Designing New Interfaces for Digital Interactive Television Usable by Older Adults

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The adoption of digital television (DTV), if appropriately designed, could be particularly attractive for older people, who tend to be overlooked when new services and applications are introduced, and remain a marginalized segment of the television broadcasting population. This article explores a range of methodologies and interactive approaches designed to support older people who have difficulties in using current interface models for DTV. Following an extensive requirements-gathering exercise, four different navigational layouts with a simplified remote control were tested and evaluated with older users to assess their ease of use. The results demonstrated the expected difficulties in understanding some of the terminology and interactive concepts utilized in "traditional" DTV design. Aspects of the experimental layouts suggest promising new directions in the development of visualization and navigation metaphors for user-led activities on DTV for older adults.

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1. INTRODUCTION

Technical advances and the convergence of information technology and other consumer electronics in the home have opened up a wide range of future possibilities for digital television (DTV) as a gateway to new and emerging services.

New opportunities exist for domestic technologies to support socially oriented activities for a wide range of people. For older people, known variations of age related changes to vision, cognition and manual dexterity [Fisk et al. 2000], and cultural and generational differences with technology [e.g. Docampa Rama 2001], suggest that the design of digital applications and services to support this important segment of the population is a necessary area of research.

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While studies of DTV have explored the means for enriching sociable aspects of television viewing via voice [Vanparijs et al. 2004] and integrated web-based communication [Luyten et al. 2006], it is unclear the extent to which such applications would interest less technologically orientated audience groups. In the UK, a survey by the Office of Communications reported that "nearly two in five (37%) of people aged 65 and over spend 'all or nearly all' of their leisure time at home, compared to 17% of all UK adults" [Ofcom 2007, p. 8]. Television usage is known to provide a sense of companionship for many older viewers [Rubin and Rubin 1982]. Despite this, there is evidence to suggest that many older people are reluctant to adopt DTV [Freeman and Lessiter 2003]. Consequently, questions remain as to how the design of appropriate applications and services could offer substantial benefits to this audience group.

Given political pressure to confront the poor design of accessibility and usability of enhanced/interactive TV services and set-top box systems [Carmichael et al. 2005b], research on universal access has increasingly argued for "inclusively" improving the television experience. Recommendations include the optimization of graphical output (e.g., color contrast, screen spacing, font size, and typeface); navigational input (i.e., clearly defined labels and buttons on remote controls); and accessible audio description [Gill and Perera 2003; Rice 2003] for people with diminished vision; and appropriate screen caption/subtitles (both closed and live) for deaf and hard of hearing audiences [Bokšan-Cullen 2006]. As a result of the constraints of conventional text-based captioning, a new form of graphical representation, called "emotive captions" have been developed specifically to support hearing impaired viewers [Lee et al. 2007].

As well as providing accessibility features on current DTV systems, there is a requirement to consider not only the mode of input and output of a more "comprehensive" interface, but to develop alternative models of interaction which could better accommodate the heterogeneous requirements of different user groups, such as older people. According to Neale and Carroll [1997], a diversity of metaphors (e.g., real world, spatial, and concrete) offer huge potential for contemporary interface design and new multimedia formats. However, TV-based applications remain influenced by metaphorical features which are not traditionally associated with leisure and entertainment activities of the home. This limitation has led to calls for alterative paradigms of interaction that can more easily provide access to domestic technologies [Chorianopoulos et al. 2003].

To date, few studies have investigated the design of DTV applications for older people, beyond the usability evaluation of existing services [Obrist et al. 2007]. One example has been the development of a digital TV avatar system, complete with speech interface, which was evaluated with older and visually impaired users [Carmichael et al. 2003]. In testing, the researchers reported that older volunteers generally experienced more difficulties in using the system than their younger visually impaired counterparts [Carmichael et al. 2003]. In particular, they found that the older participants had disproportionately more difficulties understanding and responding to implicit screen prompts.

Notably, a large amount of human factors research for older people and DTV is available from Carmichael's 'Style Guide' [1999]. This guide offers detailed information on the design of digital services appropriate to this user group, in relation to their sensory and cognitive abilities and the demands the system may place on them. For example, the importance of clear visual/spatial navigational support, such as suitable highlighting and lowlighting, to relieve working memory load, minimize errors, and help guide attention through operations on screen. However, while DTV studies have, for example,

investigated effective means of navigating and manipulating video content (e.g., Chorianopoulos and Spinellis [2004] and Kim et al. [2006]), they have been evaluated with relatively young subjects. Given the variety of characteristics and functionality of older users, research that can be applied to the wider population is necessary.

The research in this article is part of an ongoing project exploring how DTV could be appropriately designed to be more attractive to and usable by older people by adopting an approach that puts the users' perspective at the forefront of every design decision. First, by investigating user-centered methods in the conceptual design of new DTV applications, the authors aim to raise awareness of the issues surrounding effective requirements-gathering with inexperienced older people who are familiar with more traditional forms of technology. Second, by examining different animation techniques that focus on the concept of continuity from the viewpoint of the user via interaction, we aim to illustrate the potential for more intuitive navigational strategies for older adults. Given the explorative nature of these studies, the research presented here is based on qualitative user feedback rather than measured performance.

The next section describes two requirements-gathering studies, which explored the use of "Forum Theatre," brainstorming, and paper prototyping to identify areas of interest for applications and to understand how the participants use the applications. The third section describes the procedure and results of the main study comparing the use of new navigational layouts, each of which represent relatively radical changes to the fundamental metaphor of traditional DTV interaction. The fourth and final section summarizes and discusses the results.

