

iTV as a platform for rich multimedia reminders for people with dementia

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Abstract. This paper gives an overview of a reminder system, based on digital television technology, which can present rich multi-media prompting messages in order to help maintain a regular daily schedule for people with mild to moderate dementia. The ongoing development of this application has the aim of supporting busy carers by making it easy to create, adapt and maintain a schedule of reminders to help keep a regular daily routine, relieving some of the burden of care and freeing more time for better human contact and interaction.

Key words: Dementia, DTV, Older People, Carers, Functional Prototypes, Prompting & Reminder Systems, Activities of Daily Living, Schedule Control

1 Introduction

It is well known that the population aged 65 years and over is expanding both absolutely and as a proportion of the population as a whole. Of this group, about 5-6% are estimated to suffer from some form of dementia. Prevalence at the age of 65 is about 2% and this percentage approximately doubles for each subsequent 5 year age band, i.e. 4% at 70 yrs., 16% at 80 yrs. [1]. Alzheimer's disease (or Dementia of the Alzheimer's Type; DAT) is the most common form, and accounts for about 60% of all dementia cases, making it a major (and increasing) healthcare issue in later life.

A progressive disease, people with DAT experience a range of cognitive impairments that typically start with relatively minor working memory problems as is common among many older adults. Symptoms can vary from very mild cognitive decline or memory lapses, such as forgetting familiar words or names (which again can be difficult to distinguish from the effects of 'normal' ageing), to very severe cognitive decline including loss of the capacity to understand (and occasionally even recognise) speech and to communicate more generally. As mentioned, over time the extent of these declines is generally progressive, however, over the shorter term the impacts can undergo relatively unpredictable cycles of remission and relapse. Further, these complicated trajectories of change can be different for different people and for different aspects of cognitive functioning, including the individual's degree of awareness of their current cognitive state. In addition to declines in cognitive ability *per se*, DAT can also have negative impacts on a sufferer's affective state which can

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manifest as relatively generalized depression or as a wide range of more idiosyncratic ‘mood-swings’ which in turn can be accompanied by various challenging behaviours [2]. There can also be physical impacts which can compromise musculoskeletal functioning including the ability to walk without assistance and even to sit without support [3]. Consequently, many people with DAT can feel scared, frustrated and/or ashamed by their increasing frailty, memory and cognitive difficulties, and the accompanying dependence on others that this can bring.

A very important issue for people with DAT and their carers is the maintenance of a stable and regular daily routine [2]. This is far from being a trivial issue given the wide range of other care requirements the individual may have (often exacerbated by a general paucity of resources to meet them) which in the main are dealt with by over-stretched care workers or informal carers such as their spouse or other family member. Although a wide range of ‘memory aids’ have been researched and developed for people with mild cognitive impairment or memory problems, most become of limited utility when the user’s cognitive limitations are severe enough to *need* them (e.g. they forget that a ‘beep’ is a reminder prompt), other issues also limit the utility of such devices intended for operation by the person with DAT [4, 5].

This paper describes the use of interactive digital television as a platform to provide rich, personalised multi-media prompts and reminders for people with DAT, primarily to relieve carers of some of the burden of this scheduling activity, particularly ‘nagging’ (i.e. repetitively reminding) their charge and the emotional challenges associated with ‘telling them what to do’. The main focus is on reminders for activities of daily living such as meals, but there is also clear potential for its role to be extended to include ‘encouragement’ for events the patient may resist, ‘calming’ for potentially agitating events (or if the patient becomes agitated without any connection to a scheduled event *per se*), and more general ‘reality orientation’ (day, time, etc.). It is not intended for this application to replace human care, but rather to support carers in achieving a beneficial, stable routine for their charge, while alleviating some of the burden on their time and emotional resources. Helping to expand and improve the quality of the human contact between carer and patient is a key goal. It is worth noting that this application is a work-in-progress and is currently at a point where it can act as a functional prototype suitable for hands-on evaluations with carers and patients and can be readily adapted in light of feedback from such sessions.

