

Investigating Ubiquitous Computing in the Home

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Abstract. In this paper, we describe a series of workshops which were carried out in homes of five families in Scotland. The aim of the workshops was to explore the requirements that people have for new technologies in a household environment. The workshops were video-taped, transcribed and analysed from a number of perspectives. In this paper we concentrate on an analysis of the transcripts from the perspective of ubiquitous computing. The designs of possible future technologies will also be examined. Conclusions as to the applicability of the methods used here for future ubiquitous computing research and research in households are presented.

Keywords. Ubiquitous, households, families, HCI, technology.

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Introduction

One of the main challenges of ubiquitous computing is to meet the needs of real people living in the real houses rather than meeting the needs of a fuzzy idea of ‘users’ in ‘smart homes’ which have been purpose built. The majority of the population live in homes, which are more than twenty years old. Therefore it is imperative that designers and researchers investigate existing homes and families and try to understand their needs and thoughts.

The majority of recent approaches to design of interactive technologies have been developed for work environments. However, with technology migrating into the home, we need to consider the methodological challenges and opportunities in the home environment with respect to tools and methods for design of household technology. At present a number of studies of the use of household technologies have been conducted (O’Brien *et al.* 1999; Petersen and Madsen 1999; Kraut *et al.* 1998). However, few have looked into tools and methods specifically for the design of future household technologies. We describe in the following section the tools and methods we used in a series of home workshops.

Workshops

There is a general lack of relevant literature and research in the area of requirements and design in household settings with a few notable exceptions i.e. (Venkatesh 1996; Kraut *et al.* 1998; O’Brien *et al.* 1999). As O’Brien *et al.* pointed out, the new focus by manufacturers on consumers in the home has important implications for HCI in particular. The problem for us as researchers was to what extent can HCI ideas and methods used to understand work environments would transfer to investigations in the home. As O’Brien commented Compared to work environments, how and in what ways domestic environments may be best investigated for the purposes of design remain little explored.

Methods of requirements gathering such as observation, simple interviews and so on do not transfer well to a domestic setting (Kjaer *et al.* 2000). Accordingly it was felt that a series of design workshops was appropriate. HCI researchers in the past have used design workshops as a way of establishing creative and collaborative settings for design (Petersen and Madsen 1999; Buur and Bødker 2000; Bødker *et al.* 2000). Therefore we decided that this may be a

way of gaining insight into the home and finding out more about how people use and interact with their technologies. We therefore carried out some situated ‘requirements determination’ workshops. The overall aim of the workshop series was two fold; (i) to explore the effectiveness of methods for gathering contextualised requirements for information and communication technologies in the home and (ii) invite participants to conceptualise in the form of a paper prototype their ideas for a home device. As argued by Druin (1999), we need to take into account who the users of the technology we are designing for are. While Druin’s work concentrated on designing technology with children, in these sessions, we sought to engage with the whole family. The series consists of three sessions with each family, at home, with approximately three weeks in between each session. As illustrated in the following table, the focus of the sessions developed through the course of the engagement with the families.

	Session 1	<i>Inter-session activities</i>	Session 2	Session 3
Focus	Investigate current problems and future possibilities	<i>Collection of data in-between sessions</i>	Contextualise ideas in home and daily life	Discussion, critique and iteration
Methods	1. Technology tour 2. Representations of emerging technologies 3. Materializing ideas for future technologies	1. <i>Post-it notes</i> 2. <i>Annotations on devices or drawings.</i>	1. Informal interview 2. Scenario analysis. 3. Positioning the technology physically in the home	Sharing ideas across families Modifying and elaborate on proposals.

Table 1. The Focus and Methods in the three sessions held in each family

Venkatesh (1999) conceptualised the household in terms of Home as Living Space, consisting of three key ‘spaces’: the social space, the technological space, and the physical space. In our first session we decided to focus initially but not exclusively on what Venkatesh (1996) termed

‘The Technological Space’, which represents the nature of the technological environment within the household.

