Tabletop Sharing of Digital Photographs for the Elderly

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ABSTRACT
We have recently begun to see hardware support for the tabletop user interface, offering a number of new ways for humans to interact with computers. Tabletops offer great potential for face-to-face social interaction; advances in touch technology and computer graphics provide natural ways to directly manipulate virtual objects, which we can display on the tabletop surface. Such an interface has the potential to benefit a wide range of the population and it is important that we design for usability and learnability with diverse groups of people.

This paper describes the design of SharePic – a multi-user, multi-touch, gestural, collaborative digital photograph sharing application for a tabletop – and our evaluation with both young adult and elderly user groups. We describe the guidelines we have developed for the design of tabletop interfaces for a range of adult users, including elders, and the user interface we have built based on them. Novel aspects of the interface include a design strongly influenced by the metaphor of physical photographs placed on the table with interaction techniques designed to be easy to learn and easy to remember. In our evaluation, we gave users the final task of creating a digital postcard from a collage of photographs and performed a realistic think-aloud with pairs of novice participants learning together, from a tutorial script.

Author Keywords
Elderly, tabletop interface, digital photograph, photograph sharing, learnability, gesture, touch

ACM Classification Keywords
H.5.3 Information Interfaces and Presentation: Group and Organization Interfaces; K.3.1 Computers and Education: Computer Uses in Education—*collaborative learning*; I.3.6 Computer Graphics: Methodology and Techniques—*interaction techniques*; D.2.2 Software Engineering: Tools and Techniques—*user interfaces*

INTRODUCTION
A primary goal of photo sharing is the "communication of experience" [12]. However, in the context of sharing photographs, CHI and CSCW researchers have mostly neglected the special needs of the population demographic with (in raw terms at least) the most life experience — the elderly. The need for more suitable ways to share digital photographs is well understood [8, 12, 19]. Recent work has considered sophisticated navigation and browsing [10, 13] and novel interface design [3, 22] for reducing constraints inherent in the sharing of photographs in purely digital form compared with printed photographs. However, design, usability and learnability for elderly users has not yet been considered. We have been exploring this in the design of SharePic, a tabletop interface for photo sharing.

In design for elders, we need to take account of the well documented effects of aging. Essentially, as we age, we have increasing levels of disability and illness. In particular, interface design needs to take account of losses in vision, cognition and motor skills. Visual losses that are relevant to the design of a system like SharePic are reduced visual acuity, loss in colour perception and increased sensitivity to glare [1]. Relevant cognitive losses include declining performance of working memory and learning [24]. Problems in motor skills include slower movements, poorer co-ordination and difficulties with fine motor actions [5, 6]. There is a considerable body of knowledge as well as guidelines about ways that design of user interfaces can help ameliorate the effects of such deficits. For example, Becker [4] studied web usability for older adults. In addition, currently elders will tend to have less experience with computers and are representative of other users who lack confidence and have some physical or cognitive loss. This makes them a very challenging group for user interface designers.

Given the novelty of tabletop interfaces, there has been little work with a focus on design for tabletop interfaces. There has been some foundation work such as Scott [21] who studied users managing photographs at a tabletop towards the design of personal spaces and storage bins. From many general guidelines [15] of user interface design and the research on elders, we have established principles to guide the design of SharePic. We describe them in relation to the particular challenges faced by elders:

G1. Ensure the user can easily make interface elements larger. This ameliorates the effects of vision impairment and also, by allowing the user to enlarge user interface

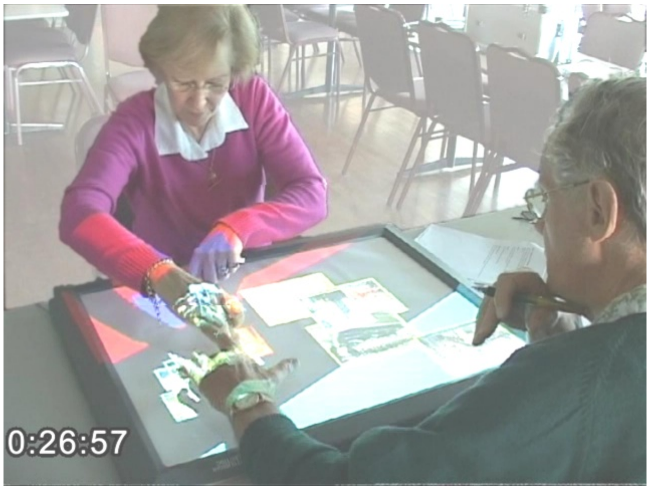


Figure 1. A pair of our elderly participants using the interface during Task 2

Figure 2. The projected image for 2 users

elements as much as they please, they can reduce the need for fine motor co-ordination.

G2. Focus on learnability and memorability. Addresses greater difficulty in learning new concepts and helps with declining short term memory.