2. REQUIREMENT-GATHERING METHODOLOGIES

When working with older users, conventional methods for eliciting requirements for the design of systems in a user-centred context have been found to be problematic [Eisma et al. 2004]. Although this is not true of all older adults, HCI researchers found that due to lack of experience many older people do not understand and thus criticise design concepts [Eisma et al. 2003]. Studies show that older people, owing to a limited understanding of computer systems, can be more reluctant to complain about aspects of technology and its usage [Hawthorn 2007].

Part of the problem of knowing how to design for older people is that conventional user-centred methods do not provide adequate or appropriate insights into how this should be addressed. For example, Muller [2003] argues that due to a lack of appropriate involvement with the relevant parties, traditional methods of design analysis and usability evaluation are far too "one directional" in their implementation and usage, and therefore rarely offer genuinely new insights about users. The prominence mainstream designers give to adapting (recycling) old ideas, rather than providing new solutions, has also been criticized [Rosson and Carroll 2003].

In the context of DTV, reevaluating methods that go beyond traditional forms of usability evaluation such as efficiency and task completion have also been established as important factors in the development of entertainment systems [Chorianopoulos 2005; Eronen 2005]. However, while this does not entail abandoning usability engineering techniques, it does require DTV practitioners to consider suitable methods for involving users in conceptualizing new leisure-orientated applications [Chorianopoulos 2005].

2.1 Interactive Theatre

In view of these issues and challenges, we have attempted to explore new methods to assist in gathering information from older people who have little or no experience with

computer systems. Influenced by participatory design (PD) practices [Schuler and Namioka 1993; Muller 2003], which encourage the empowerment of end users in the user-centered design process, we used live theatrical performance to present ideas in a tangible form, in order to raise questions and elicit solutions in the development of novel TV-based applications appropriate for the user group [Rice et al. 2007].

Our research team has already examined the use of dramaturgy and interactive narrative as a means to educate, open dialogue, and facilitate discussion on design-related issues in the development of technology for older adults. Examples include dramatized stories through video to assist in the development of an automated fall-monitoring system for older people in their homes [McKenna et al. 2006], and showing the "real world" problems faced by many older people when using computer interfaces [Carmichael et al. 2005a]. These studies involved developing scenarios about the target group's experiences with technology, which were successful because they illustrated the "human impact" through a process that allowed audiences to empathize and readily identify with the characters portrayed.

Live Forum Theatre involved older audiences, researchers, professional actors, and a skilled facilitator. Discussion sessions with older user groups were used to stimulate ideas about possible social applications via DTV [Rice et al. 2007], and were held in a theatre specifically designed for user-centered research. The theatre was fitted with various household props, a screen projector, and built-in camera and microphone equipment. The stories (which lasted approximately seven minutes each) were based on ideas from the discussion groups that were iteratively developed by the principal researcher and a professional scriptwriter. Like any good drama, the stories contained humor and dramatic tension, and were carefully designed to illustrate both the human aspects of using the applications and the errors that could occur through their use. The application areas that were acted out included a two-way visual communication facility for family and friends, a facility to capture and share images of physical artefacts through the television, and a daily reminder system. Social audio-visual communication with distant friends and family generated the most interest, and comments highlighted the importance of checking on the well-being of individuals (particularly those seldom seen in person). The possibility of capturing, storing, and accessing different types of multimedia (i.e., photographs and video) with a "digital scrapbook" was thought to be a good means to assist users to reminisce and share information, and it was suggested that the reminder system would be helpful for the elderly, particularly those living on their own in sheltered accommodation.

After watching the different scenarios, a number of interesting issues were raised by the audience, including:

Etiquette and social protocol. There were questions about the intrusiveness of any video system that would allow someone to 'automatically see themselves on screen (particularly in the context of commercial misuse). Such issues led to strong concerns over the kinds of control mechanisms, procedures, and prior agreements that would be necessary for all parties.

Language and terminology. Participants provided their personal experiences in attempting to interpret the technical language they encountered, which some referred to as "Hong Kong English" or "buzz word stuff". For example, participants highlighted difficulties in understanding instructions for digital technology, which were criticized for not being clearly sequenced or grouped.

Fig.1. (*Left*) illustration of the interactive theatre: facilitator, actors, and audience; (*top right)* acting out a playlet; (*bottom right*) audience members contributing to the discussion.

Input control. Concerns were raised over the poor design and number of buttons on standard remote controls, particularly for users with arthritis. Alternative suggestions included limited and larger buttons, cardboard sleeves placed over the controller (to limit the number of visible keys), customized keyboards, and voice-activated devices.

Customization of systems. There was a desire to limit application functionality. In one case, this approach was referred to as a "modular system". In view of the perceived complexities of learning new technologies at an older age, comments were also raised over the feasibility of starting from a minimum rather than maximum level of functionality in the development of a working set-top box (STB) system.

Technical feasibility. There were questions about whether such applications would work on a global scale, whether the same equipment would have to be acquired by both sources, or the feasibility of operating such applications on existing STBs (i.e., without a return path) or through a "special television". Given the speed of technical advancements in digital systems, the life span of relevant technologies was also of concern.