Five families in Scotland agreed to participate in the workshops. The families cover a spectrum ranging from the family with two young children to a single 80-year-old woman (see Table 2). Each session lasted approximately one and a half hours.

Code	Who	Sex	Age	Occupation	House	Technologies
Cook	Rob father	M	48	Lecturer	Victorian, large, 4 bedrooms, dining room, drawing room, lounge kitchen, 2 bathrooms, cellar.	A mixture of old and new, games consoles, computers, Television.
	Sue mother	F	47	House Wife		
	Dianne daughter	F	10			
	Tarquin son	M	7			
Petric & Naysmith	Catherine partner	F	27	Recruitment Consultant	Semi-detached, newly acquired, 2 bedrooms, lounge, kitchen, bathroom	Mainly new technologies games console, mobile phones, etc
	Gordon partner	M	31	Admin Officer		
Suttons	Emily wife	F	68	Retired teacher	Victorian, large house, converted for their lifestyle e.g. converted, 2 bedrooms into 1 large room for entertaining.	low tech, standards technologies, TV, Hi-Fi etc
	Peter husband	M	70	Semi-retired builder (own business)		
Smiths	Simon Father	M	45	Joiner	Local authority flat, 2 bedrooms, lounge, kitchen, bathroom	High tech, lots of new technologies e.g. digital TV, PC, Mobile phones etc
	Barbara mother	F	43	Catering Asst		
	Mike son	M	15			
Reilly	Agnes	F	74	Retired Cook	Local authority, 2 bedrooms, lounge, kitchen, bathroom	Low tech, portable tv, small Hi-Fi

Table 2. Households in the study (pseudonyms have been used).¹

¹ For a fuller description of the families and their homes see Baillie *et al.* (2001).

TECHNOLOGY TOURS AND USER STORIES

After a brief introduction to the purpose of the sessions – to investigate people’s use of technology in the home – members of the family were asked to take the researcher on a tour of their technology. Typically the tours were quite unstructured with members of the family coming and going, commenting and cutting in as appropriate. Although this led to some difficulty in the analysis (see below), it was certainly grounded in the situation! Several researchers have pointed out how the way the technology is integrated in the physical and social organisation of the house provides useful clues of understanding the use of these technologies (O’Brien *et al.* 1999; Stolzoff *et al.* 2000; Abowd and Mynatt 2000; Venkatesh *et al.* 2000). Thus we maintained this focus in the technology tours. For example, Sue pointed out a radio cassette that she had:

Sue: I have got this umm... tape and radio but I am afraid only the radio works now.

Researcher: Right

Sue: As you can see it has seen better days

Researcher: Why have you still got it?

Sue: Well it comes in handy when I am moving round the house doing different things, the other one [she points to the new music system in the corner] has to stay where it is.

In these rounds we asked about possible conflicts in ownership of physical space (O’Brien *et al.* 1999; Venkatesh 1996) as well as the history, flexibility and motivation for the physical organisation of the space. We further asked them to describe problematic situations they had experienced with the technology and we asked people to show us how they used the technology. This prompting produced some particularly interesting accounts, focusing on specific incidents and breakdowns. For example, Emily had to change the batteries in her phone: the phone had instructions as to where the positive and negative symbols should be facing on the phone but no instructions as to how to insert or place the batteries, therefore Emily spent several frustrating hours trying to fix the phone only to find that when she threw the phone down in disgust the batteries slipped into place. Stories are valuable in that they are repositories of accumulated wisdom (Brown and Duguid 1996), provide accounts of the social,

physical and technological space of the situation (Venkatesh *et al.* 2000) and as a collection contribute significantly to the systems requirements (Imaz and Benyon 1999).