(a) Rely on familiar aspects of manipulating physical photographs. This reduces the amount to learn and remembering is easier since the user already knows how to move and share physical photographs.

(b) Minimise the number of interface elements, based on common user interface goal of simplicity.

(c) Strive for predictability by maximising consistency.

(d) Use new objects with new appearances for new interface behaviours [25]. This avoids clashes with the user's existing knowledge.

G3. Support user in reducing clutter. This is especially important if many user interface elements need to be large. In general, we should reduce distraction from the current focus.

G4. Address special aspects associated with tabletop user interfaces:

(a) They may be large so user may be unable to reach whole table easily.

(b) They are social spaces, commonly used with other people. G1 is also significant here; e.g. when users enlarge an image in order to discuss it.

G2 is largely adapted from classic guidelines such as Nielsen [15], which emphasise predictability, consistency, feedback, error prevention and reduction of memory load. G1 is special to the tabletop interface and our emphasis on the elderly – a user cannot pick a photograph up to examine it closer and the large dot pitch of the projection means that leaning closer to the table helps only slightly. G3 and G4 are also particular to the table, because it is easy to create new images and multiple people may interact in parallel.

We now give an overview of SharePic, explaining the design according to the above principles.

SHAREPIC OVERVIEW

Before describing our approach to designing a user interface for elders, we briefly overview the hardware and software underlying the work. We also set the context with the high-level user interface goals of the work and the overall appearance of the final system.

SharePic is our multi-user, multi-touch, gestural collaborative digital photograph sharing application built on top of TouchGL – our accelerated, OpenGL-based toolkit – and the DiamondTouch hardware system from Mitsubishi Electronic Research Laboratories. TouchGL provides a scalable software framework to handle a large number of high-quality digital photographs while taking advantage of the rendering speed-up from dedicated graphics cards.

DiamondTouch [9] supports arbitrary parts of the body being used for interacting with the display, but in practice, two hands, fingers, thumbs or palms are typically all that are used. When users touch the DiamondTouch, weak electric signals for the row(s) and column(s) that they make contact with are transmitted through the body to a grounding pad on which they sit. In this way, DiamondTouch supports multiple users unambiguously. An example of the interaction can be seen in Figure 1, which shows two elderly participants interacting with SharePic. The man in the foreground is using his left hand to interact with SharePic while the woman is using both hands.

SharePic supports simultaneous use by up to four users, and the hardware allows users to interact synchronously on the shared surface (i.e. they do not need to take turns). For this work, we configured the application for use in pairs; users were seated opposite each other at the long edges of the table, with a coloured triangular "personal space" in front of them. This can be seen in Figure 1 – the colour of the personal space for the far participant is red, and cyan for the close

Function		Why Core	Design Influence	Guideline
Select		Establish Focus, *raise* to top		
Move		Pass photographs, organise, layout, etc.	Tight coupling with selection point	G2a
*	Rotate	Orientation for user view and for postcard layout	Large activation area in photo corner, bound to photo	G1
	Resize	Make focus for discussion or view (enlarge), make smaller when not focus	Same activation as for Rotate (fewer actions to remember); Easy, flexible enlarge when vision is poor	G2b, G1, G4b
Copy		Duplicate whole photos and control objects	Builds on move	G2b
Personal Spaces		Area close to you in which to work	Limited reach of person opposite; familiar with own place for own things	G2a, G4b
Delete (Hide)		via the "Black Hole": Reduce table clutter, remove mistakes	Avoiding cluttered displays; gradual, reversible action with continuous feedback	G3, G2b
Capture		via the "Frame": crop photos and create new photos (a postcard) from a layout of other photos		G2d

Table 1. Summary of Core Functionality in SharePic
* *Rotate and resize is a combined action* – rosize

one. As well as the personal spaces, users see a number of photographs and some control objects that they may interact with, such as in Figure 2. When a user selects a photo, the selection border will be a brighter shade of the colour of their personal space.

One example of the sort of task a person might perform with the SharePic interface is to construct a digital postcard using a collage of other photographs. Conventionally, such a task would be performed using advanced functionality of photo editing software such as Adobe Photoshop, including the use of image layers, transparency, z-order, arbitrary rotations and layer scaling, as well as (rectangular) selection, copying and pasting. The design goal for SharePic was to support all these operations in a highly learnable interface that is easy to use. The design process described below resulted in a user interface that allows users to move, rotate, resize and copy photographs *and control objects*, as well as generate new photographs from copies of whole photos, parts of photos or a layout of multiple photos. The design of these actions for the elderly is summarised in Table 1 and discussed in the following section.

Some justification for this task comes from our own ethnographic study of elders [18]. This study used a *cultural probe* to gather qualitative information on memory sharing activities in the home. Technology was not the focus of this study but rather current memory sharing activities supported by people, places, events or physical items. Prominent physical items included photo albums and scrap books, where photos and other items are laid out on a page and subsequently used as a focus for story telling. A digital postcard creation task supports a similar activity and allows the creation to be shared electronically; e.g. in an email to friends and family whilst travelling.

