Chapter 1

Memojog – an interactive memory aid with remote communication

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1.1 Background

Independence is a defining attribute of being an adult. We guard and preserve our right to determine how and where we live our lives, and the routines that we maintain. These rights are fundamental to the 'independent living' and 'care in the community' movements of recent years. Loss of this independence is not only demoralising for all the people directly and indirectly involved, but also increases care costs to the individuals, their families, and to the wider community. Conversely, if independence can be maintained, a reduction of the workload of professional carers and reduced health care costs is possible.

One condition that can severely affect the degree of independence is the extent to which people can organise, plan and, crucially, *remember* to carry out even simple everyday tasks. Memory dysfunction can hamper the quality of everyday lives of memory-impaired individuals, leaving them extremely dependent on carers (Wilson *et al.,* 2003). In this paper we describe issues in the development of a memory aid system with remote communication to re-create independence for memory-impaired, elderly people and present data from an evaluation of this system.

1.1.1 Independence and the use of memory aids

Memory dysfunction is among the most common effects of brain injury (Evans, 2003) and is associated with the ageing process (Huppert *et al.,* 2000). A prospective memory dysfunction is characterized by the inability to remember to do things at certain times in the future. This can be particularly distressing as people may forget to do such important tasks as taking medication. Electronic memory aids, such as pagers, dictaphones, mobile phones and small handheld

computers or Personal Digital Assistants (PDAs) have been successfully used to display timely and active action prompts to people with prospective memory problems, either in text or speech form (for a review see Inglis *et al.,* 2003). The provision of short prompts such as 'pack lunch' has usually been found to be sufficient (Wilson *et al.,* 1997), and memory aids have helped memory-impaired individuals to regain their independence (Wilson *et al.,* 2003).

Typically with electronic aids, either the user or carer enters data directly onto the device, or contacts a centre where reminders are entered into a central paging or calling system, and transmitted to the memory-impaired user at appropriate times. Ease of interaction is critical for user acceptance, and the NeuroPage pager developed by Hearsh and Treadgold (1994), for example, simply required the touch of a button to acknowledge a reminder (Wilson *et al.,* 2003). Despite the success of NeuroPage due to its simple functionality (i.e., to prompt actions) and mode of operation (a single button press to acknowledge action prompts), it has several shortcomings:

(i) the necessity of using a commercial paging company to provide action prompts to the pager not only is costly but also lacks flexibility, and means that there are indirect links between the client or carer deciding when they want a particular prompt at a particular time and that being inserted into the system;

(ii) although one of the major advantages of the systems is that the pager itself is very simple to use, the pager lacks functionality which would be particularly valuable for people with memory deficits. In particular it is a one-way communication system from the central paging company to the user. It is thus not possible to check whether the client has noticed the message, or if the message had been read but not acted upon by the client. Therefore it is not a fail-safe system and the health and safety dangers mean that the situations where the pager can be safely used without external supervision are restricted, as are the type of clients for which it could be prescribed. This is particularly serious in terms of medication reminders as compliance with medication is a major problem in health care with elderly patients.

(iii) the pager requires clients to have adequate reading and comprehension skills and adequate eyesight and thus cannot be easily adapted to users demands.

The ability for the memory-impaired user to interact with a memory aid would greatly enhance its value, particularly for those without widespread cognitive impairment. Progress in appropriate technologies, particularly palmtop computers with telecommunications capabilities, make this a possibility, but the design of the system as a memory aid is a significant challenge and demands an innovative approach for the design of the user interface of the device and the server system, which will control it, to make it acceptable to and usable by memory-impaired people and their carers.

One critical aspect in the design of the memory aid system is how easy it is to learn how to use the device. Learning to use electronic organisers often produces significant problems for the memory-impaired user (Wilson & Moffat, 1984), and the assistance of a carer or long or repeated training periods may be necessary. For example, in a study by Kim *et al.* (2000) brain injured patients were given supervised training twice a week during regular therapeutic sessions with a small

handheld computer (i.e., a Personal Digital Assistant - PDA). It can be inferred that the level of training required does not diminish with progressive use of the device. This is not unexpected, as current time-management software running on PDAs requires at least some training even for a non-impaired, average, user. Although the ease of use of software applications varies across the range of devices and platforms available (e.g., EPOC/PalmOS/PocketPC/Symbian), they have not been designed for memory-impaired users. However, the effectiveness of customisation of such devices to the needs of users is a significant factor in determining the success of a memory aid, as a study with brain-injured users by Wright *et al.* (2001) shows. Furthermore, studies indicating that memory-impaired people benefit from errorless learning techniques (Clare *et al.,* 2000; Wilson & Evans, 1996) clearly point to the need for training required to learn how to use such devices to be minimal and to produce as few errors as possible.