REPRESENTATIONS OF FUTURE DEVICES

After the technology tour, people were given pictures of a number of emerging technologies; things such as the fridge that 'knows' when it is out of milk, the microwave with e-mail and so on. The researcher then discussed with the families how they make use of the technology, how it might constrain or liberate them and so on. Through the technology tour and the discussion on emerging technologies, ideas often arose for new devices that the members of the families would be interested in having. Some were happy to take one of the examples shown and elaborate on the idea. Others, who did not want any of the examples, were asked to materialise their suggestions in the form of preliminary paper prototype. For example, one woman wanted an automatic food record system which would contain: what food she had in her kitchen, suggestions of recipes for what she had in the kitchen and a general recipe book. But whether they designed their own or selected one of the examples of future devices or services, they were asked to leave the representation in the households, and live with it, until the next workshop.

POST-IT NOTES

Researchers in the past have experimented with limited success with short questionnaires as a way of gaining insights into interesting cases of technology use in between visits and with getting people to video themselves when the researcher was absent (Kraut *et al.* 1998). Neither of these had proved successful and yet it was important to capture data between visits. It was decided to leave some blank post-its with the participants, encouraging them to write any comments on the post-its and stick them onto an existing device or their newly envisioned device. When the researcher returned for the next workshop session, some of the participants had been moving the mock up device around their house. For instance, some people had recorded the extra facilities they would like from the device on post-its, others had annotated

the picture of the device itself. This provided an effective method of gathering people's reactions to devices when *they* felt ready, and not when the researcher was ready.

For example Reilly, a computer literate eighty-year-old woman, had attached notes to a picture of a microwave oven that included a TV screen (Figure 1). Subsequently she re-designed the device as something she would have in her living room which had TV, e-mail DVD, internet and so on, on it, touch screen and voice activation.