2.2 User-Generated Dialogue and Paper Prototyping

Following the Forum Theatre sessions, a follow-up study was undertaken to investigate the practical implications of using a two-way visual application on digital television. The study specifically avoided the use of any technical information that could confuse users. Given the participants' interest in directly communicating with family and friends, the authors (in order to gather ideas for future development work) critically examined how older people could engage with such a system. The study was divided into two parts, with small groups of two to three people set up to explore potential issues. For the first part, participants were asked to generate a wide range of ideas on how they envisaged setting up the communication system. To aid the discussion, a small set of colored prompting cards were presented to users (see Figure 2), illustrating the possible interactive steps necessary for a two-way conversation between a TV caller and the recipient. Within this process, participants were encouraged not only to verbally describe, but also sketch, any

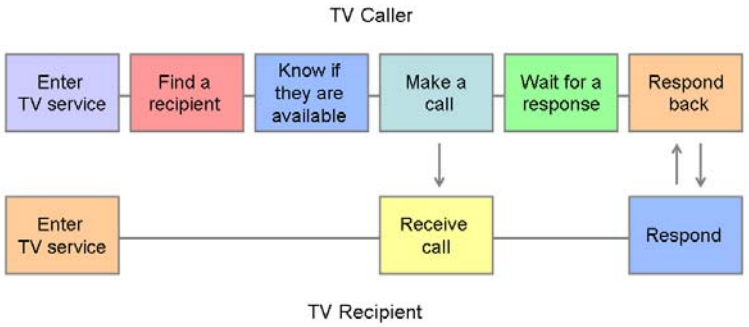

Fig. 2. Diagram of the set-up procedure for the communication system.

Fig. 3. (*Top left*) two older participants in a discussion using the prompting cards; (*bottom left*) an example of a customized layout; (*right*) selected prototype cut-outs with hand-drawn ideas.

design ideas they thought relevant, using colored pens and a paper tablecloth centrally positioned within the group (see Figure 3).

For the second part of the study, participants were given more concrete representations of what the communication system might look like via paper prototypes based on conventional design metaphors for DTV. However, rather than simply present screen shots or hand drawings, participants undertook the physical task of assembling the interfaces themselves. In the participatory design approach, the ability to change the physical artefact is an important way to engage with and explore different points of view [Muller 2003]. Using the "blank canvas" as a metaphor, each stage of the communication procedure (as illustrated in Figure 2) presents users with different design possibilities from which they have to choose. Using cardboard and transparent cut-outs of various graphical components such as menus, labels, and textual and pictorial icons, participants were encouraged to select from and personalize the interface layouts (see Figure 3). Once again, they were prompted to consider implementing such a system in their home environments more widely, while comparing these design concepts to earlier ideas they had generated themselves.

There were several issues regarding the design and use of a communication system. Visual examples, such as the graphical cut-outs, encouraged open discussion and enabled the participants to make reasonable choices among the various ideas presented. In a number of instances, ideas were elaborated via personal accounts and experiences with technology. Participants also predicted how other people in their age group would use this technology.

Some of the issues regarding design and use of a communications system included the following:

Conventional systems. Strong parallels, perhaps naturally, were drawn between conventional and mobile telephones. For example, participants imagined the potential for "dialling" the person they wanted to speak to, leaving voice messages on an answering machine, and automatic call-back and engagement options if the person was not available. Participants also commented on the use of a personalized ring tone when receiving an incoming call on the television and dial-up numbers on a remote control handset, similar to a mobile phone, which itself could be attached to the television. In one case, it was assumed that the caller would first have to telephone the callee to identify whether he or she was available, before they could "attune" (i.e., connect between) the TV-based systems. In addition to the telephone analogies, participants with some computer experience made similar comparisons to email and MSN chat applications, using terms such as "logging on," "clicking on," and "keying in" information.

Design issues. Designing simple and limited functionality in relation to the interface was seen as fundamental for the technology's success. In many respects, participants favored building on technological concepts they were happy with, particularly on simple everyday things, to take the associated nervousness and possible stigma out of adopting something distinctly alien and new. In some, but not all, cases, text-based information was thought of as a more explicit means of representing screen content than the ambiguity of graphical icons. However, the clear and concise use of graphics was thought important to improve screen legibility, particularly given the age-related loss of vision of older people.

Synchronous and asynchronous communication. There were suggestions for the use of "visual" and "non-visual" options to empower the TV recipient to choose whether or not to identify the incoming caller, with the possibility that both would have to agree to "visualize" each other. Among the ideas discussed was the option of holding the incoming call to prepare before communicating with the other person. However, not everyone was happy with the demands of answering a call while watching a program, or staying online if the person at the other end was not available. Similarly to turning off the television (because it is polite) when a visitor comes to call, most participants expected the broadcast channel to switch off automatically before they began a conversation. In addition to this synchronous form of communication, some participants liked the possibility of leaving visual messages, given that some individuals would be difficult to contact, or they themselves could be preoccupied when receiving an incoming call.

Further interaction issues. Uncertainties were voiced as to whether calls would still be received if the system were turned off or on standby. There were also questions about the implications of "pressing the wrong number," the feasibility of inviting a third party to

participate, and, as with a telephone, the outcome for two people with different systems "dialling" the same number. The advantages of using such a system led to questions about the feasibility of an emergency line to directly contact a family member or even a doctor; but there were concerns that this was open to misuse. Similar to the findings from the Forum Theatre sessions, privacy issues were highlighted with respect to commercial advertisers or outside agencies hacking or imposing themselves onto users' television sets. While some commercial advertising was thought a necessity, due to the expense of using the system, user control over content was felt to be critical in adopting this type of application.

2.3 Concluding the Section

Bridging the conceptual gap for older people, many of whom lack knowledge of digital technologies, raises significant challenges as to the types of research tools that should be used to bridge that gap; the participants cited the following problems:

> "It's trying to visualize it, when you don't have the vision, and don't know the technology, it's very, very hard to say."

