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Problems people with dementia have with kitchen tasks: The challenge for pervasive computing

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ABSTRACT

Technologies from pervasive computing can be used to ameliorate the difficulties that people with dementia have with multi-step tasks. This paper is intended to inform the design of technologies that help people perform daily tasks, by prompting them when they have difficulties, thus fostering independence and quality of life. Six people with mild to moderate dementia were video recorded performing activities of their own choosing in the familiar context of their own kitchens. In total there were 22 video recordings. Activities included making a cup of tea or coffee, a bowl of soup, beans on toast, or coffee with toast. The video recordings were transcribed using an adapted version of the Action Coding System. Incidents, where prompting was judged to be needed were categorised using a data-driven analysis as problems in: *Sequencing* (intrusion, omission and repetition), *Finding things* (locating and identifying), *Operation of appliances*, and *Incoherence* (toying and inactivity). Detailed examples of each type of incident, and the contexts in which it occurred, are provided as a resource for the design of pervasive computing solutions. What needs to be detected and what form prompts might take is specified for each category.

1. Introduction

People with mild to moderate dementia have problems with multi-step tasks, such as making a hot drink or getting dressed. These difficulties in performing activities of daily living at home may trigger the need for personal assistance or relocation to residential care settings (Gill and Kurland, 2003). Moreover, an inability to carry out activities of daily living is associated with a diminished quality of life, poor self-esteem, anxiety, and social isolation for the person with dementia and their caregiver (Burns and Rabins, 2000). In cognitive theory, problems with multi-step tasks are explained as due to deficits in executive function, that is, problems in planning, sequencing and attentional control (Boyle et al., 2003; Nadler et al., 1993).

Wherton and Monk (2008) pointed to recent advances in pervasive computing that raise new possibilities for supporting people with deficits in executive function who wish to live in their own homes. For example, computer vision algorithms make it possible to detect, where someone is and what they are doing. RFID tags allow everyday objects such as cups and utensils to be uniquely labelled and then located. Data from sensors can then be used to infer what someone is doing and when they are not progressing through the task. The COACH system (Mihailidis et al., 2007), for example, can monitor someone's progress washing their hands and prompt only when necessary. Wherton and Monk (2008) conducted interviews to identify the daily activities of people living at home that might most usefully be supported by automated cognitive prostheses of this kind. Simple kitchen tasks were shown to be particularly important in this respect.

Non-technological approaches in neuropsychological rehabilitation are based on an understanding of how task demands need to be transformed to match the cognitive capabilities of the patient. This is commonly done by manipulating the environmental context, e.g., making clearly visible only the objects relevant to the task in hand (Beck et al., 1993; Gitlin et al., 2001). Similarly, cognitive prosthesis design should be based on an understanding of how the underlying deficits interact with task demands imposed by the environmental context so as to provide appropriate prompts, where necessary.

This paper reports the findings from observations of people with mild to moderate dementia performing daily activities, that they themselves identified as important, in the familiar environment of their own kitchens. Wherton and Monk (2008) found that problems with cooking and preparing hot drinks were commonly reported, also, such activities are important to people because of the obvious health implications and their relationship to self-esteem and a sense of control. Before describing the study we briefly

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review methodologies for recording behaviour and the outcomes in relation to cognitive theory.

1.1. Methods for analysing action disorders during everyday tasks

Descriptions of action errors in healthy volunteers have been based on self-reports (Norman, 1981; Reason and Mycielska, 1982) providing useful material for theories of the controlling of actions during everyday activities that lead to slips and mistakes. For example, Norman (1981) describes problems in the formation of intention and faulty activation during the execution of routines. Cognitive theory developed in this way has been applied to the problem of preventing human error in complex control tasks involving electronic displays (Hollnagel, 1993).

Observations in clinical settings have been used to identify errors associated with specific pathologies. Typically the person being observed is video recorded carrying out some standard task. Points where they make a mistake or require assistance from the researcher or care worker are then identified. Gendron (1993) evaluated the functional autonomy of patients with Alzheimer's type dementia. Thirteen people living in a care facility performed four activities (getting dressed, getting washed, eating, and going to the toilet). Each resident was observed on two or three occasions for each activity. When they performed an incorrect action, or failed to initiate an action, assistance was provided. Three levels of prompts were used. First, verbal instructions of the action would be given. If the verbal prompt did not work, then miming the action or pointing to the relevant object would be used. If the patient still failed to act, then physical assistance would be provided. The observations revealed 19 'blocking' behaviours that hindered performance. These behaviours were incorporated into the OPTIMAGE instrument for assessing functional ability (Gendron, 1993).