DESIGNING SHAREPIC FOR ELDERLY USERS

User interface actions are intended to be as natural as possible through the use of a variety of visual affordances. Some of these affordances are derived from equivalent, purely physical interactions that occur with printed photographs placed on the tabletop. We do this to reduce the semantic gap and to minimise the number and complexity of new concepts our participants were required to learn. To maintain the link with the physical world, users interact only with photographs – there are no buttons, menus or toolbars to be navigated.

Where possible, the use of different interface concepts can form a continuum of actions or gestures, and the same visual affordance may be used for multiple actions, depending on how it is used. Continuous feedback is given throughout the actions, so the user can immediately see the effects of their interaction, and the actions are designed to support an early exit with minimal, reversible changes if the user decides from the feedback that it was not their intended action.

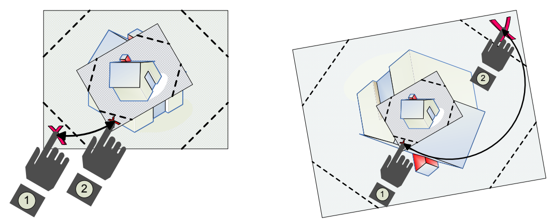
In this section we discuss the design of the core functionality to support the goals above and our elderly users. This functionality is the subset of the photo sharing framework we have implemented that is relevant to our evaluation.

Select

Select is accomplished by physically touching an image. Once selected, *photo corners* are displayed within the image boundary and indicating the two parts of an image: corners and the "centre", which is all parts other than the corners. This visual affordance can be seen in the photos of Figure 3 and is borrowed from the physical world where one might mount a printed photograph using small pouches or slots into which the corners of a photograph are placed. In our implementation they are used to carry out further actions on the photograph, discussed later in this section. Note that their placement within the image boundary allows these actions to be fluidly activated in a single motion, without requiring an explicit *select*.

Move

Move is the most fundamental action on a photograph. To move a photograph, a user touches the main part of the image and slides their finger over the surface. The photograph is translated the same displacement as the finger movement while keeping the touch point under the user's



(a) A reducing rotate/resize gesture

(b) An enlarging rotate/resize gesture

Figure 3. The *rotate/resize* gesture

The centre of the image remains fixed while the image rotates and resizes to keep the "✘" under a user's finger.

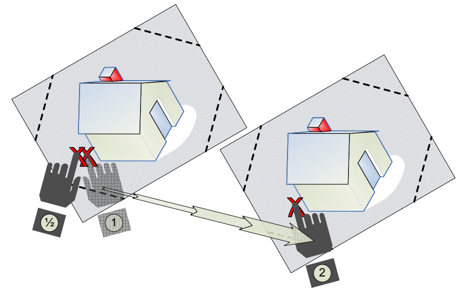


Figure 4. The copy gesture

The left finger and picture remain stationary while the copy appears beneath the right finger, as it is moved away.

finger (supporting guideline G2a), unless the photo would be moved off the table or into another user's *personal space* (see below).

Rotate / Resize (*Rosize*)

This is a composite gesture that we created as a way to achieve simple interaction (guidelines G1 and G2b). *Rosize* makes it possible to maintain the appearance of a particular point on a photo being "stuck" to the participant's finger tip (as it is for *move*). To activate, a user touches the image in one of the photo corners (with or without a *select*) and slides their finger over the surface. The photo is rotated and resized concurrently such that the location on the photograph of the initial touch continually remains beneath the user's finger, as in Figure 3. Note that it would not be possible to maintain this *stuck* effect if we performed only a rotation or resize without requiring the user to restrict their movement to a purely radial or circular motion.

For example, Figure 3(a) shows a user's finger moving from position 1, inwards and with a slight, anti-clockwise rotation, ending at position 2. This causes the photo to reduce slightly while rotating approximately 45 degrees. Figure 3(b) shows a user's finger moving from position 1, on an arc and ending further from the photo centre at position 2. This causes the photo to rotate almost 180 degrees while increasing in size by approximately 200 percent. In both cases the original touch-point, indicated by an "✘", remains under the user's finger throughout the action.

In maintaining the desire for a tight coupling with the physical metaphor of printed photographs, we note a similarity to the approach taken by Kruger et al. [14], where rotation and translation occur in a single action (RNT). That work found that the combined gesture was well understood and efficient as well as preferred over separate actions for their participants, sourced from a university population. However, for our work with the elderly, we wished to prioritise a *resize* operation to assist users who might have poor vision and also to assist sharing of images through a simple zoom operation. In our current system, a resize is incompatible with a translation. Hence, a combined rotate and resize action, which we have called *rosize*. Other work with touch and tabletop interfaces that we are aware of performs a resize independently of other actions: similar to the operation for application windows in common computer desktop environments (e.g. [17]), sometimes with enlarged corner handles going outside the bounds of the window frame (e.g. [23]); implicitly based on location on the tabletop (e.g. [26]), or with a multi-touch gesture (e.g. [16]).