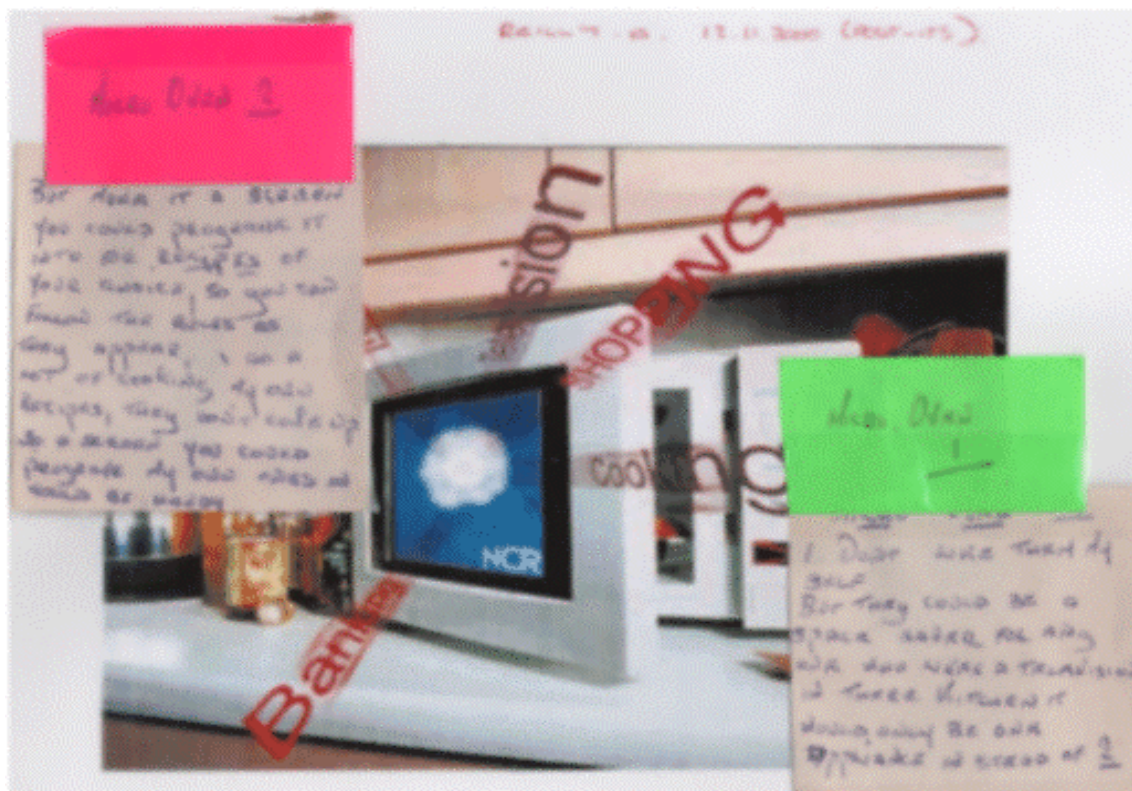


Figure1. Post-its (Agnes Reilly).

SCENARIOS

In the second session, after discussion about the post-its, the families were invited to imagine how they would go about an activity based on a scenario of some people arriving for a meal. This scenario had been generated by the researchers with the aim of getting people to think about future devices and services that could help them with such a situation. Unfortunately, this produced little useful data as far as requirements for devices were concerned; the researcher had imposed too many assumed concerns onto the users. The scenario *concept* was

useful and the families started to develop their own, based on their own interests. It was the *particular* scenario – that failed to ground activities within their context — that was the problem.

DESIGN

The participants were asked to develop a design solution in the form of a paper prototype. The participants were asked to either design a solution to a current problem or to envision a new device that would be of benefit to them in their home. Some of the older participants were hesitant about drawing their own device therefore in one instance one of the research team drew the device as it was dictated to them by one of the participants, all the other participants managed to draw their own devices. The only problem that arose during this session was that some of the participants felt that their ideas weren't good enough. The researcher reassured them that their ideas were good enough.

Workshop 1&2: Emerging themes

In this section we discuss issues raised by the participants during the workshops which we felt were of particular relevance to ubiquitous computing. These themes arose in some ways accidentally, that is to say, the researcher was not concentrating on ubiquitous computing per se. Our focus for the workshops was based more around the concept of single technologies in the home. However, people were asked for their ideas and opinions and from their comments three main themes emerged: smart homes, control of physical space, and control of social space.

SMART HOMES

When talking to the families about 'smart homes' the idea provoked favourable images. Many of the families felt that these homes would be especially good for the disabled or more senior citizens. Two small excerpts from the workshops are given below:

Peter: There wont be lines outside or inside (he is talking about wireless technology).

Researcher: Well this is what they are talking about for the home, wireless technology, everything will be mobile.

Emily: A picture will just hang in the air. They have had it on Tomorrows World (television programme)

Researcher: Yes, h::m would you like that, wireless technology I mean?

Emily: Of course ((she is smiling broadly and Peter is nodding his head in agreement))

Another participant said he would like a smart home to do the following:

Mike: Run the lighting in the home, run the bath, do other household tasks, heating and such like, run a bath for you and take the temperature of the bath (he is smiling broadly and points at the walls, floor, and ceiling of the room)).

It can be seen from the above that the participants seemed to welcome the concept of ubiquitous and digital homes. However some of the families felt that if everyone had a ‘smart home’ it may make people lazy as they would have everything done for them.

CONTROL OF THE PHYSICAL SPACE

Three of the families in the study owned their own homes and had modeled them and added to them over time to suit there lifestyles (see table two). However, two families lived in local authority housing were the control of the home and its fixtures and fittings belong to the local authority. Mrs. Reilly found this extremely frustrating when workers from the local authority came round and change the electrical points in her home, she made the following comments about her kitchen:

Researcher: So is this your ideal set up for your kitchen?

Agnes: No, you can see it’s all been set up for the sockets

Researcher: Yes

Agnes: See they are stupid there (Agnes is pointing to some sockets right next to her back door).

Researcher: So if you had been designing this room you would not have had those sockets there?

Agnes: No. They were just put there, they never used to be there, it’s only in the last year that those sockets have been put in.

Researcher: So did you have any input into were the sockets where going to be?

Agnes: No. I wouldn't have put them there.

