End User Programming and Context Responsiveness in Handheld Prompting Systems for Persons with Cognitive Disabilities and Caregivers

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ABSTRACT
Providing instructions via handheld prompters holds much promise for supporting independence for persons with cognitive disabilities. Because users of these tools are paired – caregivers who make scripts and a person with cognitive disabilities who uses them - designing such a system presents unique *meta-design* problems. The problems of changing content and configuration on a handheld computer, as needs and abilities change of the users with cognitive disabilities, produce a critical need for end-user programming tools. This paper describes the design and testing of the MAPS (Memory Aiding Prompting System) system, consisting of a handheld prompter and a multimedia editing tool for script creation, storage, and modification. The unique meta-design challenges of supporting end-user programming of context-responsive systems, and its broader implications, are presented.

Author Keywords
End-user programming; assistive technology; technology abandonment; context aware mobile systems

ACM Classification Keywords
H.5.2 [Information Interfaces and Presentation]: User Interfaces - User-centered design; K.4.2 [Computers and Society]: Social Issues - Assistive technologies for persons with disabilities.

INTRODUCTION
In the U.S., there are approximately 20 million persons with cognitive impairments [1]. Individuals with cognitive disabilities are often unable to live independently because they might not be able to perform daily tasks such as cooking, shopping for groceries, and taking public transportation. By creating socio-technical environments to extend their independence, persons with cognitive disabilities can have richer, fuller lives.

Traditionally, *Activities of Daily Living* (ADL) support has been provided by training: repeatedly performing tasks utilizing prompting and task segmentation techniques. Scripts are used, consisting of linked sets of images and verbal prompts that together pilot the person with cognitive disabilities thru accomplishing the task. Having learned a specific task individuals then go into the world with new skills. However some individuals lack the capacity to memorize and properly recall the steps necessary for certain tasks. Further, the context of the task as well as the task itself may change, rendering useless the training. Recent advances in computer technology - powerful PDA (Personal Digital Assistant) devices, ubiquitous wireless networking, and sensor technology, have provided an opportunity to create prompting systems that could remedy this problem.

The target users for the system are young adults with cognitive disabilities, typically evaluated at "trainable Mentally Handicapped' (IQ 55-72) and the upper range of 'Severely Mentally Handicapped" (IQ < 55), who will use the handheld prompter; and a caregiver (often a family member) who would design the scripts for the prompter. The caregivers will be assumed to be able to compose a letter on a word processor, or read email. In this paper the MAPS user who is a person with cognitive disabilities will be referred to as a prompter-user and a user who is a caregiver will be referred to as a script-editor-user.

A substantial portion of all assistive technology is abandoned after initial purchase and use, as high as 70% in some cases [2, 3]. A large component of the cause for such abandonment is difficulty in configuring and adapting software [4]. All too often systems are delivered with elegantly designed user interfaces for the person with cognitive disabilities, but only rudimentary facilities for the caregiver's (re)configuration of the devices. This can result in a good initial fit but eventual abandonment as the end-user with cognitive disabilities changes and as tasks themselves change

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RELATED RESEARCH

Studies in distributed cognition, learning and using on demand, and situated action [5] provide a theoretical basis for this research. There is a small body of literature concerning design and adoption of assistive technology [6] and computationally based prompting systems [7]. Existing computer based prompting tools of interest include the Visions System [8], a prompting tool using touch screens to prompt thru tasks like cooking. PDA-based systems include the Able Link team's 'Pocket Coach'[9] and the Swedish Isaac project [10].

Why other applications did not thrive

The prompter-user for MAPS often lacks ability to make and use abstractions [11]; therefore scripts to aid them in ADLs need to be as concrete as possible, reflecting the specifics of the task (i.e. using pictures of the specific arriving bus instead of an icon). This requirement that each script be individually tailored exemplifies the *universe of one* problem, where each user must have the system deeply configured specifically for them Changing and creating new scripts on existing systems often became an insurmountable barrier to adoption.