> "Some people, especially those who have never had contact with computer technology, really can't quite encompass the idea of what to imagine."

Live performance provided a strong communication tool to visually convey the possibilities of new DTV applications in both a believable and recognizable manner. Theatrical sessions allowed audiences to empathize with the characters, and by "hot seating" the actors, that is, questioning their actions, to think about the role of this technology. Paper prototyping and brainstorming sessions provided further evidence as to how older people perceived using a two-way communication application. Such findings strengthen the argument for new metaphors and interaction models suitable for this age group.

3. HI-FIDELITY PROTOTYPES

Based on the results of these preliminary studies, a decision was made to focus on the development of a system that would support more intuitive navigational methods for searching and organizing information on DTV. In particular, the authors decided to think more creatively, beyond the standard practice, about the display and interaction of on-screen content within a domestic environment, with attention focused on the development of a more usable and appropriate input device to map between a remote control and TV interface.

Four prototypes were developed to explore different ways older users might interact with on-screen content in the context of a "scrapbook" application. A decision was made to explore a form of social activity, discussed in the preliminary studies (sharing multimedia such as photographs, music, text, and video messages). It was envisaged that this system would allow for the storage, organization, and viewing of personal multimedia content, in addition to the sharing of this content with family members and friends. The prototypes were designed to work on PC and STB platforms, with real-time support from web camera facilities. Given current advances in home multimedia and STB systems, it is expected that equivalent facilities will become available in the near future and be deliverable over IP and cable networks.

Using insights from our requirements-gathering work, different navigational concepts were explored, each reflecting participants' original desires for an application modelled

on familiar objects from the physical world, using recognized approaches that they could identify with. To achieve this, the authors developed a series of experimental graphical layouts designed to depict realistic and tangible objects to interact with (see Figures 5 to 8). The layouts explored continuity as a key navigational concept, primarily to avoid disorientation due to "snapping" (moving abruptly from one screen item, or one screen, to another). This is similar to treating the problem of "getting lost" in hypertext systems [Kim and Hirtle 1995] by means of the continuity concept, intended to limit the disorientation caused by the snapping effect which could prevent older users from navigating through the system.

A number of layouts were designed influenced by the visualization work of Bederson et al. [2000], Card et al. [1991], and Fry [2004], as well as by work specifically related to animated transitions [Gonzalez 1996]. Due to problems with input control, identified from earlier interactive theatre sessions, the interfaces were all developed so they could be manipulated with a simplified remote control that had six navigational buttons (see Figure 4). Given the acknowledged usability problems with current remote control handsets [Carmichael et al. 2005b], the buttons were much larger than on standard handsets and clearly grouped.

Thus far, conventional interface models have been designed using concepts such as the desktop metaphor, drawn from the workplace and built on principles of efficiency and productivity [Crabtree et al. 2003]. The interactive techniques in this study are focused on engagement and ease-of-use, affordances, and a navigational narrative. Given participants' understanding of more traditional forms of technology, the prototypes took into account the generational differences among potential users by exploring more natural, and real-world metaphors and visual cues to directly and visibly guide them through the tasks at hand, while at the same time trying to reduce the complexity of displaying multiple amounts of information all at once. A fourth interface was built based on the familiar navigational structures found on current digital interactive systems as a "control" for the novel approaches we described above.

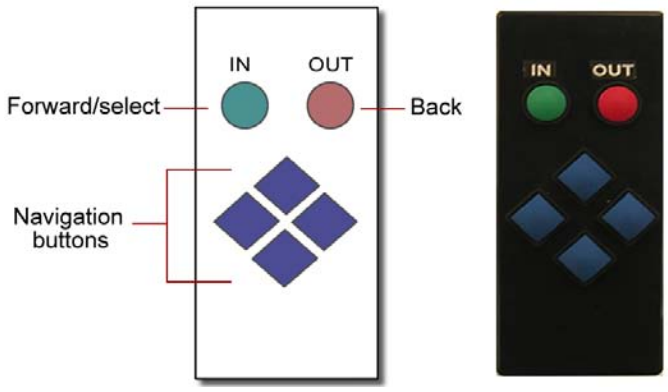

Fig.4. Illustration and image of the remote control handset.

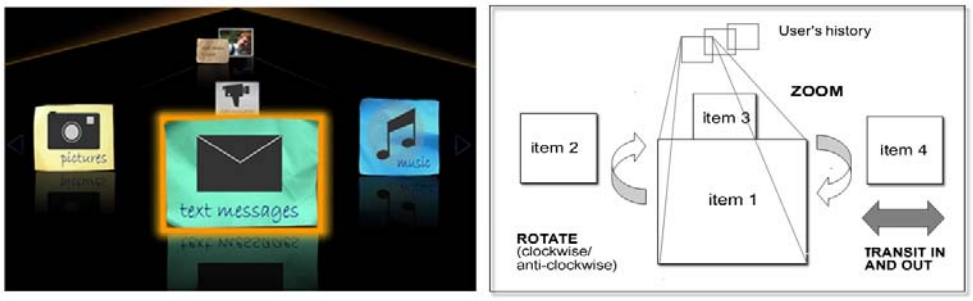

Fig. 5. (*Left*) screenshot of the *Carousel* interface; (*right*) items can be selected by pressing the left and right navigational buttons to rotate smoothly around the carousel. Typically, once the item in the forefront of the screen is selected, it zooms to the back of the screen to form a continuation of the history list. The remaining layer then slowly transits towards the right of the screen and the next layer subsequently emerges to allow selection.