It can be seen from these comments that Mrs. Reilly would have been happier with her house if the Local Authority had asked her where she wanted new sockets installed instead of presuming that they knew best. Both of the families who lived in the local authority homes felt that they were not in control of what happened to their own homes. The comments from these families make it clear that they wish to be consulted about any changes to their homes. It also shows how our concerns as designers must go well beyond what we would normally consider 'the technology'.

CONTROL OF SOCIAL SPACE

This section emerged from the issues of control within families. One of the main issues raised by families was control over the technology this had two main themes:

1. Parents or children?
2. Householders or the technology/ system?

O'Brien *et al.* (1999) when carrying out a study of television set-top boxes in the home found that interaction with technology is in complex ways, a managed activity in domestic environments, and this management is closely linked with relationships within the home. Therefore we would suggest that designers need to take into account issues of management and control within families when designing a new system for the home. This issue became more apparent during the workshops when the idea of voice activation was raised. The participants in one family in particular were keen on voice activation. The father in the family seemed to be quite positive about the idea of voice activation and wanted to be able to tell a screen on the wall in his home to carry out most household task, for example: run a bath, change the television channels, and so on. However when discussing voice activation with two of the other families they were more negative about the possibilities thinking that voice activation may cause arguments one of the participants made the following comment:

Researcher: Can you see yourselves using voice activation?

Emily: Oh that would just cause arguments. It's bad enough pressing buttons but if he could activate it with his voice it would be much worse.

In another family the father was concerned about who had control of the system him or his children and seemed quite adamant that he should be the one controlling any home system. The main problem with voice activation did not seem to be anti the technology more anti the problems it would cause for the way technology and family relationship were managed in the home.

Workshop 2&3: Designing your own device

We as researchers are sometimes guilty of feeling that people cannot articulate their ideas for the future without help from us. We can also sometimes assume that they cannot come up with novel solutions or ideas for the future. During the course of the workshops it became clear that people can indeed come up with novel ideas for future homes/devices, if not practical at the present time. The devices discussed here were never intended to be seen as finished designs but were in fact intended to be seen as visualisations of possible future homes or devices which the participants wished they could have. We have not included all the designs here as there are twelve designs in total, instead we have instead picked out the designs, which seemed to be most relevant to ubiquitous computing and its ideas and concepts. Some of the devices are explained and shown in the subsequent sections.

HOME DEVICE REMOTE CONTROL

Catherine briefly explains her design:

Catherine: it is a remote control that does everything switches on your lights, fire, central heating, hot water, television, video, stereo...

The remote control (see Figure 2 below) has a small screen and a tracker ball (Catherine did not draw on the tracker ball as her design had spots on it) for ease of use. She felt that it was important that people were able to choose their own colours and design.

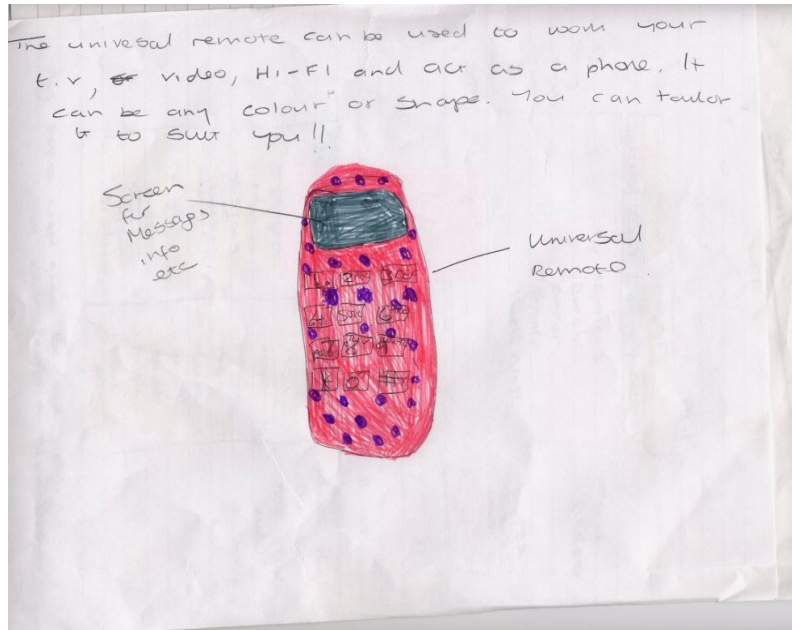


Figure 2. Universal remote (Catherine Naysmith).

