland". This will require further training and make the prototypes more expensive to produce but to get reliable results in testing a variety of interfaces it may be necessary. This is already happening in practice (Buchenau & Suri, 2000) and needs to be available in research also.
- Strategies to get around the kinds of issues encountered can work successfully (e.g. the 3D models and training interface), but need to be well thought out and well tested.

Low-fidelity prototypes in Intuitive Interaction research

So far low-fidelity prototypes have been used mainly as tools during the design process. Bonner & Van Schaik (2004) argue that design tools are needed early in the design process. Testing of the tool previously developed has shown that finding out what users are already familiar with is a serious challenge for designers (Blackler et al., 2007a). However, it is essential that designers understand what users are already comfortable with so that they can apply familiar things to interfaces in order to make them intuitive. Therefore, the team is developing methods and tools to help designers learn more about the users' existing knowledge, and to assess intuitiveness of their ideas. Students involved in the re-design project used various methods for these purposes. Methods are discussed in depth elsewhere (Blackler et al., 2007a) but have included:

- literature searches
- product reviews
- questionnaires
- recognition exercises to identify the most suitable icons/symbols
- observations using real products, electronic and paper prototypes (Figure 8)
- expert appraisals
- evaluations checklists
- basic participatory design

Figure 8. Paper prototype testing of alternatives for the microwave interface

Ehn & Kyng (1991) and Rust (2004a, 2004b) discuss the potential of low-fidelity prototypes as participatory design tools. Bonner and van Schaik (2004) used paper prototypes and asked participants to assess them incrementally during the design process. They claim that this allowed for a higher degree of impartiality on the part of the designers as the decisions were based on users' feedback. However, participants hinted that they were sometimes making uninformed, arbitrary decisions. This suggests that this approach needs to be used carefully.

All these methods have potential and need to be explored further in the context of designing for intuitive use. The methods and tools this team develops will allow designers to establish those features and concepts with which relevant users are already familiar and which they could therefore adapt and apply to new interfaces. The use of prototypes may become particularly important in this work because of the ability of low-fidelity prototypes to elicit tacit knowledge and the link between tacit knowledge and intuitive use.

Tacit or implicit knowledge and intuition

In terms of designing for intuitive interaction and researching methods to assist with that, implicit or tacit knowledge is particularly important. This is because storage and utilisation of tacit knowledge, like intuition, is a non-conscious process. Many researchers agree that the understanding or knowledge required during the intuitive process is retrieved from memory during non-conscious processing (Bastick, 2003; Bowers, Regehr, Balthazard, & Parker, 1990; Dreyfus, Dreyfus, & Athanasiou, 1986; King & Clark, 2002; Klein, 1993, 1998; Laughlin, 1997; Noddings & 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 (Wickens, Gordon, & Liu, 1998). Intuitive interaction is not always completely automatic, but it is generally non-conscious (Blackler, 2006).

Implicit learning is a process whereby knowledge 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 learning forms implicit or tacit knowledge, which often makes up a large part of experiential knowledge. Intuition and therefore intuitive interaction rely on experiential knowledge (Blackler, 2006; Blackler et al., 2007b).

Therefore, the existing knowledge that participants draw on to use new interfaces is often tacit knowledge. The ability of low-fidelity prototypes to allow articulation of tacit knowledge during the design process suggests an important role for low-fidelity prototyping in designing for intuitive interaction. If designers can elicit what tacit knowledge users have they can apply it to new interfaces to make them both intuitive and innovative. Using low-fidelity prototypes specifically to elicit tacit knowledge is a method the team has yet to explore as a design tool yet it may offer the most potential as other methods may not tap users' tacit knowledge.

Low-fidelity prototypes and older people

However, the current focus of the team is on investigating intuitive interaction and older people. Knowledge of aging and its effects is not enough – designers need to get involved with older people as part of the design process (Hawthorn, 2007), so tools for facilitating that process are under development. The challenge is to develop tools and methods that are engaging and motivating for older people who are participants in the design process. Hawthorn (2007) found that older people do not work well with low-fidelity (paper) prototypes and became frustrated with trying out scenarios using them. Older people did not see low-fidelity prototypes as representing an application, but they did work well with high-fidelity (software based) prototypes. The problem with the paper prototypes seemed to be partly due to the fact that some of the interface elements that matter to older users – e.g. font size and positioning, contrast, etc - were not included in the paper prototypes (Hawthorn, 2007).

Hawthorn's (2007) older testers were in their 50s so not yet officially "old." People are considered to be "older" if over 60 (Fisk, Rogers, Charness, Czaja, & Sharit, 2004). Nevertheless, these testers complained that trying to understand the designers' explanations along with the low-fidelity prototypes gave them too much to think about at once. After several projects with similar outcomes, Hawthorn has concluded that low-fidelity prototypes tend not to be understood by older people. Gould & Schaefer (n.d.) concur. They tested six people over 60 using a paper prototype of an email client and found that the concept of the paper prototype was equally or more confusing to them than a typical computer interface. Gould and Schaeffer (n.d.) addressed the issue by typing the text on their paper prototype rather than handwriting it, which made it easier to read (this also allows testing of fonts and sizes, etc). By doing this they increased understanding of the prototype for older people by increasing fidelity but still maintained malleability so that the prototype was obviously flexible and users understood they could contribute their own knowledge and ideas.

Hawthorn (2007) also claims that allowing the older testers to understand the malleability of high-fidelity prototypes meant that they contributed their own suggestions for changes, which suggests that tacit knowledge elicitation may also be possible with malleable higher fidelity prototypes. Therefore, a compromise which involves higher fidelity and greater malleability might be a suitable approach. Re-entering the "borderland" may be a way to tackle this problem. Alternatively, it may eventuate that there are more appropriate methods for eliciting the tacit knowledge of older people and the use of prototyping tools may be retained for younger user groups only.

Conclusion

This paper has demonstrated that prototypes have various uses in different aspects of a research program focussed on human centred design issues (specifically intuitive interaction). It has shown that high-fidelity touchscreen prototypes can be successfully employed as experimental tools and that low-fidelity prototypes may have an important and exciting application in developing design tools.

A lot has been learned through the exercise of creating prototypes for the purposes of research and the team looks forward to learning more about developing tools to allow designers to work with low fidelity prototypes for tacit knowledge elicitation. The design tools developed will involve more than just prototyping as that would be very limited; they will allow for the most suitable methods for various situations. However, prototypes have the potential to be an important part of the toolkit, and prototypes of various fidelities are an important tool for design research.

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Acknowledgements

Team members Vesna Popovic and Doug Mahar;

Researchers Rafael Gomez and Ben Kraal;

Student designers Tam Elder, Bruce Summers and Chelsea Steinohrt.

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received a PhD in 2006, having made a significant contribution to interface design research. She pioneered the work on intuitive interaction, an area which had never been formally investigated before and which is now gaining international interest and attention. She continues to investigate this issue and remains at the forefront of research going on in the area. In 2007 she won a prestigious ARC Discovery grant to further investigate intuitive interaction for older people. She is a Senior Lecturer at Queensland University of Technology, and teaches in the areas of design history, theory and criticism and design research.

Appendix A. Labelled pictures for new microwave