Cognitive Impairments, HCI and Daily Living

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Abstract. As computer systems become increasingly more pervasive in everyday life, it is simultaneously becoming ever more important that the concept of universal access is accepted as a design mantra. While many physical impairments and their implications for human-computer interaction are well understood, cognitive impairments have received comparatively little attention. One of the reasons for this is the general lack of sufficiently detailed cognitive models. This paper examines how cognitive impairments can affect human-computer interaction in everyday life and the issues involved in trying to make information technology more accessible to users with cognitive impairments.

1 Introduction

In a paper presented to the 4th International Conference on Universal Access in Human-Computer Interaction it was observed that cognitive impairments and the related issue of learning difficulties are often overlooked in much of the research performed into enabling Universal Access (UA) to information technology (IT) [1].

The IBM Human Ability and Accessibility Center, along with IBM T.J. Watson Research Center, has a longstanding interest in addressing the needs of users with cognitive impairments and learning difficulties. After sponsoring an international symposium of leading experts in the field in October 2005, a series of follow-up meetings has been held over a number of years to identify potential areas of research. This paper discusses much of the background thinking that is informing the ongoing development of a strategy to improve access to HCI for users with cognitive impairments.

1.1 Terminology

In this paper, the term "cognitive impairments" will be used as an umbrella term for the more usual interpretations of cognitive impairments (e.g. memory loss) as well as learning difficulties (e.g. dyslexia) and also behavioural disorders (e.g. attention-deficit/hyperactivity disorder – ADHD). The following is an example list of conditions considered:

- Attention-Deficit/Hyperactivity Disorder
- Auditory Processing Disorder

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- Asperger's Syndrome
- Autism Spectrum
- Childhood Disintegrative Disorder
- Dementia
- Depression
- Dyscalculia
- Dysgraphia
- Dyslexia
- Dyspraxia
- Rett Syndrome
- Visual Processing Disorder

This paper examines the role of cognition in accessing IT systems, especially in the context of daily living activities and how those activities are affected for those with cognitive impairments.

2 Cognitive Impairments and UA Research

There are several reasons why cognitive impairments are often overlooked:

- They are "invisible" – whereas many sensory or motor impairments are often easily discernible by other people, cognitive impairments are not necessarily
- They are difficult to diagnose – while some symptoms of cognitive impairments can be identified (e.g. memory tests), not all can be
- They are not universally defined – some researchers believe that learning difficulties and (especially) behavioural disorders should be treated separately from cognitive impairments.
- They are not easy to design for – the lack of a clear understanding of the design problem to be addressed (what is the impairment and what are the implications of it?) makes it difficult to solve.

This last point is arguably the most significant. Common attempts to address the issue of how to design for users with cognitive impairments focus on providing best practice guidelines.

2.1 Example Best Practice Guidelines

Keates and Varker [1] proposed the following best practice guidelines gathered from an international symposium held at the IBM T.J. Watson Research Center in October 2005:

- Find the required set of demands to complete the range of tasks compared with what the IT system demands and ensure that the IT system does not introduce new demands.
- Involve users with cognitive and learning difficulties in the design process.
- Use clear, unambiguous language and reinforce with images where appropriate.

- Use "scaffolding" techniques that build a support structure beneath each new concept, which consists of strong links to other, already learned, bits of knowledge.
- Use positive reinforcement and provide feedback.
- Recognise the use of coping strategies by users and try to complement, support and augment these wherever possible.
- Design for people's learning strengths, not for their weaknesses.
- Design for flexibility, e.g. provide information in multiple formats or with sliding levels of complexity.
- "Chunk" information into more manageable pieces.
- Keep menu hierarchy depths to a minimum.
- "Help" systems and documentation needs to be concrete, repeatable and consistent.
- Present assistance options carefully to avoid potential stigma.
- Avoid "feature creep" and only add new functionality that is required.
- Try to be consistent with design features.

While design best practice guidelines such as these are very important for designers, they are only part of the solution. To successfully design an IT system that is accessible to a user with a cognitive impairment requires a full understanding of the IT system and the user's wants, needs and aspirations.

Much research in usability in human-computer interaction (HCI) focuses on "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [2]. For many users with moderate or severe cognitive impairments, their aim is usable access to the activities of daily living.