The idea emerged when Catherine was trying to think of an idea for a device, she was sitting in her living room at the time and was anxiously looking round for an idea, her gaze fell upon one of her remotes (television) and she picked it up, she then looked around the room and focused for a few seconds on each of her remotes, she has ones for the video and stereo as well as the television remote. Her mobile phone is also sitting nearby. Being in her own living room and seeing the remotes in context seemed to help Catherine find the idea for the universal remote concept.

HOME SECURITY DEVICE

This device will let you know if anyone is in the home who shouldn't be. It will send you a text message to update you on the houses 'well being'. The device can also be accessed by the emergency services in the case of an emergency i.e. if there is a fire, who is in the house and where they are located.

HOME WARNING DEVICE

This is a panel that would hang on your wall and would have a family picture, painting, or drawing displayed when not in use (see Figure 3). Peter felt very strongly that he did not want a screen taking up space and dominating the room, he wanted something pleasurable to look at and that would merge into the background of the room. Peter is explaining his device:

Peter: It would flash up, A light would flash if the doorbell rings, in case you cant hear it, or a light would flash if you had left the oven on to long. It would have to be somewhere in the room that it would catch your eye and then you would go up to it and see the individual light and see what has happened. I would want the light to flash and for the display to pop up, it could be in your lounge, bedroom, kitchen, it could also be in the toilet also, but there you are

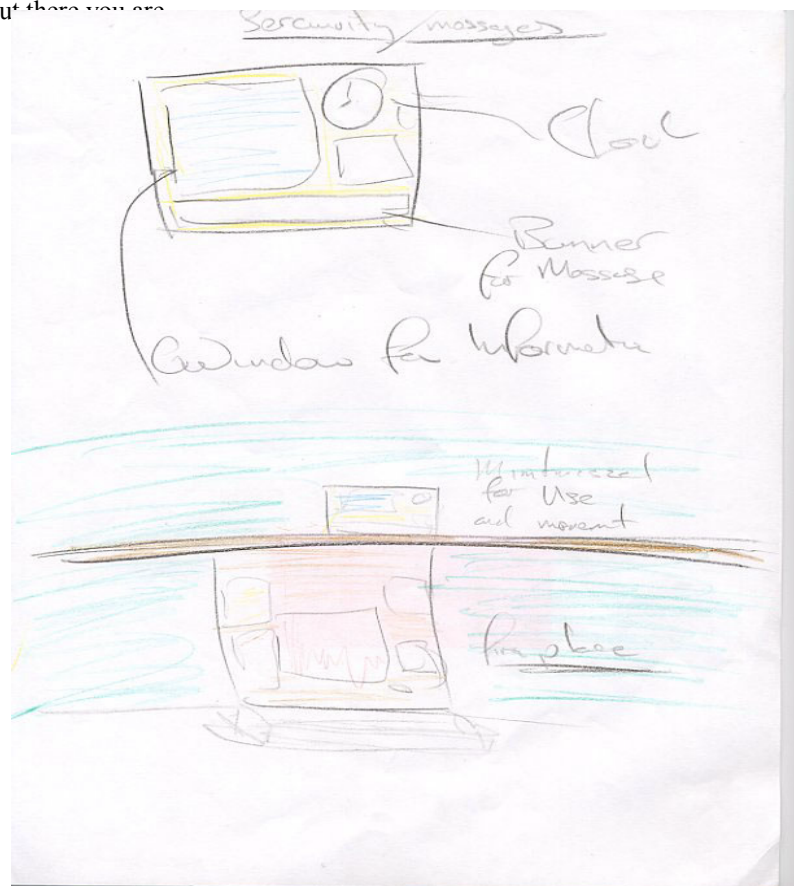


Figure3. Home warning device remote (Peter Sutton).