2 Interactive Systems for Cognitive Support

Information and communication technology (ICT) is increasingly being employed as a prosthetic for ‘information and communication’ functions which have been affected by illness, accident, or aging. To date, the increasing capacity and power of computational systems has been recognised as having the potential to provide ‘scaffolding for cognitive tasks’ [6]. Similarly, recent years have seen digital technology become an increasingly important part of the ‘mainstream’ domestic environment, a development that has been identified as having both positive and negative impacts on home life. This ‘domestication’ of technology has highlighted its

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potential to support people with non-mainstream needs in their own homes. In particular, attention has been paid to the use of 'smart home' technologies to provide functional support for independent living in areas of safety, security and social interaction for older and/or disabled people. Some of these systems primarily monitor the patient and 'report' to others, while some interact with the patient to provide support. For example, Hoey et al [7] developed an intelligent prompting system that monitors a user's progress and uses visual and verbal prompts to assist them during the (relatively constrained) activity of hand washing.

Another area of development has brought the capabilities of digital technology to bear on fostering and potentially enhancing human interaction between carer and patient [8]. For example, *CIRCA* a touch-screen, PC based support for reminiscence and conversation [9] has been found to be successful and more efficient than non-technological equivalents (e.g. boxes of photos and memorabilia) which serve their purpose but tend to distract the carer's attention from the interaction itself in order to deal with the material supporting it. The success of *CIRCA* has led the same team to develop *LIM* (Living In the Moment) [10] which utilises a similar interaction approach for a system that DAT patients can operate themselves in order to engage in mentally stimulating (and fun) activities without the need for assistance.

Another aspect of the domestication of ICT relates to the emergence of digital television which is currently in the process of replacing analogue broadcast in the UK (with many other countries following close behind). Beyond the potential to simply provide more television channels, the processing requirements for receiving digital broadcasts has also made it possible to support interactive services of various kinds. A wide variety of such services are available, some related to programme and channel content and others related to the provision of government and other commercial services. This development from 'TV' to 'ICT' also supports the potential for 'local' interactive applications that reside on the user's home equipment (Set-Top-Box) and can be configured to their own requirements, either in relation to 'TV' or as more generalised 'ICT'.

In the UK, it has been identified that older people represent the largest proportion of television viewers, particularly in day-time audience groups, averaging around 36 hours per week for those aged 65-75 years [11]. It seems reasonable to assume that a similar pattern relates to older people who are relatively frail and/or have minor or moderate cognitive limitations, either as a consequence of 'normal' ageing or of entering the early stages of DAT (or other dementia).

These various factors make TV a feasible platform for a personalised application that can present rich multi-media prompts and reminders, using the TV as an output channel. The utility of such an approach is clearly limited to circumstances where the recipient is in the proximity of the TV and/or engaged with it. Despite this, the potential benefits of supporting a regular routine and relieving even a small amount of the care burden could have significant value. Further, the adaptability of digital TV means that a 'basic' reminder application can be extended to incorporate (or be connected with) other interactive 'modules' that are emerging for this platform. Examples of this include the development of iTV systems that support social communication either as a stand-alone activity, or in association with TV viewing. Researchers have explored, for example, the conceptual design of audio-based applications to communicate with family and friends [12], including the use of

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graphical overlays indicating availability and status of possible interlocutors [13] and 'instant-messaging' type features aimed at enriching engagement in interactive communication [14]. However, mixed reactions to two-way communication via TV have been reported [12], suggesting possible limitations (currently at least) on people's willingness to breakaway from relatively passive 'TV viewing'.

3 Designing Reminders for Everyday Routines

A fundamental requirement of the reminder system is that it must reside in the context of the relationship between the carer(s) and the person with dementia in a meaningful manner. That is, not only should the system provide effective reminders that relate to routines of daily life, but that the carer can set and modify these in accordance with their daily routines. A number of issues arise in the design of the prompts themselves. Such as, the delivery of prompts through an embodied agent, the potential qualities of the prompts (e.g. 'tone', layout, frequency, etc.) including the provision of supporting information in different modalities (text, graphics, sound/music), and issues of prompt presentation and integration into existing programming (or not). There are also a host of issues surrounding the design of the carer's 'schedule control' interface. These issues will be discussed in the following sections.