Fig. 6. (*Left*) screenshot of the *Flipper* interface; (*right*) in this case items are organized, monthly by separating them onto individual sheets of paper. To select a message, users flip over the paper by consecutively moving the left and right navigational buttons (thus working through the "pile" with cues as to their whereabouts within it). Users can also zoom in and out of the paper to select and watch a prerecorded message.

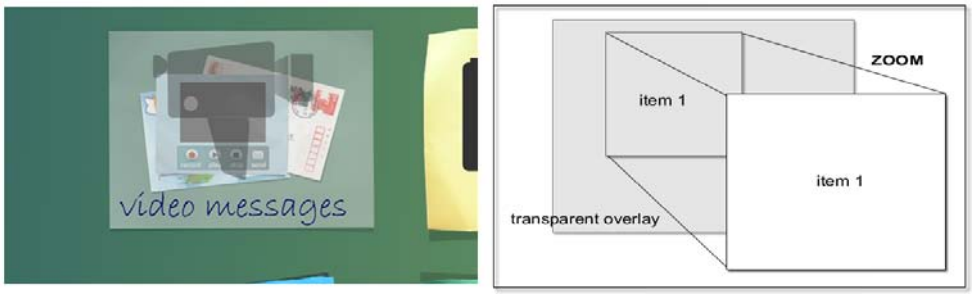

Fig. 7. (*Left*) screenshot of the *Transparency* interface; (*right*) once a menu item like "video messages" is chosen, the application automatically zooms onto the graphical object, becomes semitransparent, and the subsequent layer is revealed. Users then have the options to zoom back, or to zoom in to reveal the underlying item.

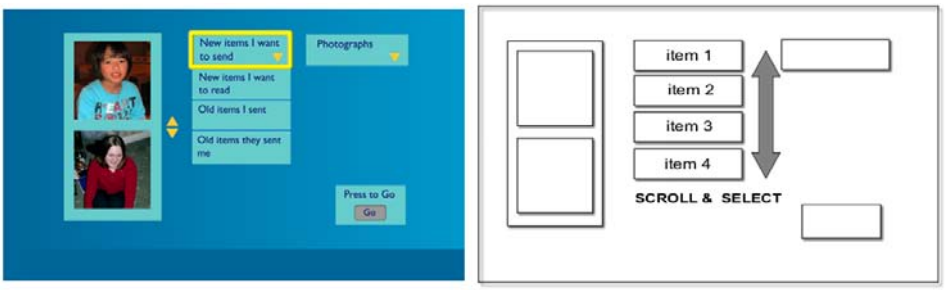

Fig. 8. (*Left*) screenshot of the *Standard* DTV interface; (*right*) users can scroll up and down each item by pressing the up and down buttons. To select an item, press the "in" button. Users move across menus by pressing the left and right navigation buttons. Once an item is selected the screen "snaps" to the next set of options.

3.1 Procedure

In total, 19 older people (7 males, average age 70 years; 12 females, average age 71 years) were recruited from the local area. This group made up a broad mixture of computer and DTV users and non-users. By means of a "Wizard of Oz" approach, participants were asked to navigate through a real- time system. Initial pilot studies established that the number of tasks proved overwhelming, hence some components of feedback were amended before the main study was undertaken.

Given participants limited technological experience, an experienced facilitator demonstrated four interactive examples of the different types of navigation. Following this, each participant was guided through the process of controlling the on-screen multimedia using the simplified remote control, to allow them to become familiar with the navigational handset and screen concepts. Once participants felt comfortable, they were presented with four prototypes and asked to complete two tasks: (i) record and send a new video message, and (ii) find and replay an "old" (previously recorded) video message. To limit any learning bias, the studies counterbalanced the presentation order of layouts across sessions. Following the completion of tasks, participants were presented with four (alphanumeric) input devices to discuss in relation to the layouts (see *Alternative input devices*, below).

To replicate a real-world system, the prototypes were iteratively developed in Adobe Actionscript 2/Flash 8, in conjunction with Flash Media Server (FMS) for real-time video streaming. Earlier versions of Flash Player (5+), a standard for delivering web content, are now increasingly supported on a number of commercial set-top box systems [Adobe Systems 2007]. Information was displayed on a 26" widescreen LCD television screen connected to a single PC unit, with the use of a Logitech Quickcam Pro 4000 web camera for video messaging.

3.2 Selected Findings

Overall, users were intrigued by and engaged with the prototypes. However, in some cases, inexperienced participants were apprehensive and uncertain in making screen selections, and asked for more confirmation and reassurance for actions they were about to undertake, or had just made. In such cases, it was important for the facilitator to motivate participants, subtly encouraging them to explore alternative directions while reemphasizing the acceptability of errors in the study. In other instances, users felt very

comfortable in experimenting with the different layouts. At times, hesitancy was countered by the expectation that an understanding of the different layouts would be acquired through practice. However, it is difficult to assess the extent to which older users would persist with some of the more difficult aspects of the layouts were they in more familiar settings (like their homes).

In terms of prototype preferences, participants favored the carousel design (see Figure 5), commenting upon its simplicity, ease-of-use, and its ability to guide them through the various steps. However, participants were also largely positive about *all* the layouts, despite observations finding noticeable differences between what users *said* they preferred compared to what they could *actually* do. Similar to findings from previous studies with older people [Dickinson et al. 2007], our sessions found noticeable weaknesses in using the think-aloud protocol. Given the cognitive demands of completing tasks for the first time in a controlled environment, getting users to describe their actions became counter-productive to the study. Speaking aloud appeared to interfere with accuracy, so most participants simply stopped describing what they were doing.