This idea seems to be one that would be relatively easy to implement. It is interesting that Peter only wants the device to be visible when it is required and disappear into the background when not in use.

THE RECIPE AND KITCHEN STORE DEVICE

Barbara designed a device (see Figure 4) that would provide recipes and would keep track of the food contents of her fridge, freezer, and cupboards. If she chose a recipe she wanted the device to check what she had in stock against the recipe list. She also wanted the device to print her a general shopping list when required. She did not want the device to carry out any of the shopping for her, when asked why, she said: "I enjoy shopping".

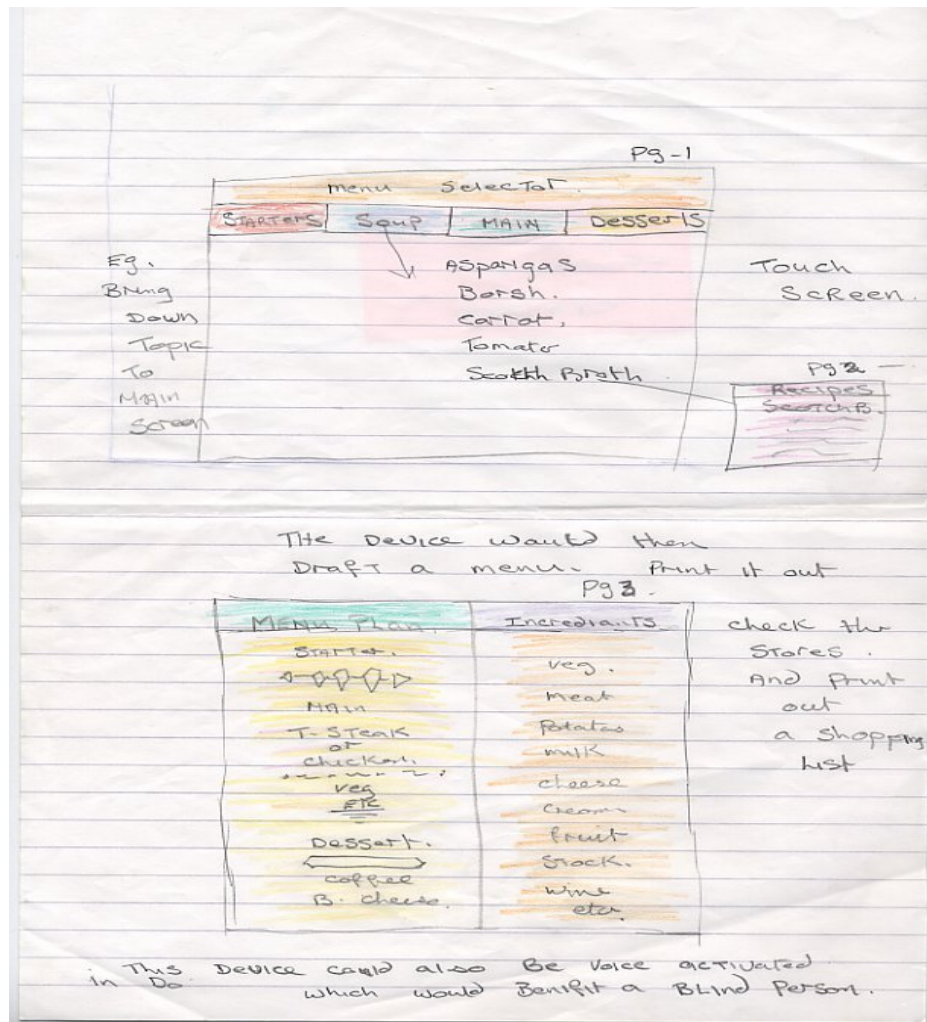


Figure 4. Home recipe and kitchen store (Barbara Smith).