2.2 Activities of Daily Living

Most discussion of the activities of daily living (ADLs) focuses on a medical perspective, specifically helping someone get through the day. ADLs are often considered at 2 levels:

1. **Basic/self-care ADLs** – these are related to day-to-day basic requirements for living, for example: bathing, eating, using the toilet and so on.
2. **Instrumental ADLs** – these are more advanced ADLs that are required for successful independent living, for example: housework, preparing food, shopping, managing money

From an IT perspective, especially for a company such as IBM, these definitions of ADLs are too basic. A new classification is required.

2.3 Areas of Life Endeavour

A better approach to the issue of cognitive impairments and HCI is to consider areas of life endeavour and five such areas have been identified as being of interest, specifically:

1. Lifelong learning and education
2. Workplace
3. Real world (i.e. extended ADLs)

4. Entertainment
5. Socialising

It is worth looking at each of these areas in more detail.

Lifelong learning and education. While traditional classroom (K12) learning environments are the most obvious examples of a learning context, they are not the only ones of interest here. The concept of "lifelong learning" mandates that learning continue long after a person leaves school. Access to learning is especially important for users with cognitive impairments, where the very nature of the impairment may make acquiring and retaining learned knowledge especially challenging.

It is important to consider the rate of acquisition of knowledge here, along with the level of retention.

Workplace. There are two perspectives to consider for the workplace:

1. Gaining initial access to the workplace – how to secure a job
2. Maintaining employability – how to keep a job

In the first case, it is often necessary to acquire brand new skills and knowledge to enter the job market, especially for someone with a congenital condition present from early life. In the second case, the basic skills will have been acquired some time ago. However, due to a change in circumstances (such as a traumatic brain injury or even the ageing process), the user may need to reacquire some of the skills, adapt existing skills or learn alternative skills to compensate for the acquired impairment.

Common tasks to be considered include:

- Learning / acquiring new skills – (discussed above)
- Workflow management – ensuring that tasks are identified and addressed in a timely and consistent manner
- Collaboration – identifying the appropriate team members to work with and communicating concepts and ideas correctly and efficiently
- Creative problem solving – identifying all of the key points and interrelationships of a problem and developing innovative and appropriate solutions
- Task efficiency – identifying the key goals of a task and maintaining focus on those goals
- Personnel management – supporting typical everyday management activities

Real world / extended ADLs. This category is an extended concept of the more typical interpretation of ADLs as described earlier in this paper. Access to real world activities, as defined here, includes:

- Transportation/travel
- Daily living/personal care
- Self-organisation
- Commerce/shopping
- Crisis management

Socialising. The ability to socialise is a required capability in many common daily activities for independent living. Socialising, as defined here, includes:

- Verbal communication – person-to-person
- Non-verbal communication – person-to-person and including gestures, body language and emotions
- Remote communication – communication conducted via an attenuating medium (e.g. a phone line)
- Social Networking Software (for example, Facebook with accessibility enhancements, such as icons to indicate emotional content for an autistic person)

Entertainment. Not all aspects of IT are focused on accomplishing tasks. Entertainment is a key activity for many domestic IT users. Indeed the games market is now larger than the market for many of forms of entertainment [3]. As different forms of media continue to converge and become more powerful, in terms of their computing capability, media consumption is increasingly becoming more reliant on IT access solutions.

3 Decomposing the Areas of Life Endeavour

Having identified a number of prospective areas for future research, it is necessary to consider methods of decomposing them into more manageable concepts for designers and researchers to consider. Fundamentally, issuing the design challenge "Design a new game for someone with a cognitive impairment" is too vague to be meaningful. A more pragmatic approach is to consider functional capabilities to be considered. For example, Adams proposed a model of cognitive operation that consists of 8 components moderated by a ninth element that ties them all together [4]:

- Working memory
- Emotions and drives
- Perception
- Output
- Feedback
- Complex output sequences
- Cognitive models
- Long-term memory
- Executive functions (moderating component)

For the purposes of this discussion, though, a different set of cognitive capabilities has been identified as being of most relevance and usefulness. The principal areas of focus are:

- Attention
- Memory
- Organisational skills
- Language skills
- Social skills

This is by no means a full description of all areas of potential interest, though, simply the ones that are thought to be most appropriate for this discussion. Other additional areas of potential interest that we do not cover in this discussion include, but are not limited to:

- Mood and emotion
- Impulse control
- Visual-motor and spatial processing
- Abstract thought

Having identified the areas of life endeavour and the five principal areas of cognitive capabilities that are of most interest, the next step is to relate these to one another in a matrix describing the scale of the solution design problem to be addressed.