In initial discussions with familial caregivers and assistive technology professionals, high on the list of concerns was the possibility that the system could leverage the prompter-user into environments that, if the system failed, could put that user in harms way. They also expressed apprehension about the fragility of current commercial computer technology, compounded by this special population's need for reliable support. The moment-to-moment changing environment, unexpected events, and user mishaps almost guarantee that planned task support does not exactly fit the situation. This led to a requirement for both a prompter-user accessible 'panic button' and a system that could capture the common script failure events (i.e. handheld computer batteries die, user becomes confused and repeatedly requests a prompt) and attempt corrective action to provide a safety net for both the prompter-user and caregiver.

UNIQUE REQUIREMENTS

The need for creating and tailoring scripts for individual prompter-users and for these scripts to be responsive to changing environments presents a unique design problem.

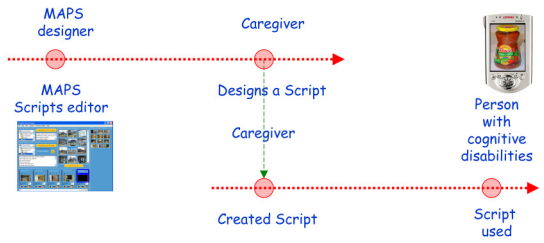

Figure 1: Meta-design at two levels

Meta-design [12] concerns itself with systems that facilitate end-users participation in the development of the tools rather than as passive users of tools. Here, meta-design is used to describe tools that are created to facilitate caregivers becoming programmers of scripts that are used by person with cognitive disabilities. Figure 1 unfolds the situation: The MAPS script editor is designed to give to the caregiver an extremely low-learning-threshold editor to design scripts that will be used later to assist persons with cognitive disabilities in accomplishing ADLs.

Dual user interface

MAPS is designed with two user interfaces: one, tailored for the caregiver to design scripts, and the second for the person with cognitive disabilities using the handheld prompter. The notion of a *dual user interface* [13] is not new to the domain of assistive technology, however its use in this unique meta-design environment is novel. By seeing both interfaces as first class objects we might mitigate the difficulties that script-editor-users had with system re-configuration (e.g. creating and modifying the scripts).

Need to allow tailoring of errors

For the prompting system to be really safe and effective, beyond provision of individually tailored scripts, both active and passive safety net functionality is needed. Specifically, a panic button and some way to detect when the actions of the person with cognitive disabilities are no longer getting them towards the goal of a completed task, either of these triggering the *right* sort of help. Here I will discuss the insertion of annotations into the script by caregivers at script design time (the left side of Figure 1).

MAPS DESIGN

In designing the MAPS script editor, the target level of computer fluency was set at barely skilled enough to access email and write a simple MS word document. The design problem was set so very high because caregivers, whether members of the family or paid professionals in group homes, should be able to immediately have a satisfying and productive experience without long training sessions. Using task centered design techniques [14] and borrowing much from the model/metaphor of the suite of Microsoft products an editor was designed so that the caregiver could re-use as many previously acquired skills as possible.

Scripts may be created in two fashions: *design by composition* and *design by modificati*on. In design by composition mode the script-editor-user selects images and wav files from the displayed contents of selected directories. The selected prompts are inserted into a filmstrip metaphor panel on the bottom of the application. The completed script may be displayed in a side panel as in PowerPoint, or serially previewed in a preview panel

with the same size and aspect ratio as will be shown on the PDA. Scripts are stored in a database, where stored scripts may be retrieved and modified as desired. There is a web-based repository of over one hundred scripts that can be used as templates for script creation in design by modification mode. In addition to a textural help system, the MAPS script editor provides a set of topically organized short help videos, each less than one minute long, consisting of recorded actions on the screen and a verbal commentary describing a single typical task.

The MAPS script editor allows the insertion of contextual

Figure 2 - MAPS handheld prompter (left) and Script Editor (right)

test annotations into any step of a script. The embedded instructions can initiate corrective actions, based on the caregivers' intimate knowledge of the person with cognitive disabilities and the task being scripted. The caregiver, at script design time, is given an option to annotate a script with a wizard that presents sets of tests and consequences that the caregiver can tailor to the specifics of the prompter-user and the situation. Further prompter-user configuration allows the caregiver to specify panic button functioning.

