Distributed Cognition: A Conceptual Framework for Design-for-All

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Abstract

In most traditional approaches, *human cognition* has been seen as existing solely 'inside' a person's head, and studies on cognition have often disregarded the physical and social surroundings in which cognition takes place. The fundamental assumptions underlying our research are: (1) *distributed cognition* provides an effective theoretical framework for understanding what humans can achieve and how artifacts, tools, and socio-technical environments can be designed and evaluated to empower humans beings and to change tasks; and (2) applying this framework to people with *cognitive disabilities* in design-for-all approaches creates new unique challenges, and in return will create a deeper understanding of distributed cognition.

1 Introduction

The central challenge for the our research project "CLever: Cognitive Levers — Helping People Help Themselves" (funded by the Coleman Institute at the University of Colorado; for details see: http://www.cs.colorado.edu/~l3d/clever/) is to provide knowledge and develop socio-technical environments that can be used to improve the human condition. We have developed innovative socio-technical systems [Fischer, 2000] that are doman-oriented, have interpretive capabilities, context awareness, and can be personalized (based on user and task modeling), and they do not only support the individual human mind, but the *social mind* (including specifically caregivers and other support personnel in the case of people with cognitive disabilities) [Arias et al., 2000].

2 Distributed Cognition: A Framework for Design-for-All

The theory of distributed cognition [Hollan et al., 2001; Salomon, 1993] provides an effective conceptual framework for understanding human-computer interaction, including a fertile framework for designing and evaluating artifacts specifically for the cognitively disabled.

Information Prosthesis: Minds are Improvable. Anatomy and cognitive abilities are not destiny — an important intellectual or philosophical grounding of this mission is provided by Postman [Postman, 1985]: *"The invention of eyeglasses in the twelfth century not only made it possible to improve defective vision but suggested the idea that human beings need not accept as final either the endowments of nature nor the ravages of time. Eyeglasses refuted the belief that anatomy is destiny by putting forward the idea that our minds as well as our bodies are improvable!"* The observation that "our minds are improvable" through media and technologies has led to the following research objectives for the CLever project:

The assertion that the cognitive abilities of all of us are limited — the most convincing example is provided by the limitations of our memories that was addressed by the invention of reading and writing.

The development of computational media (as briefly described below) that provide unique opportunities to "improve our minds" (and especially the minds of those of us who have a cognitive disability) leading to fundamental research challenges in distributed cognition, informational prosthesis, and media as extensions of humans.

Distributed Cognition: Achieving Optimal Flow. To be able to live a productive and enjoyable life, human beings often have to balance their capabilities and skills against the demands and challenges of life. Csikszentmihalyi [Csikszentmihalyi, 1990] has identified this balance as *optimal flow* (see Figure 1). People do not experience optimal flow when tasks are too difficult causing *anxiety* (A), or when tasks are too easy causing *boredom* (B).
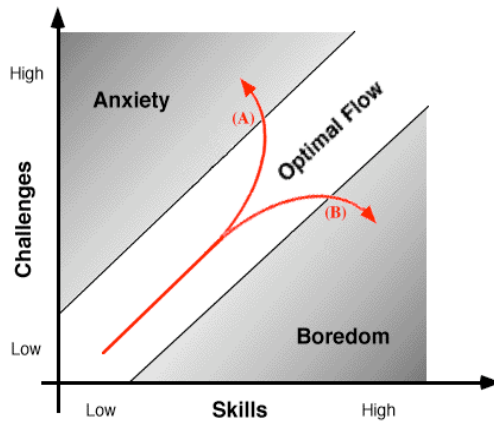

Figure 1: Optimal flow

Figure 2 illustrates different situations: (top) in a tool-free environment, individuals can achieve a set of tasks of a certain difficulty; (middle) for people with disabilities these tasks will be difficult (leading to anxiety and posing severe limitations); and (bottom) in a tool-rich socio-technical environment, more difficult tasks can be achieved by distributing the demands between individuals, their tools, and their co-workers and/or caregivers.
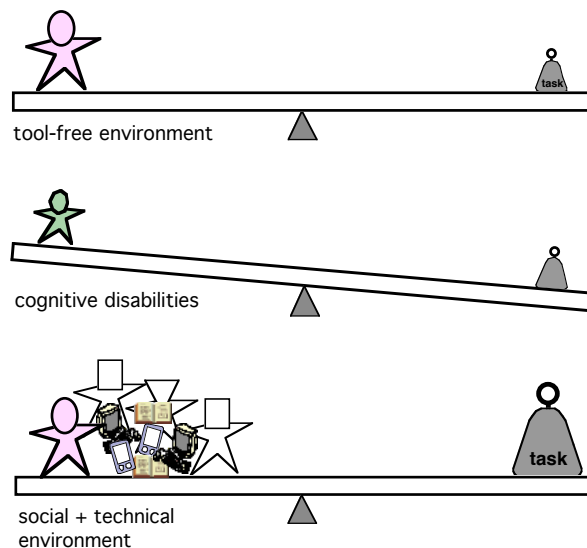

Figure 2: Balancing task demands and support of the socio-Technical environment

3 Socio-Technical Environments Based on Distributed Cognition Frameworks

In design-for-all, the standard tool sets often fail because people with disabilities are lacking the cognitive requirements to use the tools. More than "alterations" to existing tools that were developed for people without disabilities are needed, namely tools and socio-technical environments explicitly designed and developed for the unique abilities of people with cognitive disabilities.