3.1 Prompting Through Embodied Agents

Embodied conversation agents (ECAs) intended to 'persuade' humans, or effect behavioural change, raise important ethical issues which are beyond the scope of our inquiry. However, Bickmore [15, p.727] cites a range of analyses of these issues. Existing studies evaluating the effectiveness of ECAs have used limited empirical approaches that do not identify objectively measurable variables, nor do they adequately explore the impact of the low level of functionality of current agents. For example, Bernsen and Dybkjær [16] gather subjective data of users' perceptions of interactions with an ECA through structured interviews and present the results of conversational analysis of the transcripts. The challenges of designing and building ECAs has meant that research has focused more on "specific problems which are prerequisites for developing full-fledged multimodal ECAs" [17, p. xv], rather than focusing directly on evaluating the full systems [17, p. xvi]. More fully-fledged ECAs have been developed but still the focus of even 'full' system development has been on relatively limited aspects of the ECA's behaviour.

The potential of ECAs to affect behaviour has however been demonstrated in previous work on persuasion and social influence [18,19,20] which primarily use metrics based on self-reports of attitudes and belief, although a limited number of empirical studies have measured behaviour change directly. Bickmore et al. [15] used a *relational agent*, ("computational artefacts that build and maintain long-term social-emotional relationships with users", p. 711), in the role of an exercise advisor to encourage older adults to meet the minimum level of physical activity currently recommended, and used a combination of both questionnaires and direct behavioural

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measures to indicate effectiveness. One direct behavioural measure was the number of steps taken each day, recorded on a pedometer. The results demonstrated that relational agents significantly increased the amount of physical activity (i.e. number of steps) faster over the duration of the study than the control group (who used a conventional text interface). This suggests using embodied agents for presenting the prompts should be feasible and even beneficial, although this cannot be taken for granted. It is possible that some people with DAT may fail to ‘engage’ with a virtual person or may be unsettled by it, thus it will be beneficial to incorporate additional ‘communication channels’ in the prompts so that the carer can ‘mix and match’ to suit their (and their charge’s) requirements and preferences.

3.2 Prompt Qualities

The use of ICT means that the breadth of possible qualities of a prompt is very wide, however, the practicalities of allowing the carer to easily create and adapt prompts makes it vital that a scope of possible customizations is sensibly chosen. As described, a major element will be the embodied agent or avatar, the utterances derive from text input and therefore can also be presented without the avatar present. This also allows for the possibility of shaping the emotional tone (and other qualities) of the voice, although this has not been included in the current implementation (this and other technical limitations are indicated below). Given the known difficulties older people, particularly those with DAT, can have with perceiving and understanding speech (and which go beyond ‘deafness’, *per se* [21]), there will also be benefits in allowing the spoken message to be supported by the presentation of the text equivalent (i.e. ‘captioning’), which has previously been shown to be of benefit to older adults [22]. Less directly, the ‘message’ of a prompt can also be supported by the use of suitable photographs and other graphics. Some of the current implementations of these possible layouts are illustrated in Figure 1.

The use of text input and the possibility to include either generic or personal pictures gives the carer a great deal of choice and flexibility for tailoring the prompts in a way that they feel will maximize their efficacy. The relative limitations of the current layout style are intended to have two related, but distinct benefits. First, it should allow a prompt ‘message’ to contain sufficient information to serve its purpose (i.e. ‘engage’ and ‘inform’) while avoiding possible ‘information overload’ for the person with DAT. Second, it makes it feasible to develop a control interface (used by the carer to input/update the content for prompts and to schedule them) that can be used easily and effectively by someone who may have limited capabilities themselves, and/or little time, and/or many distractions. The current implementation of the control interface is described further in section 4.2, below and loosely constrains the user through selection and creation of content for each prompt and its scheduling and currently supports text input via a virtual (or possibly real) keyboard and handwriting recognition. This layout is intended as a suitable basis to initiate formative evaluations with a range of carers in order to inform further development.