Perhaps the most influential of these clinical approaches is the Action Coding System (ACS) (Schwartz et al., 1995, 1991). The system required the transcription of individual actions, termed 'action units' (e.g., picking up a bottle of milk). This provided a transcript at the action level (A1). The A1 transcripts were recorded using a semi-formal notation to describe four different types of action: *MOVE*, *ALTER*, *TAKE*, and *GIVE*. For example, MOVE refers to the moving of an item from one location to another in a single action (e.g., moving sugar from a jar to a cup as a step in making tea). The A1 transcripts provide a low level description of interaction with the environment that allowed errors to be identified and recorded. The ACS also involved grouping A1 transcripts into sub-procedures (e.g., sugaring the tea), which were termed A2 scripts. The purpose of A2 scripts was to identify problems with the transition between sub-goals. For example, difficulties in initiating actions occurred at the beginning, rather than during, the sub-gaol. The A2 script also allowed the flow to be analysed, such as the degree of overlap between different sub-goals.

Schwartz et al. used the ACS to observe two stroke patients HH (Schwartz et al., 1991) and JK (Schwartz et al., 1995) performing tasks such as making a cup of coffee or brushing their teeth. Across a number of video recordings they recognised a range of error types. These included 'place substitutions', (e.g., instant coffee grounds in oatmeal), 'object substitutions' (e.g., orange juice added to the cup of coffee), 'drinking anticipation' (e.g., sipping coffee before it has been fully prepared), 'omission errors' (e.g., failure to open a bottle before pouring), 'instrumental substitutions' (e.g., stirring with a fork), and 'faulty execution' (e.g., partial opening of a sugar packet). Also observed were incoherent actions, including 'independent acts' (picking an item up and putting it down again) and 'toying' behaviour, in which the patient would make gestures with objects without any apparent goal. The ACS was also used by Humphreys and Forde (1998).

These studies led to the development of a standardised test of action disorders, the Multi Level Action Test (MLAT, Schwartz et al., 1998). The person being assessed is asked to carry out three tasks: making a slice of toast with butter and jam, wrapping a present, and packing a lunchbox for a child. The tasks are completed under four conditions that range in difficulty: *Solo basic* (only the materials needed are presented), *solo-distracters* (functionally related items are also presented), *dual-basic* (the primary task with another specific task, such as wrapping a present and preparing a letter), and *dual-search* (some of the materials are located in a closed drawer with other task-irrelevant items). The test is typically used in a lab setting with the testee seated at a 'U' shaped table upon which the items are located in standardised positions.

The MLAT is scored according to a detailed error taxonomy giving frequencies of: (i) *omission*, e.g., failing to add cream to coffee, (ii) *sequence error*, which includes anticipation-omission, e.g., closing the lunchbox before packing, reversal, e.g., stir mug, then add instant coffee grounds, and perservation, e.g., make two sandwiches instead of one, (iii) *object substitution*, e.g., stir coffee with fork, (iv) *action addition*, e.g., pack extraneous items in the lunch box, (v) *gesture substitution*, e.g., spoon rather than pour milk into cup, (vi) *grasp-spatial misorientation*, e.g., hold wrong end of scissors, (vii) *spatial misorientation*, e.g., cut paper too small to wrap around present, (vii) *tool omission*, e.g., spread jam with finger, and (x) *quality*, e.g., fill cup to point of overflow. There is also a shortened version of the MLAT, often referred to as the Naturalistic Action Test or NAT (Schwartz et al., 2002).

The MLAT and NAT have been used with different clinical groups, including people with: dementia (Giovannetti et al., 2002), closed head injury, and stroke (Schwartz et al., 1998). Across these studies, the clinical groups had error rates that were at least five time that of age-matched controls. Interestingly the proportions of error types were very similar between different patient groups and controls. Omissions were found to be most frequent. This was followed by sequence errors. For all groups, the presence of distracter objects increased the occurrence of omission errors. For people with dementia, omission errors and substitution errors occurred more frequently when distracters objects were present (Giovannetti et al., 2002). It was concluded that the uniformity of results across patients indicates that the different error types result from an impairment to a single cognitive process responsible for goal-directed behaviour (see also, Feyereisen, 1999; Rusted and Sheppard, 2002).

The work has also led to the development of a sophisticated model of action error. The Norman and Shallice (1986) contention scheduling model proposes that pathological weakening of top-down activation from a supervisory attentional system means that the contention scheduling system that selects action schemas can no longer work properly. Bottom-up activation internally from associated action schemas and externally from environmental triggers result in actions that do not follow the intended goal. Consistent with this claim, it has been found that reduced capacity of sustained attention explains the frequent occurrence of action errors in traumatic brain injured patients (Robertson et al., 1997).

Cooper and Shallice (2000) used artificial neural network to simulate the contention scheduling system (Norman and Shallice, 1986). They built models for making a cup of coffee (Cooper and Shallice, 2000) and the packing a lunch box task used in the MLAT (Cooper et al., 2005). The architecture included the hierarchical structure of action schemas, which received both top-down and bottom-up activation. The implemented models further emphasised the role of the environment with the inclusion of a separate network for 'object representations'. The action schemas interact directly with the object representations, responding to the 'post-conditions' and 'pre-conditions' of the environment. The model also makes a distinction between objects that are 'sources' (e.g.,