Copy (*Gesture*)

To *copy* a photo, a user must first be touching in the "centre" then add a second finger near the first. As they slide one finger away from the other, a duplicate of the photo is produced, as shown in Figure 4. Unlike other actions, this *copy* action is invoked using a two-finger *gesture*. The finger can be on the same or different hands, which is reliant on the configuration of an appropriate threshold used in determining if the fingers have moved apart enough to invoke a copy. Once both fingers are released, the two photos behave as if they were completely separate.

For a copy of this nature, there is no simple analogy in the physical world, but it was hoped that this gesture would be easily understood while supporting guideline G2b. The intention was that by touching in two places during a *move,* one could move a photo to two different places simultaneously, thus creating a copy.

Personal Spaces

Personal space objects are coloured triangular elements drawn on the display so as to demarcate the exclusive area for each user (G2a and G4b). Once the centre point of a photo is contained within one user's personal space, no other user may select that photo. Similarly, a photo may not be moved into another user's personal space.

Delete (*Black Hole*)

In designing the delete operation (and to support G3), we wanted a *reversible* action that could be executed simply and with continuous feedback, such that the action could be cancelled early if was started unintentionally. Thus an image could not simply disappear, based on some trigger. Nor did we wish the user to navigate a command hierarchy, toolbars or text which might be difficult to read and understand by our elderly users (G2b). Furthermore, the dot pitch of the image projected onto the table and the problem of orientation means

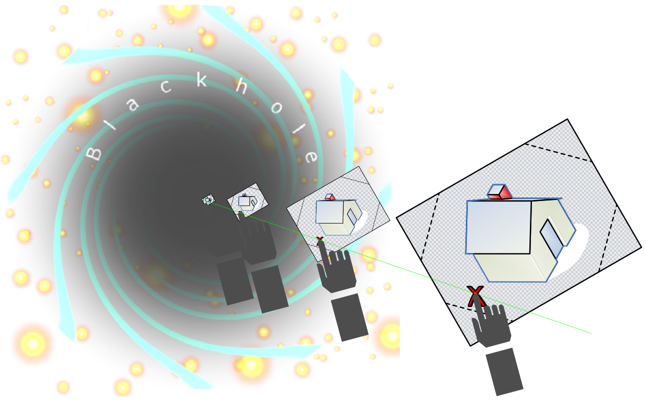


Figure 5. Putting an image into the Black Hole

that text and toolbar glyphs are often difficult to read. Our solution to this was the *Black Hole*.

The Black Hole is a semi-translucent photo with swirls as shown in Figure 5. It is always shown in front of other photos and can be manipulated as a typical photo but cannot be copied or moved into any personal space. The Black Hole is an object with a "sphere of influence", that affects the size of photos within and around it (i.e. that overlap the Black Hole photo). Photos closer to the centre of the Black Hole are proportionally smaller than photos on the fringes. Very close to the centre, the photo is hidden. Figure 5 shows a user moving a photo into the Black Hole. As the photo is *moved* from the right to left, the photo gets smaller as it moves closer to the centre. This gives the impression of the photo being *sucked* into the Black Hole.

The Black Hole helps support the ability to free screen space and dispose of irrelevant images. This is somewhat like the *Trash* can on many desktop user interfaces, but the Black Hole also satisfies a number of natural interaction rules that improve its usefulness for collaborative interaction.

- photos placed in or near the Black Hole can be recovered (photos are not deleted permanently);
- photos can be "partially removed" (i.e. out of the way, but easily retrieved);
- photos maintain a physical-virtual coupling as they progresses from normal $\mapsto$ partially hidden $\mapsto$ hidden $\mapsto$ retrieved;
- photos influenced by the Black Hole do not suddenly appear or disappear;
- photos placed in or near the Black Hole remain bound to it (e.g. when moved);
- as the Black Hole is resized, the photos within its sphere of influence change their size accordingly.

To get photos *out*, the Black Hole can be made smaller and photos not very near the centre may then be removed from the fringes. If a photo has been completely hidden, the only way to retrieve it is to drag the Black Hole into your personal space. *All* images in the Black Hole will then be "dumped" into your personal space.

Capture (*Frame*)

To create a postcard, users required an operation to *capture* a photo layout they had previously constructed using the move, rotate, resize and possibly copy actions. For the capture operation, we use the physical analogy of a camera viewfinder implemented as a transparent blue object we called the *Frame* (G2d). This can be copied, moved, rotated and resized like all other photos. As it is moved over other photos (e.g. a postcard layout), the photos are visible through it and the area that would be captured is highlighted blue, as if seen through a piece of coloured glass.