1.1.2 Interactive aids

There have been a number of attempts to develop interactive memory aids in recent years, including ISAAC, MAPS, Memos, and the system we have developed - Memojog.

Jönsson and Svensk (1995) describe ISAAC - a personal digital assistant for users with cognitive dysfunctions, which incorporates a pen-based computer with a digital camera, GPS satellite receiver and mobile phone channels for both voice and data. The project demonstrated the technological feasibility of devising an interactive system using a combination of palm-top and mobile phone technologies in a prosthetic context but evolved in such a way that its emphasis became communication by pictures. It thus did not further develop or evaluate the use of the technology as a memory aid, nor was an interface developed for use by average users who were becoming memory-impaired, and their families/carers.

Another interactive system, MAPS, was developed at the University of Colorado (Fischer, 2003). MAPS is a prompting device for cognitively impaired individuals that runs scripts and collects logs for adaptive behaviour. Prompting systems break down a task into its constituent parts and images and verbal prompts are given to the user to perform these tasks. The system itself comprises a mobile device (PDA or mobile phone) used by the cognitively impaired user and a PC-based script editor tool the carer uses to generate scripts. This system thus required at least some training on part of the carer as behavioural scripts had to be created in a way the user can understand them.

Memos (www.memos-online.de) is an interactive memory aid system for people with memory impairments using a portable memory aid and a service centre where client-related data are managed. It has similar features to the Memojog system we have developed over recent years. In this paper we describe the Memojog memory aid system (Inglis *et al.,* 2003; Szymkowiak *et al.,* 2003), developed at Applied Computing at the Dundee University in collaboration with the Oliver Zangwill Centre in Ely. Memojog is a remote and interactive communication system that functions as a prompting device for memory-impaired people. We will describe this memory aid system in more detail next.

1.2 Memojog

A PDA with mobile telephony was used to give text based action prompts announced by an audio alarm to users. The memory-impaired user (or carer) entered action prompts directly onto the device or a carer entered data remotely from any Internet accessible PC. In both cases a website was accessed, either on the PDA or from a PC, from which the reminders were entered into a central database. Alternatively, the memory-impaired client could phone an administrator who in turn entered the reminders on an Internet accessible PC on the relevant website. This gave users and carers control over the memory aid system, but also provided the option to involve a third party for data entry if they wished to do so. The prompts or reminders were then wirelessly transmitted from the Internet database to the PDA at the appropriate times (see Figure 1.1 for the system architecture).