Mobility-for-All: Creating Human Centered Public Transportation Systems. Mobility is a basic human need and transportation systems of all kinds have been developed to satisfy this need. Public transportation systems are among the most ubiquitous and complex large-scale systems found in modern society. For those unable to drive (e.g., the cognitively disabled or the elderly), these systems are essential gateways for participation in community activities, socialization, and independence. To use current public transportation, it is necessary to comprehend, manipulate, and process *essential navigation artifacts* (i.e., maps, schedules, landmarks, labels and signs, and clocks) encoded often in compact and efficient representations. Because of their generality, these navigational artifacts create cognitive burdens for travelers who are only interested in a small fraction of the information presented.

In collaborations with assistive technology specialists, urban designers, and technology researchers, we have identified the following needs and opportunities for making public transportation systems better serve the needs of people with disabilities [Fischer & Sullivan, 2002]:

to reduce the complexities of the current systems with the powerful role of technology as a social medium for socialization, independence, and self-worth;

to support both users with cognitive disabilities and their support communities;

to move beyond "one size fits all" solutions based on "the average user myth" for all users in all situations [Fischer, 2001]; and,

the emergence of ubiquitous, location-ware, mobile technologies with potential to deliver personalized information tailored to individual needs and abilities.

Figure 3: The Mobility-for-All Prototype

The Mobility-for-All prototype (see Figure 3) is a socio-technical environment that serves as a dynamic "navigational assistant." It reduces the cognitive demands of current transportation systems. Its architecture leverages two emerging ubiquitous technologies: (1) mobile, wireless, location-aware personal digital assistants (PDAs) or phones, and (2) mobile GPS technology now appearing as "standard equipment" on public transit vehicles.

Memory Aiding Prompting System (MAPS). Cognitively impaired individuals are often unable to live on their own because of deficiencies in memory, attention, and executive functionalities. These deficits can create inability to consistently perform normal domestic tasks like cooking, taking medications, performing personal hygiene, and using public transportation. A common way of transitioning from assisted living to independent or semi-independent living is through the use of prompting systems. Prompting systems consist of breaking down a task into constituent parts creating prompts which consists of pairs of images and verbal instructions for each step. MAPS [Carmien, 2002] provides a mobile prompting platform, providing context sensitive prompts, and acknowledging dual user interface requirements in assistive technology design (see Figure 4).
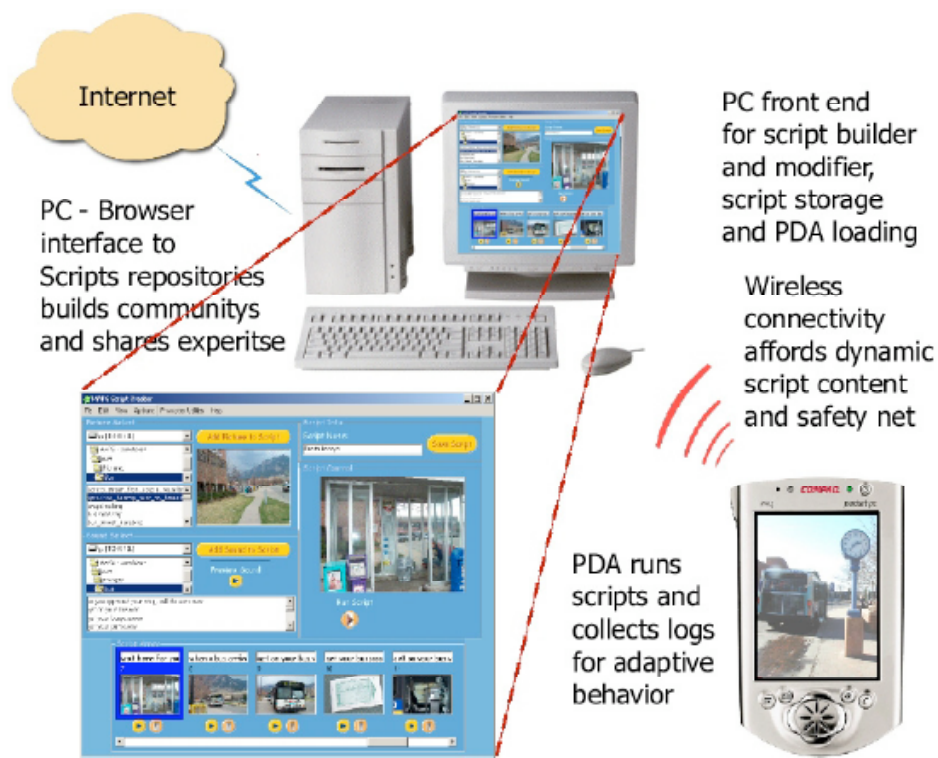

Figure 4: The Components of the MAPS System

The MAPS system consists of a personal digital assistant or a cellular phone (as shown in Figure 4) to be used by the person with the cognitive disability and a PC-based script editor tool to be used by the caregiver to create scripts. Grounded in our distributed cognition framework, the computational environment allows users to operate within the band of optimal flow (see Figure 1); this is achieved by providing simple ways to backtrack or to start over, to allow for mistakes during task completion, appropriate wireless connectivity for dynamic, context based prompt generation, and a 'panic button' to activate the human back-up system in case the technology fails.

4   Assessment

Research grounded in distributed cognition should not be restricted to cognition only but account for other aspects of a social environment, such as personal support and motivation. Social issues

need the same attention as assistive technologies supporting the communities of cognitively disabled people. There are no "silver bullet" technologies that can or should replace caregivers.

5   Conclusions

CLever is grounded in the basic belief that improvements in human-computer interaction are not an end, but a means to the end to provide knowledge and develop socio-technical environments that can be used to improve the human condition — particularly for people with cognitive disabilities. The history of the human race is one of ever-increasing intellectual capability. For the last few thousands years, our brains have gotten no bigger, but new media and new technologies have been developed to exploit the power of distributed cognition. To make further progress is nowhere more needed than in the design-for-all effort for people with cognitive disabilities.

6   Acknowledgements

7   References

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