To activate the "shutter", a user holds her finger, stationary on the Frame for one second (a *dwell* action). When invoked, users see a brief "flash" in the form of blackened screen. The screen pixels beneath the Frame are then loaded in as a new photograph, which slides in from the corner of the table.

Because we work directly with what the users see (i.e. the video frame buffer), the result of the capture operation is immediately evident. The Frame also allows users to crop photos and copy whole photos.

EVALUATION

To assess the effectiveness of our design, we designed an evaluation that would provide insights into the following aspects of the interface:

- performance: could elders successfully perform photograph sharing and reminiscence tasks, with minimal training?
- learnability: could elders learn the core concepts embodied in SharePic from a combination of being explicitly told about elements, being encouraged to infer elements and being able to explore and discover other elements?
- affect: overall, did elders find SharePic pleasing for photo sharing activities?

We ran two sets of trials, one with young adults and one with elders. We considered it critical to study SharePic's learnability for elders. This aspect could be affected strongly by a user's ability to learn and remember new facts, as well as their confidence in exploring. We took care to minimise the number of interface elements and to ensure consistency among them. We wanted the evaluation to provide insight into how well elderly first-time users could learn about SharePic's core elements, as well as how well they could infer and explore.

Finally, we wanted to learn how elders would regard their SharePic experience. Clearly, this is closely related to the other aspects of SharePic's usability but it also includes the elders' response to such an unfamiliar interface.

Method

When presenting a completely new interface for a user trial, it is common for researchers to participate in an interactive training session with the participants (e.g. [11, 20, 27]) and ignore data from early trials to discount learning effects (e.g. [17]). In this work, we wished to examine learning effects and in particular, analyse whether attempts to minimise the number of new concepts and make action invocation easy to remember was supported. Furthermore, we considered the needs of our elderly users in formulating the evaluation. For example, difficulty in remembering new concepts suggests the need for a reference that the participant could refer back to in the trial.

Thus, in our evaluation we presented participants with a printed tutorial script rather than providing an interactive training session. We believed that our user interface was easy enough to learn that a one- to two-page tutorial would be sufficient. We used a natural think-aloud evaluation, with pairs of participants making use of SharePic; making it natural for them to speak about any problems and explain what they were doing and thinking. All experiments were conducted by a single observer; the first author of the paper. We videotaped the experiment from two angles, each focused on one of the users as well as the touch surface. We recorded audio from each camera.

The nature of a tabletop interface makes it very natural to use in a social setting with two or more people. We designed the evaluation to give insight into the way learning may be supported and influenced by working with a partner; also a novice. We now give a brief outline of the experimental setup. For further details see [2]. The experimental session had three parts: a tutorial task to introduce functionality; Task 1, which provides more familiarisation without the load of decision making (i.e. practice); and Task 2, which is a more authentic photo sharing activity, designed in light of our earlier ethnographic study [18].

Tutorial Task

The printed tutorial introduction was approximately one and a half A4 pages in 12-point font. It had seven, clearly numbered steps. Participants were able to refer back to the printed materials during the subsequent tasks. Indeed, some did just this.

The tutorial was designed for active learning, with participants asked to try things as they progressed through the steps and also asking them to experiment to discover other aspects. For some elements, participants were asked to write down what they discovered into spaces in the document. To keep the tutorial short, we carefully chose some concepts that were introduced, either explicitly or in discovery activities. This meant that there were concepts left for participants to infer as they performed subsequent tasks. We expected participants to be able to deduce these untaught concepts by generalising from the behaviour of interface objects and from concepts they learnt about in the tutorial. This design was intended to indicate the ease of predicting functionality of SharePic.

When considering the special needs of our elderly participants, the printed tutorial seemed better than a demonstration. A demonstration might pose problems for participants with hearing loss. Furthermore, we wanted each participant to be able to take the tutorial at their own pace. This seemed particularly important with the participants working in pairs;

Figure 6. Initial state for Task 1

we were concerned that if one member of the pair did not understand part of the demonstration when their partner did, the former may have felt uncomfortable about slowing things down. Finally, we were conscious of the possibility that elders may have some difficulty remembering elements they had recently met for the first time in an interface as unfamiliar as SharePic.

Each of the tutorial's seven steps introduced one aspect:

1. the idea of personal space;
2. exploring it in relation to another person's space;
3. how to shrink, enlarge and rotate photos;
4. coping an image;
5. making an image float on top of other photos;
6. Black Hole and experimentation with it;
7. Frame and experimentation with it.

For the tutorial, the interface was setup as in Figure 6. The "photos" are all simple line drawings, each with a large, clear number in the centre for easy identification.