Further, in recalling the different prototypes at the end of each session, users commonly forgot which layout was which, and needed visual prompting to remind them. In terms of constructive feedback, all prototypes were praised for their ease-of-use compared to more conventional computer systems. In particular, participants tended to be critical of themselves for not understanding aspects of the layouts, rather than it being a result of poor design.

To illustrate some of the results, a selected summary of the qualitative research is given below.

Fig.9. Screenshots (shown on a 26” widescreen television) of participants with the prototype remote control interacting with the various layouts.

The remote control. The handset was rated positively because it was big and simple to use. Participants commented that the keys were easily distinguishable, particularly in comparison to more standard remote controls. In one case, the handset was directly compared to a mobile crane control in its shape, design, and functionality, while another participant noted (positively) that it had the simplicity of something a young child could use.

There were some mapping issues in relation to the on- screen layouts, particularly as the learning and unlearning of each prototype further complicated the direct manipulation of screen objects. The ambiguity of the "in" and "out" buttons (referred to as the "positive" and "negative"), and the multi-functionality of the "in" button, in comparison to the "out" button (which singularly operates navigation), also caused some confusion. As one participant commented:

> "Every fibre of my being wants to press the out button, because it's going out… you're actually in the place, you're in the recording studio as it were, so to send the message you would be sending it out, or is that stupid? "

In relation to the well-known difficulties associated with the use of conventional handsets (unclear labels, insufficient tactile feedback, poor position and size of buttons) by older people, it is also important to stress the difficulties of simplifying the remote control, and getting it right the first time. As Carmichael [1999] notes, while fewer buttons may reduce demands on memory, it can increase the workload when attempting to match more functions to fewer buttons.

Video-messaging. The novelty of video-messaging made some participants somewhat reluctant to see themselves on screen for the first time. Noticeable problems with the four- button video controls (record, play, stop, and send) included a tendency for participants to repetitively press buttons to stop functions, highlight (but not select) items, and more generally, forget appropriate mappings, even after correct button sequences had been chosen. For example, one of the misinterpretations of the button press was based on the assumption that highlighting alone automatically activated the selected object. Additionally, the sequence of buttons (ordered as record, play, stop, and send) and labelling the button "play" rather than "replay" seemed to cause some navigation difficulties, as it involved skipping across buttons (i.e., navigating from record to stop to make an appropriate selection).

In terms of understanding video messaging, our research also shows that some participants had an immediate expectation that they could record a message, without pressing any buttons or navigating to any specific point on the screen. Although this may be accounted for by the initial nervousness caused by using the system for the first time, it also demonstrates another challenge presented by older users unfamiliar with even the basic concepts of video messaging (similar observations were made about familiar technologies, such as a video cassette running inside the system). We also noticed intriguing patterns of behavior where, for example, to create a new message one participant pressed play before pressing the record button. When asked why he did this, he explained that this is how he would record something on his stereo at home (pressing "play" *and* "record"). Beyond indicating an ability to draw on apparently related mental

models from previous experience, such differences in the ways older people perceive technology was summarized well by one of the participants:

> "I was fourteen when I left school, and technology for me was when I learned how to use a pencil sharpener."

Furthermore, these examples highlight how older users in unfamiliar situations can associate seemingly different design concepts as the default metaphor. Hence it is important to understand these experiences in order to design more usable digital systems for older users.

On-screen navigation. Our studies found noticeable differences between the new prototypes and more conventional layouts. To show this, the following section will present examples from the *Standard, Flipper, Carousel, and Transparency* interface presentations.

Standard DTV version. It appeared that the more traditional linear drop-down boxes and menu lists on the *standard* interface were far more difficult to grasp than other layouts because, unlike the other layouts, information was largely concealed from view. For example, without initial prompting from the facilitator, it was not obvious to many of the participants that they had to scroll down through menu items. Few people felt that the directional arrow icons actually provided any indication as to how a text box should be opened, particularly given the mapping problems in opening drop-down menus by pressing "in" instead of "down". But once they became familiar with the navigational concept, the majority of participants understood how to navigate through drop-down menu lists. More experienced computer users, however, could draw from first hand experience in using linear menu sequences and scroll bars on standard desktop displays.

Initially, many participants had trouble finding information, such as a specific contact, and often assumed that when a contact was not directly visible, information about them would be stored on a separate drop-down box with the heading *photographs.* In this example, as each contact was represented as an image, there was some confusion between finding the "photograph" of the contact, and "photographs" as a separate multimedia category related to that person. Attempts to select from additional menu lists meant a drop-down box could be highlighted but not opened if a previous menu choice had been made incorrectly. These issues were further complicated by a lack of on-screen feedback, limiting participants' ability to recognize relatively small changes on the screen, such as a change in the heading of a drop-down box from the menu item selected. While confusion as to why drop-down menus could not be accessed only led to additional hesitancy and anxiety, which also led to questions over the availability of a search facility.

Some participants also had a strong tendency to select the "press to go" button (on-screen), particularly when they assumed that no relevant information was explicitly available for them to view. However, once all appropriate menu selections on the page had been made, this supposed shortcut option was actually designed to take users to the next screen only. Use of the "press to go" button also raised questions about an equivalent "go" button function on the remote control handset. The graphical button's position on screen (bottom right) meant that users had to navigate across additional menu boxes to highlight it. However, few people seemed to see the importance of first selecting from a drop-down box (before navigating to the required item), which, again seemed to

stem from the participants' uncertainty that these menus headings held any relevant information. As a consequence of all the aforementioned problems, nobody was able to complete the first task with the *standard* interface without help or prompting from the facilitator.