Beyond the use of individual prompts for particular events, there is potential for further benefits in the presentation of messages that ‘lead-into’ and/or ‘follow-up’ a main prompt. For example, there could be circumstances where a series of messages

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with an 'encouraging' or 'comforting' tone could better prepare the recipient for an event that is prone to agitate or upset them. In other circumstances post-prompt messages may be helpful, and are particularly likely to require instigation on an ad hoc basis, such that, the appropriate follow-up will be different if a reminder was simply missed compared to one that was 'ignored'.



Fig. 1. Example layouts of the different elements of a prompt.

Such follow-up messages will also benefit from the system's endless patience, meaning that (suitably designed) follow-up messages should minimize, for all involved, the emotional impact usually related to 'nagging'. The current system has the capability to support such pre- and post-prompts, but these will not be implemented until the 'basic' control interface has been refined and a clearer picture has emerged about the feasibility of including control for these extra elements.

These variations on the theme of reminders also open the possibility of the system incorporating other elements aimed at 'calming' or 'reality orientation' unrelated to reminders *per se*, although these will not be introduced until the current system has been further evaluated. Similarly, there is potential for the current system to be connected with associated, but effectively stand-alone, applications aimed at mental stimulation and engagement, such as *CIRCA* and *LIM* described above.

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3.3 Prompt Introduction and Integration

Another major issue for the presentation of reminder messages on the TV is how the prompt is integrated with the surrounding content. An initial issue here is whether a prompt is scheduled to appear with regard to 'clock' time or 'TV' time. Using 'clock' time may be suitable in certain circumstances, although the possible negative impact of interrupting the current content cannot be overlooked. On the other hand, prompts coordinated with the 'breaks' in scheduled TV content may be less intrusive but to such an extent that the challenge is ensuring they 'stand out' from TV content, so that the personal relevance of the reminder can be recognised by the 'remindee'. Both of these approaches to scheduling will be made available, but initial evaluations will focus on 'clock' time. The current approach to 'announcing' a prompt is for a pair of theatre style curtains to close over the current content and re-open to reveal the reminder, although there are many other possible graphic approaches, as well as the inclusion of music. As described below, the aesthetic quality of the current implementation is compromised (plain coloured panels) by technical difficulties, but the intention is that the timing and appearance (colour, pattern etc.) of the transition effect can be configured by the carer but then kept constant in order to help reinforce subsequent recognition of upcoming reminder messages by their intended recipient.

4. Prototype Reminder System

4.1 Architecture

The TV prompting interface was built to run on a 3.0 GHz Intel Pentium PC, while the carer interface was developed on a Samsung Q1 7" 900 MHz Intel Celeron M touch-screen display. The development environment used was Microsoft Visual Studio 2005 and the user interfaces were implemented and written in Visual C#. Creation of a 3D animated character is provided by the third party Haptik Player¹ plug-in, which is embedded as an Active-X control in the TV prompting application.

The PC is responsible for simulating a TV broadcast, using short clips of prerecorded videos coupled with channel numbers to give the appearance of watching and changing between a small set of TV programmes. These changes are currently implemented by mapping software *event listeners* to key press functions to imitate channel switching. When running the TV application, the system checks an XML data file before the reminder is given, and identifies the reminder to be played. Updates to the file are also checked for regularly to see if they will be played on the day they are added. Once the prompt is initiated, the Haptik character is made visible (via a transitional effect) and produces an appropriate utterance along with lip-synching for the model. In addition, the spoken message of the reminder is optionally displayed in a text form (i.e. 'captioning').

To set a prompting message, an XML file (which is stored locally on the Q1 touch-screen), is automatically updated to the TV prompting system via the schedule control

¹ <http://www.haptik.com/>

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interface. Prompts are presented within forms, which once set, are transmitted via Wi-Fi to the remote mini-PC unit (Q1 touch-screen). Through this process, the new prompting message is automatically updated on the TV interface.