At the end of the tutorial period, the printed materials asked for general comments on the positive and negative aspects of SharePic. Most users preferred to do this verbally: so these comments were extracted from the video transcripts. This stage also served partly as a graceful opportunity for a slower participant to catch up with their partner. Once both participants were satisfied that they had completed the tutorial, they commenced Task 1.

Task 1

This task had two parts: making a defined postcard, then cleaning up the table. At the beginning of the task, the table was reset to the same layout as at the beginning of the tutorial. The printed instructions presented an image of the precise appearance of the postcard that each person was to make.

The two participants were each asked to create different postcards from three images. One of the images was needed for both postcards, so participants needed to create an extra copy of this. The printed material for this task showed an image of the *target* postcard and coached participants to do the task, suggesting that they:

- take a copy (if necessary) of all the pictures they need;
- put these into their personal space;
- capture the postcard with the Frame;
- put the resulting image in their personal space;
- reminding them that the newly created image would slide in after a second or two;
- pointing out to participants that their partner would also need the Frame.

The design of this task deserves some explanation. Firstly, it tests whether participants learnt the main elements from the tutorial. Secondly, we removed creative aspects from the postcard creation task: involving very stylised images; specifying exactly what the postcard should look like; and involving exactly the same images and initial setup as in the tutorial. This allowed participants to avoid the potential distraction and cognitive load of deciding what pictures to choose and how to arrange them.

Creating the postcard required all participants to move and rotate photographs as well as to make use of the Frame. Although the instructions encouraged participants to make copies of photos, it was quite possible that one member of the pair could make the copy that was essential for both participants to complete the task. The task also called upon participants to show understanding of the notion of personal space; to move images into and out of it, as instructed.

The second part of Task 1 asked participants to clean up, moving the Frame out of their personal space if it was there, their postcard into their personal space and all other images into the Black Hole. This part enabled participants to demonstrate awareness of the concept of the personal space and the ability to use the Black Hole to dispose of images. Once Task 1 was complete, participants commenced Task 2.

Task 2

This was a more authentic task using high-quality digital photographs. It was impractical in this experiment for users to provide their own photographs, so the images were sourced from an author's collection. Each participant was asked to pretend that they were making a postcard for a friend. In the case of Participant A, this friend was interested in sculpture; for Participant B, the friend was interested in architecture. At the beginning of this task, the table was initialised with a collection of 15 photographs. Of these, at least four were clearly sculptures and a different set of four were architectural.

This was the main experimental task, relying upon participants having learnt several of the main elements of the SharePic interface from the tutorial and Task 1. It required participants to resize and rotate images, make effective use of the Frame to capture the postcards and the Black Hole to

		Confidence			Cumulative Experience				
		Not Confident	Confident	Expert	Little or None	Days	Weeks	Months	Years
Young	Y1A		✓					✓	
	Y1B			✓					✓
	Y2A		✓					✓	
	Y2B		✓					✓	
	Y3A		✓				✓		
	Y3B	✓					✓		
	Y4A		✓					✓	
	Y4B		✓						✓
	Y5A			✓					✓
	Y5B		✓						✓
	Y6A			✓					✓
	Y6B			✓					✓
Elderly	E1A	✓			✓				
	E1B	✓						✓	
	E2A		✓					✓	
	E2B	✓				✓			
	E3A	✓			✓				
	E3B		✓						✓
	E4A	✓						✓	
	E4B		✓						✓
	E5A		✓					✓	
	E5B		✓			✓			
	E6A	✓						✓	
	E6B	✓			✓				

Table 2. Participant self-assessment of computing confidence and experience

clean up. It did not require any copying. Once complete, participants were encouraged to make general comments about the interface. This was the final stage of the experiment.

Participants

The first set of trials involved six pairs of young users. These were secondary school and university students, mostly undertaking an Arts or (fewer) a Computer Science degree and aged between 18 and 24.

Our elderly participants were another six pairs, all members of the Port Hacking Probus Club, a Rotary club for retired professionals and businesspeople. Members were aged between 63 and 81. From Table 2, we can see how each participant assessed their own computing experience and confidence – note that only 1 young participant considered themselves "not confident", compared to 7 of our elderly participants. Note that our elders considered themselves as having less *experience* with computers, but not considerably less; perhaps due to their professional backgrounds.

In summary, major differences are age, which has associated differences in confidence and experience with computers. Our tabletop interface is intended for a wide range of users, so the population of elders is particularly important in assessing our guidelines and resulting design.