SYSTEM EVALUATION

A common initial concern about this system was whether persons with cognitive disabilities that *could* benefit from such a prompting system would be able successfully *use* such a system. As an initial proof of concept, a prototype of the script editor was used to create a simple seven step script guiding the prompter-user thru assembling a hand launched glider. This script was loaded on the MAPS prompter. Aided by an assistive technology professional from our local school district [15], we selected seven students from a high school special education class. The participants ranged from 14 to 16 years old (Mean - 16.16) with IQ scores ranging from 45 to 65 (Mean – 50); four were boys and three were girls. They were given a short demonstration of the controls on the hand prompter (i.e. shown a three step script) and were asked to use the PDA to scroll thru the sample three step script. All seven students were able to successfully use the script to guide them thru the sequence of assembling the glider (although two required a single intervention to get back on track and one had a small amount of trouble with the remapped controls due to fine motor skills).

This somewhat unexpected success was partially explained by their teacher, who explained that this generation of young adults with cognitive disabilities often had devices like cell phones, gameboys, and MP3 players (the high school was in an affluent suburb). Consequently, they were comfortable of the small handheld computers that were the platform for the MAPS prompter. A subsequent test of a 45 step script to make cookies was similarly successful.

The initial prototype of the Script Editor was evaluated by a group of assistive technology experts and special education teachers. Subjects were asked to create a simple script from provided images and sound files. We used the think-aloud evaluation technique as well as videotaping the subjects while performing a fixed set of tasks. Their performance was evaluated on a checklist of subtasks as well as by observations of breakdowns. Problems exposed included misleading labels on controls, confusing application layout, poorly designed help functionality, and a need for user customization. As a result of these first tests undo functions and an autosave feature were added. Based on an analysis of the frequency of use of the controls on the application, we folded similar, redundant controls in several areas into one area. We also, based upon responses to the interviews, removed the need for the explicit choosing of append/edit modality.

A second prototype was coded, and usability testing was done on this second version with parents of young adults with cognitive disabilities (four participants), special education high school teachers (two participants), and caregivers in local group homes (four participants) [16]. Participants were selected for low computer skills, aiming for *late majority*, and *laggards*, (in Rogers, Diffusion of Innovations adopter categories [17]). Participants were given a brief introduction to the features of the system, emphasizing the 'video help' functions, and then asked to perform four script building and saving tasks. Again, subjects were videoed and evaluated on a checklist of sub-task completion. Following this the participants were given semi-structured interviews, designed to elicit how well they understood the script model (i.e. scripts were like filmstrips, prompts were made of images and verbal cues, scripts could be stored and retrieved…). One admitted technophobe continued to append and edit prompts in the script making task beyond the seven steps specified. When told she could stop the task, she responded "No! This is fun". This sort of response shows the engagement of the technology has some promise. As a

result of this the prototype design was changed to make the script-building model more obvious and to simplify the labels of controls.

IMPLICATIONS

Preliminary results of trials and demonstrations of the MAPS system confirm the assertion that adopting a *dual user interface* for complex assistive technology devices can mitigate some of the causes for device abandonment. This principle could apply to many types of assistive technology systems. By encoding context responsiveness into scripts via annotating the informational content and evaluating it at run time a dynamic bridge can be made between plans and events that holds much promise for mobile and ubiquitous computing applications.

PLANS FOR FURTHER STUDY

The next step is studying the MAPS system in realistic environments with dyads of caregivers and persons with cognitive disabilities. It is critical to test the hypothesis that we can anticipate most of the typical errors that might be encountered. We are basing our assumptions about error trapping on the assumption that the number and kind of errors, although theoretically very big, is actually quite small. There is some theoretic support for this assumption [18], and also support for this idea among assistive technology professionals. A realistic study extracting real errors is scheduled to for spring 2005.

The Lifeline project [19] implements the safety net understructure and ties the MAPS prompter-user to the caregiver. At present the MAPS/Lifeline teams are designing and implementing ways for caregivers to easily annotate scripts with error trapping and correction information and seamlessly have them communicated to the LifeLine server.

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