The Flipper, Carousel, and Transparency versions. In contrast to the standard interface, the layouts that demonstrated aspects of continuity appear strong in aiding navigation, including a 3D graphical history in the *Carousel* that illustrates each selected menu item, creating a 3D trail across the top center of the screen. However, unlike the "static breadcrumbs" navigation techniques on web pages, this was done by applying animated transitions, designed to allow the user to trace the movement of the selected menu item and to follow the item's transition off the screen when the user wants to return to a previous menu page.

The 3D *Carousel interface* was highly rated due to its fluidity of movement, whereby information was presented sequentially (with related information remaining visible). It was suggested by a few participants that an additional search facility in the navigational line would be useful to find, for example, when a previous message was sent. However, given the cognitive demands necessary to complete a task, it must be stressed that not all users were aware of this feature. There are likely to be variations in the design, such as adding auditory effects, which may work more effectively in helping to guide the user.

Further, related to these known issues, additional patterns of problematic behavior were identified. In more extreme cases, a misunderstanding of the carousel concept, with persistent attempts to navigate back and forth across the same menu item, rather than rotate in one direction in order to shift the focus of the highlighted menu item. And there were more generic problems, including:

- Pressing the "up" key to select the menu item at the back of the carousel; and by default, pressing the "in" key to select the first menu item highlighted on the screen.
- Orienting in the opposite direction (e.g., turning left to rotate the carousel anti-clockwise, rather than clockwise, meant more navigation steps were required to highlight, and subsequently select a graphical object).
- The slow speed of the carousel, particularly when returning to previous screens. (Suggestions to rectify this included holding down the "out" key to speed up transitions and a "home button" equivalent to one on a typical web browser.)

In addition to the carousel, other transitioning methods such as turning over and zooming in and out of information within the *Flipper* version seemed to be engaging and successful ideas. The virtual physicality of objects is thought of as an important property in successful web search strategies for older people [Curzon et al. 2005], while (in a desktop environment tested with educated and relatively young adults) there is some evidence that animation helps build the spatial mapping of information on a 2D screen [Bederson and Boltman 1999]. As an extension, we found the paper-based metaphor, displayed with many physical characteristics of "real paper," a powerful navigational concept. Given the limited space of the DTV interface, the option of flipping a graphical object onto its reverse side to reveal a related layer of information affords a rational means of linking between menu items and limiting clutter on screen.

Based on user feedback, response time to the animated graphics showed signs of successfully aiding navigation, particularly as the transitions enabled very visible changes

to an object's state. Comments indicated that with the *Flipper* version, screen changes were clear and menu choices apparent. For example, users quickly understood the idea of sorting through video messages, which were attached to graphical objects resembling sheets of paper (see Figure 6). Organized into a pile, each sheet displayed a group of messages for a particular month. By applying a simple navigational sequence (i.e., "left" to flip over a sheet of paper clockwise, "right" to flip it back, "in" to zoom in on a highlighted video message, and "out" to zoom out), we found users were able to search within layers and find a specific video message, unaided, and with relative ease. Praised for being logically sequenced, unlike the *Standard* version, this approach demonstrated that the older volunteers were far less perplexed than expected when the information requested was initially hidden from view. Rather, they were capable of independently finding information, provided that familiar navigational concepts were applied.

Consequently, very few errors were made, and those that were, related less to the use of animation than to inappropriate mapping and menu selections, including:

- initially selecting the wrong contact, either by default because the first person highlighted was selected or because the reason for highlighting was misunderstood;
- inappropriate selection of menu items (see the next section);
- difficulty in distinguishing the functions of the "in" and "out" buttons on the remote control handset (as previously described in this article).

The use of semi-transparent overlays (in the *Transparency* version) as an alternative caused more difficulties. While visually similar to the design of the *Flipper*, the overlays were meant to illustrate a linkage between layers. On the whole, however, the overlays appeared an unnecessary distraction. Most notably, they caused users to assume that un-selectable menu items behind the transparency layer could be retrieved, typically by repetitively pressing the navigation buttons to activate these items. The reduced legibility (due to interference from the background) caused participants to switch focus by repositioning themselves nearer, or, in some cases directly in front of, the screen to read the text-based information (similar to reading through the screen). This caused noticeably more difficulties for people with mild visual impairment (see Figure 10), a similar problem identified in previous research [Rice and Fels 2004]. It is possible that changing the level of transparency and/or transformation may alleviate these difficulties, although the overlay approach itself may not be helpful to older adults. These issues warrant further investigation.

Fig.10. (*Left*) example of the transparency effect, displaying additional menu options underneath the picture of the "contact" to whom they refer; (*right*) a participant close-up to the screen attempting to read the text from the transparency layout.

Menu options and terminology. Given the diversity of older users and their general lack of experience with digital technology, we had problems in creating descriptive labels without detailed explanations. Despite limiting the display of menu items to four at any one time, some participants still made inappropriate screen selections among the alternative layouts. In this case, part of the problem seems to relate less to the legibility or aesthetic quality of the graphical items and more to differences in what multimedia terms may mean to older (particularly elderly) people in comparison to younger techno-savvy individuals. To illustrate, initial attempts were made to choose the word "pictures" instead of "video messages" (in order to send a video message), as it was assumed the recipient would perceive the incoming message as a picture. In other instances, the word "pictures" was also thought of as an abbreviation for "motion pictures" and its association with moving images.