Physical Setting

The evaluations involving the young people were conducted in our laboratory. The elderly user tests were conducted

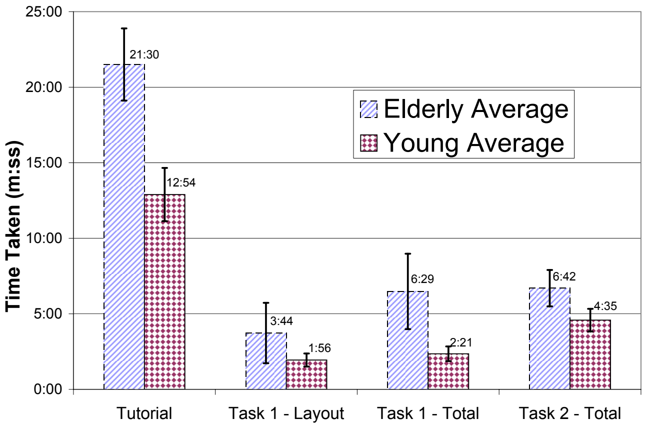


Figure 7. Task Times for Elderly and Young Participants
error bars show a 90% confidence interval for the true average

Concept: Group		Rosize 1	2	3	Copy 1	2	Black Hole 0	1	2	3	4	Frame 0	1	2
E1	A			•						†				
	B													
E2	A				•	•								
	B													
E3	A													
	B													
E4	A													
	B									✘			†	†
E5	A				•	•					✘			
	B				•	•					✘			
E6	A									†	✘			†
	B							†		†	✘			

Table 3. Difficulties with Concept Learning (Elderly)
A blank cell indicates that the participant **did** *learn the concept, during the appropriate stage of the tutorial.*
• *learnt during tutorial, but not at the stage that dealt with it;*
† *learnt concept during either Task 1 or Task 2; and*
✘ *did not show evidence of learning the concept at any time.*

in the common room of the South Cronulla Bowling Club. For these tests, no computers, keyboards, monitors or mice were visible to the users. Although the cameras and various cables were visible, participants appeared to quickly become unaware of these. One of the pairs is shown in Figure 1.

Participants sat at the long edges of the DiamondTouch, which had been placed on a table 80cm high. The LCD projector and an angled mirror were used, suspended from a ceiling rafter, to project onto the surface of the DiamondTouch. The observer sat to the side of the table and the table was placed in the centre of the common room, away from the glass walls and direct sunlight. Only indirect natural lighting was used.

RESULTS

The videos from the experiment provided a rich source of data about the manner in which the participants used SharePic and how they learn about its interface elements. The evaluation method was goal-based and in the form of a think-aloud, hence completion times and efficiency are not the focus of our analysis. Rather, we analyse whether participants were able to successfully complete the tasks and how participants learnt and used the novel interaction methods they were presented with.

However, to give an overall impression of how our elderly users coped with the task, we present the average duration of the tasks for our elderly versus our young participants. Note that participants were encouraged to feel relaxed and welcome to make comments. Participants were not put under any time pressure. This means that all timing data must be interpreted cautiously. Allowing for this, there are interesting observations for the time participants took to complete each phase of the evaluation.

Figure 7 shows average completion times for young and elderly participants. Units are in minutes and seconds. It is clear that, on average, the younger participants completed each stage considerably faster than the elders. For example, the first column shows the young users completed the tutorial in approximately thirteen minutes, while the elders took twenty one and a half minutes, on average. This is in line with observations by Coyne and Nielsen [7] where senior citizens took roughly twice as long to complete a web usability task. It is promising that the time difference was reduced for Task 2, perhaps indicating learning and increased confidence, but at a slower pace than the young participants. The nature of the evaluation means further analysis of times is not meaningful.

Task Completion

We express the goal of this aspect of the evaluation in terms of the question: could elders successfully perform photograph manipulation and the postcard creation task using SharePic, with minimal training? For our evaluation, we interpret this in relation to participants' success in working through the tutorial and Task 1 to complete Task 2, as specified. In these terms, all participants succeeded. For Task 1, two pairs did not complete the task – one because the trial was taking too long and the other because one of the pair became frustrated with trying to understand the Frame. Despite this, both groups completed Task 2 without difficulty, and the frustrated participant came to understand the Frame once given the fresh context of Task 2 and the opportunity to observe her co-participant.

Novel Interface Elements

Here we examine performance and reaction of our elderly participants to the novel interface elements we tested. We identified features we could extract from the actions of participants where they demonstrate understanding (e.g. deliberate use) of an aspect of one of the novel user interface elements. Each user interface element has a number of behaviours, which are enumerated in the columns of Table 3 and we recorded the time at which the behaviour was first understood for each participant. Note that a blank in Table 3 indicates success. That is, the participant demonstrated understanding of the concept when they were first introduced to it; in the tutorial. Overall, most participants mastered most aspects, including some subtle elements that were never explicitly taught.

Our *rosize* operation was well understood by all participants. The behaviours here were whether the participant could identify and use the *photo corners* (1), resize a photo (2) and rotate a photo (3). Only one participant had a delayed understanding of the rotate operation, because they initially chose only to resize the photograph and did not try to rotate it. It was not until later in the tutorial, when asked to experiment with the frame, that they demonstrated understanding of the rotate behaviour of *rosize*.