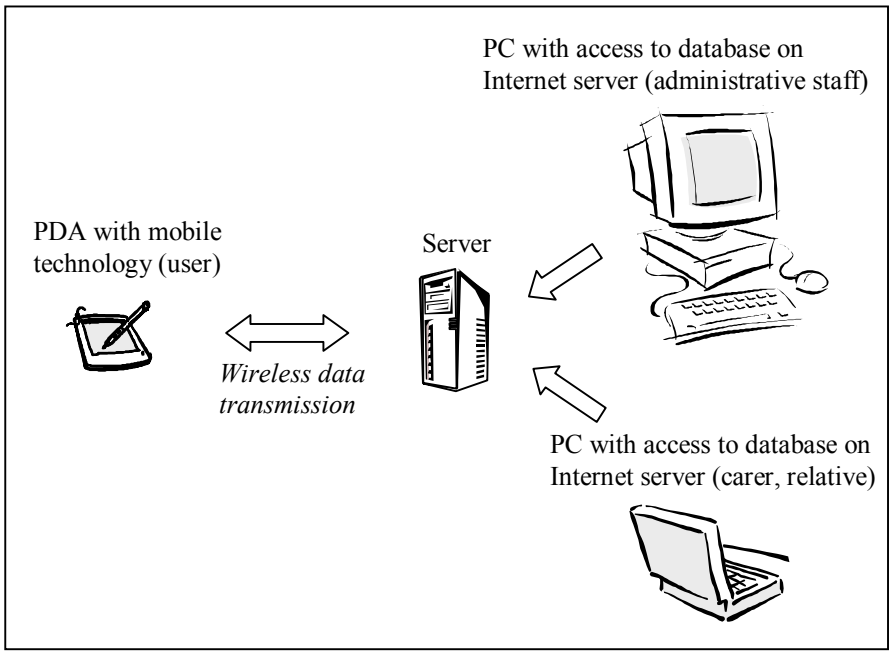


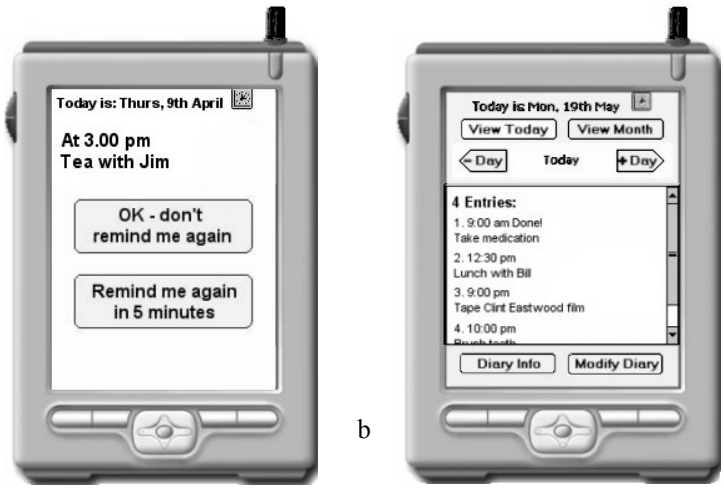
Figure 1.1. Architecture of the Memojog system

The users responses to these prompts were relayed back to the server, where, in appropriate cases, relatives or carers could be informed that the user had not acknowledged important or life critical prompts (e.g., medication prompts). The implementation of remote data entry allows the user to slowly adjust to the use of the memory aid, beginning with simple functions and moving onto more complex ones as appropriate. The memory aid system was tested with elderly memory-impaired clients at a rehabilitation clinic for brain-injured people. In the following we will describe the results from evaluations that were conducted at this clinic.

1.2.1 Evaluations with memory-impaired clients

There were two field evaluations with memory-impaired participants who used the device for 12 weeks, after which the device was withdrawn again. Participants were referred to us by health care professionals. The selection criteria included that participants experienced progressive degenerative disorder problems but no major aphasia, visual problems, or severe general intellectual impairments. In both evaluations, informed consent for participating in the study was obtained from participants and/or carers.

The PDA used as portable memory aid was a Siemens SX45, running the Windows CE 3.0 Pocket PC operating system. The PDA was equipped with a touch screen (a non-reflective TFT LCD with 65,536 colours), the size of which is 240 x 320 pixels (approx. 60 x 78 mm). The dimensions of the PDA are 124 x 87 x 26 mm and it weighs about 300 g. The main use of the device was to give action prompts to memory-impaired users, however, other functions such as entering reminders or looking up entries for selected days were implemented. In addition, users could look up information on people such as their birthdays or addresses. It was anticipated that users would use the reminder function predominantly with all other functions to be learnt with usage of the device. Figure 1.2 a depicts an example interface for an action prompt. At a set time an alarm goes off and the prompt is displayed. The client can either acknowledge the reminder or defer it to occur again in x number of minutes. The response of the client is relayed back to the Internet database where it can be monitored.



a b

Figure 1.2. Shown are two example interfaces. Users can interact with the device by manipulating its touchscreen. In (a) the interface displaying an action prompt is depicted. The client can either acknowledge the prompt with no further reminders occurring or defer the reminder to be displayed again at a later time. In (b) the default display is displayed (see text for explanation).

Figure 1.2. b shows the default display that allows users to access information for particular days. The display can be changed using the touch screen. The user can go backwards and forwards one day at a time using the "-Day" and "+Day" buttons and can also access the calendar by tapping the "View Month" button. Other information such as birthdays and addresses can be accessed using the "Diary Info" button. Reminders can be entered after tapping the "Modify Diary" button which would bring users to a website where they can enter data.