Furthermore, while sending a new message, the image of a selected contact surrounded by a small set of additional menu options on screen (e.g., to indicate items to send, sent to, or received from that individual), led to questions as to whether the contact person was "speaking" to the sender and sending a new message, or visa versa. While a relatively minor issue, such simple problems in interaction further illustrate the need for very explicit and well thought-out design, not only to increase ease of understanding, but to take into account the variability of users' knowledge of the tasks at hand.

Alternative input devices. To summarize, questions were raised over the feasibility of using alternative input devices, given, for example, the possibility of entering and annotating text-based information in the video-messaging tasks. The input devices included (a) a DTV keyboard, (b) a virtual keyboard displayed on a television monitor, (c) remote control with touch pad and stylus, and (d) remote control with additional alphanumerical buttons (similar to a mobile phone). PowerPoint illustrations or physical demonstrations of the devices were presented at the end of each study as examples. In these discussions, participants were encouraged to compare ideas, as well as state reasons for any personal preferences they may have had.

Overall, the response was quite mixed, with no device gaining majority favor. However, rather than resolve this issue, the discussions restated the problems of getting older people to appropriately visualize uses of technology, beyond what they were familiar with. To illustrate, while many participants were familiar with using a remote control and/or keyboard, they were far more uncertain over the feasibility of entering text on screen using a separate input device. Despite expressing difficulties in using mobile and computer technologies, the assumption still was that regardless of the actual input control, participants expected to adjust to its use with relative ease. The learning models of digital systems were also found comparable to those of older electronic devices, as summarized below:

> "I've just bought a new vacuum cleaner, and I mean, it's just not quite the same, but within a day or two I will have got the hang of it, you know, its just a different system for setting it up."

On a general level, preferences for input devices were for anything that was small, unobtrusive, and easy to use. However, there were more specific preferences given as well, such as for a simplified digital TV keyboard, as some participants had touch-typing skills, typically acquired via word processors or typewriters, or because a keyboard was

thought the quickest and most legible way of reading and inputting text on screen. Criticism included the keyboard's lack of association with home viewing, and more specifically its associations with computer use, assuming that this might frighten and intimidate many older people. The keyboard was also called an "unsuitable object," an "impediment in interaction," and one of the reasons older people did not use modern technology (i.e., because they could not type). Alternatively (although not very practically), a virtual keyboard operated by a remote control was proposed as better for older people with poor vision, since they could scroll across graphical keys at the bottom of the screen. Touch-screen interaction with a stylus, although difficult due to the small physical space of the display, was identified as a more personal and familiar form of writing, particularly because of its association to handwriting. In relation, little attention was paid to the alphanumerical remote control, as some participants expressed difficulties, or lacked experience, in text messaging. However, an alternative suggestion was to incorporate the functional controls on the prototype handset within a standard keyboard. Although the use of predictive text was not explicitly addressed, its potential benefit for some older adults may make it worth pursuing.

4. CONCLUSION AND FURTHER WORK

Significant work is still needed to design interfaces that can support the skills and abilities of a heterogeneous aging population. Hence more research is necessary to develop far more creative and usable interfaces for older adults, a significant challenge given the potentially widening gap in "inclusivity" for this emerging and developing technology.

Our requirements-gathering work began with the Forum Theatre. Drama-based scenarios performed with professional actors became a powerful means of demonstrating visually DTV application areas in a context familiar to audiences. A number of acceptability issues were raised which drew attention to social and technical challenges. Subsequent brainstorming and paper prototype sessions further identified the extent to which older people understood the concept of using a two-way visual communication application, heavily influenced by their familiarity with more conventional systems such as the telephone. These studies established a need for more creative navigational approaches, and they support the value of alternative methodologies to gather user requirements.

Based on feedback from users, our preliminary evaluations found that the use of continuity offers potentially more intuitive approaches for people unfamiliar with associated systems. Older users praised the use of this concept in aiding "clear and concise" navigation and in "satisfying the achievement of goals more easily". Observations of participants' successful use of the *Carousel's* 3D navigational trail provided further evidence to support the potential benefits of our layout of navigational steps. By comparison, our studies found a number of weaknesses in the design of more conventional layouts which had drawn ideas from desktop metaphors, particularly in concealing information using standard drop-down and scrolling menus.

The participants' support of the more successful navigational strategies must also be attributed to the design of a simplified remote control, which received high praise from older users despite its rather early stage of development. This includes the graphical design of interface objects on-screen that benefited from being close in appearance to their physical counterparts.

Our research indicates that navigational techniques that mimic aspects of real-world artefacts in a manner that individual's can quickly relate to present possible new

directions in DTV design. However, the success of such systems depends on research strategies that take the impact of both an appropriate input control and on-screen interaction into account. Furthermore, as none of the prototypes were fully functional applications, the number of possible screen errors was limited. Clearly, with a fully working system, it is highly likely that many of the older people would have had more difficulties rectifying navigational mistakes. As a result, we believe the examples in this article strengthen the case for DTV applications that are built on mental models more familiar or easier to develop by older people, particularly making use of the tangibility of real-world objects.

As an extension of this project, further research will focus on a quantitative analysis of the continuity concept. This will include the visualization of potentially much larger and complex sets of data that could be annotated and organized by older people. All of our methodologies will continue to reflect a user-centered approach to design.

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