4.2 Schedule Control Interface

The touch-screen interface consists of four separate but related screens and include: (a) a video demonstration facility of the system (not yet implemented); (b) a simple data table list of ready-made (but 'editable') prompts; (c) basic options to set up a new avatar prompt (i.e. date, time, frequency, title and prompt message); and, (d) more advanced features to customise the types of multimedia displayed (i.e. full animated avatar, image, text, clock, etc.).

Given the limited real estate of the 7" touch-screen, careful consideration was given to the visual design of the interface to ensure users could adequately navigate and touch activate available controls. This included appropriate visual feedback by using 'tick icons' to indicate when a menu option was correctly selected, as well as visible confirmation once all aspects of the prompt were set (see Figure 2).

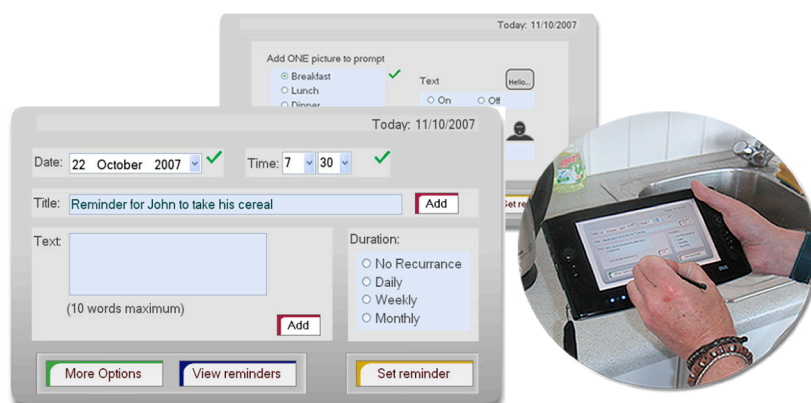


Fig. 2. Elements of the carer's schedule control interface

On the 'new reminder' screen, three simple drop-down menu boxes are used to initially set the date and time of a new prompt, followed by the display of two text boxes, one to write the title of the prompt (which is then listed in the database table for the carers own future reference), the other, to provide the text of the message (which can subsequently be both verbally and textually displayed on the patient's TV screen). Users can either hand-write the message using a stylus, or type it using an on-screen keyboard (a separate keyboard is also possible). Final options on this screen allow the user to indicate the frequency of the message (e.g. daily, weekly, monthly, or no recurrence). As previously mentioned, additional aspects of the prompt layout

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are available via the 'more options' button and include a list of different photographic and illustrative images (e.g. breakfast, lunch, dinner, new visitor, etc.) to accompany the avatar character. A list of radio buttons also allow users to turn 'on' or 'off' the avatar and/or the accompanying text and/or image, to further personalise the prompt.

4.3 Implementation Issues

Limitations have been identified with the use of the Haptik player related to the availability and control of facial expressions, gestures, body movements and emotional tone of the voice. The player also caused technical difficulties related to implementing additional overlays over the third party plug-in in order to provide high quality transitional effects between the reminder and (simulated) broadcast content. Currently, these issues warrant further investigation. Further investigation is also warranted into the most appropriate mechanisms to announce and trigger the avatar prompt through an available MPEG video stream. While questions over the development of open standards and an API to render 3D graphics, most notably on MHP (Multimedia Home Platform) also need addressing [23]. In particular, one foreseeable constraint will be the necessity for higher-end home media and set-top box systems (similar to high-spec game consoles) with adequate memory, processing power and built-in graphics card to run the prompting system. Currently, this is likely to exclude many people, particularly those who might benefit most from using this system. However, the recent history of commercial ICT suggests this barrier will reduce in the near future, particularly when digital broadcast has replaced analogue. Similarly, when the final requirements of the schedule control interface are known it can be implemented on more affordable hardware than the current mini-PC prototype.

5 Conclusion

The main challenge in developing this prototype has been achieving the balance between including enough functionality to accommodate suitably adaptable and rich multi-media reminders, and ensuring that the control interface is easily useable by carers. This will remain the focus during the planned series of formative evaluations with a wide range of carers and subsequently in conjunction with people with DAT.

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