In each of the two evaluations, each participant, accompanied by a carer, was trained individually using an errorless training procedure. The experimenter verbally explained and then demonstrated each task to the participant. The participant was then instructed to repeat the task. If the participant was unsure about how to do the task the experimenter prompted the participant to do the task in the correct way to ensure an errorless training procedure. Training time ranged from 30 minutes to 1.5 hours as required for a particular client. After the initial training, clients and their carers used the device for 12 weeks and no further systematic training was given. The only help that they could use was a manual that explained how to use the device by giving examples of how to interact with the device, and which depicted a lot of pictures for illustration. The clients were instructed to perform a number of tasks and rate their difficulty in a survey directly after training and after two weeks of usage. In the following we will discuss the clients' data separately for each evaluation and discuss which interface features changed from the first to the second evaluation.

1.2.1.1 First evaluation

In the first evaluation six memory-impaired clients aged between 34 to 93 years (mean age 60) were recruited. Four of the clients suffered from progressive neurological diseases and two clients suffered from traumatic brain injury. Two participants quit the ongoing study for personal reasons resulting in four clients who completed the study. Given that this number is too low to apply statistical analysis on the tasks clients had to perform, they are merely described[1]. To establish how well participants could use the device users had to perform ten selected tasks in each of the two evaluations. These tasks were to:

1. acknowledge a reminder;
2. find out what you have to do today;
3. find out what you are doing tomorrow;
4. find out what you did yesterday;
5. find out what you have to do on the 11th of November 2002;
6. find out the weekday of the 15th of November 2002;
7. find the address of a medical staff;
8. find the date of a relative's birthday;
9. find appointments with medical staff;
10. enter an event into the diary.

[1] The data are described in more detail elsewhere (Szymkowiak *et al.,* 2003). In this paper we want to give an overview of the two evaluations and focus on more qualitative data.

The researcher recorded a task as not executed if the user was not able to perform it. Data were collected directly after training (n=5) and after 3 weeks of usage (n=4). Each client also had to rate how easy or difficult the task was to execute on a 7-point rating scale, (with a rating of 1 being "very easy", a rating of 7 being "very difficult" and a rating of 4 being "neutral"). Directly after training, three participants could perform all the given tasks successfully, and the other two participants could not perform only one of the tasks (tasks 2 and 8). After three weeks of use with no systematic training one out of four participants could not perform three of the tasks (tasks 1, 2, and 10) whereas the other users could perform all of them. This indicates that clients generally had no great problems and the design was usable to a great extent. Therefore the general structure of the interface was be maintained for future system development. The average rating of task difficulty directly after training showed that overall the tasks were rated as rather easy with all ten tasks rated not more difficult than the neutral rating score of 4. This pattern remained stable after a three-week period in which only task 10 ("enter an event into the diary") received a worse than neutral average difficulty rating (=4).

It should be noted that tasks 1 to 4 could be executed by tapping on one virtual button on the interface, and that these are the only tasks for which ratings remained stable or improved. Indeed, ratings became more positive (i.e. participants rated them slightly easier) from the first to the second evaluation, whereas the opposite occurred for tasks that required two or more button presses to be executed (tasks 5-10).

Clients commented positively on the hardware of the device (e.g., "It is easy to see what is on the screen while still being lightweight enough to carry."). Another aspect was that carers were particularly pleased that they could input the reminders for the users, as they did not have to rely on others, i.e., administrative staff to input reminders on a short notice. Clients also commented on the versatility of the device in that it was good that different information was stored on just one device (e.g., diary, phone book, appointments). This point also illustrated that clients do want more functionality in a memory aid than it just being a cueing device. The trade-off between functionality and ease-of-use is however to be considered in any interface design project, the more so when the users have specific impairments. Another aspect users commented on was the ease of learning how to use the device. It was "not too difficult to remember how to access information, and good instructions in the manual as to how to carry out tasks when experiencing difficulty in remembering how to do things." Finally, users appreciated that they were successfully reminded to do things when they were planned to be done. In that respect we can infer that the memory aid system was a success.

However, a number of negative comments related to coverage problems. Oftentimes, connection problems, i.e. the inability to modify the diary as they could not connect to the relevant website for entering the data, resulted in frustration. This often upset clients and their carers as they are attempting to use something they are unfamiliar with, so when such problems occur the client/carer is often unsure as to whether they are doing something wrong or not, as the device does not respond. Some users expressed annoyance when this situation occurred. The other problematic situation arose if users had already a memory system in

place that they were using successfully (such as a calendar). They were reluctant to refrain from using these devices, particularly at the beginning of the trial as they were not sure if they could use the device at all. This was particularly problematic as they were unsure of the reliability of the device in comparison to a tried and tested, and familiar, method. Finally, the device had an audio alarm and displayed text messages. Some of the users would have preferred a vibrating facility particularly if they had poor eyesight or were hard of hearing. In this respect the device should have been designed using multimodal input/output elements. This did not prove to be a huge problem, as the reminders usually alerted the carers, although the clients missed some of the reminders if this was not the case.