The copy operation proved to be difficult for our elderly participants, while our younger participants encountered no difficulty. Here the behaviours were whether the copy gesture could be started (1) and successfully completed (2). From the table, it can be seen that three participants had initial difficulty, but the real difficulty for our elderly participants came when they were required to re-use the copy gesture in subsequent tasks (this is not evident in Table 3). Generally, elderly participants had difficulty remembering how the copy gesture was performed and many were hesitant to interact with a second finger or hand. In most cases, a struggling participant could refer back to the tutorial, re-learn the gesture using the initial instructions and subsequently carry it out successfully.

Generally, the Black Hole was well understood by all participants, and even enjoyed by some. The Black Hole has a complicated function, and hence many behaviours. However, despite this, users took to the basic functionality very quickly and were able to re-use it without retraining. The behaviours are whether the Black Hole can be identified (0), photos become hidden when dragged into it (1), the Black Hole may be moved (2), the Black Hole may be rotated and resized (3) and the Black Hole may not be copied (4). Difficulty with the last behaviour is often due to preceding difficulty with the copy operation. For the last group (E6), they simply did not try it. This was also the case with *rosize the Black Hole*, which they did not attempt until the tutorial was over and the tasks had begun.

The Frame, too, was generally well understood. The behaviours are whether the Frame can be identified (0), the *dwell* action can be performed (1) and the Frame creates new photos that slide in from the corner of the table (2). Understanding of the Frame's basic operation was critical to task completion. Hence, the few participants who did not understand it initially were required to learn it in order to complete Task 1. Participant B of elderly group 4 in particular, had difficulty with the Frame and subsequently become frustrated with Task 1. However, by observing her partner, the participant was able to learn the Frame's use and completed Task 2 successfully.

Affective Analysis

Strong observations were that all participants enjoyed the interface, perhaps impressed by its novelty and pleased to easily master it.

E1B: "Now swivel [the Frame]. Yeah, I love doing that, that's great."

E3A: "It was fun, I enjoyed it. Normally when I'm using the computer, I get a little up-tight, whereas this one... "

E4A: "This is like a game you'd play at home, once you got the knack of it all. It's like a board game."

E5B: "That was good fun. A lot of fun, is that."

E6A: "I'm disappointed it's ended. It was just getting interesting."

There was also considerable support for the value of our guidelines.

G1 *E4A: "I like these big screens. Small computers now are so hard on your eyes. This is much more comfortable to see; flat on the table."*

G2 *E3B: "It's definitely more user-friendly than a computer. You need two minutes training to use it."*

G3 *E2B: "Would be handy, have a black hole instead of the garbage disposal." E2A moves some images into the Black Hole and B observes, "Well that immediately makes sense with what we know of black holes."* (In general, the Black Hole was well liked by all participants.)

It is striking that the young participants moved quickly and talked less than our elderly. The young also learnt faster and remembered better (there was rarely a need refer back to the tutorial) – this is not surprising. Generally, all seemed to have fun – certainly the novelty was appealing, but part was ease of mastering, especially as expressed by our elder participants. Further analysis and full transcripts are available in a technical report [2].

CONCLUSION

We have described the design guidelines and core elements that enabled us to create a tabletop interface that is highly learnable and usable by both young and older users. Novel aspects are:

- exploration of an important new direction for future interfaces that will be part of people's everyday lives, as they have social interactions around a table that supports interaction with digital objects;
- interface design driven by guidelines intended to support learnability and usability for all users, including those with some vision impairment, some cognitive loss and some loss of physical agility and co-ordination;
- the *rosize* operation is novel and has been demonstrated in our evaluations to be highly learnable and natural;
- the two new interaction objects, the Frame and Black Hole are novel interaction elements that were easily mastered by all of our elders;
- the difficulties we observed for elders using the copy gesture, when the younger users learnt it easily, point to the need for care in the design of two-hand interaction gestures, an area where there has been little work;
- SharePic as a whole provides a minimalist tabletop interface that all participants could learn about within a half hour, from a short printed tutorial, to achieve competence

in all its core functions for managing photographs in a social setting.

Further, SharePic's personal spaces represent an exploration of an interface aspect that is natural in tabletop interfaces and our evaluations indicate that all users were quickly able to understand the core idea of a space that is owned by the user and where the ownership of that space is enforced by the interface.

Testing with elderly particularly highlighted problems with our two-handed gesture, which our young participants had no trouble with. This suggests the value of testing with elders. Our guidelines did not consider in particular the two-handed interaction possibilities of the tabletop interface. A new set of guidelines would need to take care with two-handed gestures.

SharePic represents an important direction for research towards the novel interfaces we will see embedded in the environment within the homes of the future. We believe that work towards ubiquitous computing in the home must pay attention to the needs of all users, including the very important older users. Our evaluations demonstrate that this need not be to the detriment of other users: SharePic was highly usable and fun for young people as well as the elders.

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