Discussion

METHODS

Reflecting on the methods used, the Technology Tour was effective and provided the richest set of data. In orientating people to the issues of technology and requirements it proved successful. The post-its seemed to work very well except for our error in giving people post-its that were too small! This led to people drawing on the drawing or picture of the device itself (on the back as well as the front). Scenarios should be collected from the families themselves rather than being imposed from the outside. The most appropriate scenarios should be grounded in the users stories of failing or inadequate technologies from the first session. When asking people to design a device for their home we were pleasantly surprised at the ability of people to generate their own ideas. However some of the more elderly participants were at first more reluctant to take part in this session. They did, however, overcome this initial reluctance with the aid and encouragement of the researcher. The children seemed to like this session the best and were happy to use all the craft materials brought by the researcher.

THEMES

The idea of living in a smart home in general provoked positive images from the families, for instance, many thought that the elderly or disabled would benefit from living in such homes. Some families, however, could not envisage themselves living in such a home, this was perhaps because of the groundedness of being in their own home and yet asking them to envisage a completely different type of home. Perhaps when asking questions of this nature it would be helpful to have some mock-ups or pictures of such a home so, that the participants can imagine themselves in such a home. Control over physical space was the second theme to emerge this manifested itself in the negative feelings of the families toward the lack of control, real or perceived, they had over their homes. This lack of control led one of the participants to point out the poor positioning of sockets in her home, which meant that she had no choice over the positioning of sockets and therefore devices. We found that people had strong feelings towards their physical environment with two of our families having either built additional

rooms or remodeled rooms in their homes. Therefore when studying people in their homes particular attention should be paid to this space. 'Control of Social Space' continued as an important theme throughout the course of the workshops, in the early sessions this manifested itself in the different uses of rooms and the technology within them at different times. This issue was also raised when participants were critiquing other peoples designs i.e. one or other of the parents would ask: who has control over the device? is there an override? Therefore it can be seen that interesting issues were raised by the families as pertains to the social space of the home.

DESIGNS

Abowd and Mynatt (2000) when looking at the possibilities for future research in ubiquitous computing said that people may want: computers that they wear, or have embedded in their environment, or the ability to alter their perception of the physical world, or they may wish to have information at their fingertips. During our studies we found that people did want computing embedded in their environment as can be seen by Barbara's recipe and kitchen store device, or Peter's home warning device. Ubiquitous computing is involved in looking at how we can change the physical interactions between humans and computers, instead of the current keyboard/mouse/display paradigm, in the future it will be more like the way we interact as humans with the physical world i.e. speech, gesture, touch, pen and pencil. It is evident from what the participants designed and said, i.e. Mike wanting to talk to a device and ask it to run a bath for him in a smart home, or the universal remote, or the house warning system, that they wish to have a device or system that they can talk to, or touch, or point/gesture at. It can be seen therefore that the way participants are thinking about the home is moving away from the current computer paradigm to a physical world paradigm of voice, touch, gesture.

Conclusions

As technologies become more ubiquitous and invisible, it is essential that the people who will use these devices have an input into the design and functionality of such products so as to

improve the usability and acceptability of those devices for all. It can be seen from above that people are more than willing to give up their own time and ideas so as to be able to contribute to future designs and ideas for ubiquitous and future technologies.

From our experiences to date, it appears that a suitable combination of grounded methods of data gathering and analysis can highlight important contextual issues in the household setting. We are looking for methods that focus on issues concerned with information and communication technology-based product design. It is important that the analyst is open – to surprising ideas, to different configurations of households and to alternative views of technology, but it is also important that they focus on concerns related to the social, technological and physical space. In addition to contributing to the debate about what methods for examining context transfer between work and household, we have come to understand more about the issue of usability of household technologies and indeed about the concept of household itself.

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