Given that the users were generally able to manage the interface, and they did not rate most of the functions as extremely difficult to execute, it was decided that the general structure of the interface should be maintained for the second evaluation. Changes were made to the general appearance of the interface, where possible. For example, the text was made more legible by displaying reminders in bold text. Some text could not be modified, as it was an integral part of the system software (e.g., a virtual keyboard that pops up when clients enter text into a box). The researcher testing the clients set up the keyboard to a larger size for them if they requested this but there was only an option between a small and a medium sized keyboard. Another challenge was the lack of coverage of the system. As this was an aspect that we could not directly control we instructed subjects to seek out locations that would allow better coverage (e.g. close to the window), which is something the clients may do when operating a mobile phone for example. As the devices were not equipped with vibrating technology we could not implement a multimodal interface for hearing impaired users. We are anticipating to develop a truly interactive aid in a future project.

1.2.1.2 Second evaluation

In the second evaluation six clients were recruited aged from 29 to 88 years (mean age 71 years). Five clients suffered from progressive neurological disease and one client experienced a brain haemorrhage. As in the first evaluation, two clients left the study for personal reasons, resulting in four clients who will complete the study as it is still ongoing. We present data from five participants, which were collected directly after training and after two weeks of usage of the PDA (n=5 for each sample). Tasks and procedures were the same as in the first evaluation. The only difference to the first evaluation was the collection of the second data sample. We tested participants again two weeks (instead of after three weeks) after the initial training period, as we wanted to have a more fine-grained analysis of the progress of the data.

Directly after training, one participant could not perform task 9 (“find appointments with medical staff”), another one had technical difficulties performing task 10. The average ratings of the difficulty of the ten tasks was rated better than average, and improved for all tasks except task 4 (“find out what you did yesterday”) from the evaluation directly after training to after two weeks of usage. For task 4 the ratings deteriorated, although the average rating was still better than the neutral rating of 4.

The users' comments expressed hardware-related problems in the sense that the touch screen was not sensitive to button presses and that they had to tap the screen a number of times before they could observe a response. Coverage was again a problem, as we could not control for situations in which users "roamed" in locations in which no coverage was given. This was a problem for data entry, however, once the data were stored on the PDA the reminders occurred as programmed. As in the first evaluation it would have been more appropriate to have a multimodal input/output mode. However, for the duration of the project the implementation of which was not deemed feasible. It should also be noted that the participants did not complain about the font sizes or small display features, but that this was rather due to the fact that they could physically cope with the display. For a memory aid to be truly interactive and usable for a variety of clients a truly multimodal interface that allows text as well as speech input/output would be advisable. Overall, the PDA was accepted by clients, with the support of their carers and thus it was successfully used as a cueing aid.

1.3 Conclusions

The evaluations showed that participants could use the device easily, and crucially that they were able to move from simple to more complex tasks, e.g., from data entry to looking up information or entering data. This is an important result, as the memory-impaired user group have been found not necessarily to capitalize on acquired experience with such devices. Their carers were a vital part of the study by keeping clients motivated, but also benefited themselves, as they reported feeling less worried about their relatives when they were using the memory aid. In addition, the carers kept clients motivated throughout the study, as they felt the benefit of using the memory aid. Kapur (1995) pointed out that the role of carers might be vital for the success of a therapeutic programme, which could also be seen in our study.

The biggest challenge we encountered throughout the project was the lack of coverage. The clients were mobile and thus could easily move from one location that provided network coverage to one in which that was not the case. In addition, network mainenance procedures conducted by the service provider also posed a considerable impairment of coverage, but naturally was not under our control.

One problem for the study was the difficulty in recruiting clients who exhibited a particular memory impairment and still fit the selection criteria. Given this, it was particularly troublesome to have a 33% client dropout rate, as this prohibited the use of statistical analysis procedures. An analysis of particular cases may be seen as more indicative of the success of the memory aid for a particular person, but our quest was to investigate if the technology would be at all feasible for this memory-impaired user group. So far the results have been exciting and encouraging and the potential for future developments of electronic memory aids of this type is huge, given that more sophisticated technology is put on the market very rapidly.

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