3.1 The Shape of the Matrix

The next stage was to produce a matrix that identifies how the different cognitive capabilities affect a user's ability to interact with an IT system to accomplish a particular task (or set of tasks) within an area of life endeavour. Table 1 shows the basic shape of the matrix.

Table 1. The basic layout of a matrix relating areas of life endeavour to the principal cognitive capabilities identified

	Attention	Memory	Organisational skills	Language skills	Social skills
Learning					
Workplace					
Real world					
Socialising					
Entertainment					

Having established the basic layout of the matrix, the next step is to begin populating it.

3.2 Populating the Matrix

Taking Table 1 as a guide, the next step is to identify specifically which actions and abilities each cognitive capability may affect and facilitate within each area of life endeavour. Table 2 shows an example of this for the Workplace.

3.3 Completing the Matrix

Knowing how different cognitive capabilities are relevant for particular actions and abilities is a good starting point, but needs to be developed further to be useful for designers and researchers. Having identified a particular capability as being of interest, several steps are required to target specific technological capabilities to enhancing

Table 2. The decomposition of the workplace area of life endeavour into component actions and abilitiesaffected and facilitated by each cognitive capability

Workplace	Attention	Memory	Organisational skills	Language skills	Social skills
- Workflow management - Collabora-tion - Creative problem solving - Task efficiency - Personnel management	- Identify and maintain focus on what is to be done - Avoid anxiety and distraction - Manage interruptions	- Maximise access to information that has been applied successfully in the past (professional knowledge base) - Remember what didn't work - Remember roles, procedures, individuals, etc.	- Decompose, sequence, prioritize problems/tasks - Maintain self-awareness of capabilities and limitations - Structure environment in way that is conducive to attention and memory - Identify criticality of specific things (and what can be safely forgotten, "to-do"/reminder mgmt)	- Allow language (written, spoken, affective) to affect the cognitive process – "listening" - Communicate lack of understanding or intent - Present, persuade, influence, negotiate, etc. – "outbound" language skills	- Observe, acquire and then behave appropriately in workplace environment - Interpret and respond appropriately to others, incl. mgmt - Understand personal work objectives and priorities in context of the larger whole - Ask for and obtain support - Empathize with colleagues

Table 3. A completed matrix for Lifelong learning and education

Learning	Attention	Memory	Organisational Skills	Language Skills	Social Skills
-K12 -Higher Ed -Professional education -Continuing/just in time education -Immersive learning -Rehabilitation	•Maintain focus on what is to be learned •Avoid anxiety and distraction	•Maximise access to information that is already learned; relate new material to that •Retain information / relevance of learning to problem context •Remember roles, procedures, individuals, etc.	•Decompose, sequence, prioritise learning problems/tasks • Maintain self-awareness of capabilities and limitations •Structure environment in way that is conducive to attention and memory (meaning "learning")	•Allow language (written, spoken, affective) to affect the cognitive process – "listening" •Communicate levels of understanding or lack thereof (e.g., through interrogation) •Acquire and apply extended language skills	•Behave appropriately in learning settings •Interpret and respond appropriately to others, incl. the teacher •Understand personal learning objectives in context of the group
Need to Identify…	•User's level of capability •Underlying motivations •Objects in the environment	•User's level of capability •Elements of what the query might be •Existing user knowledge base	•User's level of capability •User's native strategy	•User's level of capability •Desired outcome of communication	•User's level of capability •Representation of social network
Possible solution capabilities	•Signposting (tactical support) •Suppress unnecessary distractors	•Chunking of information •Signposting and Scaffolding •Use positive reinforcement and feedback •Offer multiple, alternative representations •Deploy alternative memory cues	•Assist with problem identification (strategic support) •Complement user's strategy •Timetabling and organizational support •Keep hierarchy depths to a minimum •"Help"/Wizards/Task automation	•Use of clear language, simple language •Use of multimedia •Be consistent	•Use positive reinforcement and feedback •Be consistent

or supporting individuals' capabilities and the specific actions supported. It is therefore necessary to identify the level of the potential user's capability and other information about the user in order to model their abilities. Finally, potential solution options can also be identified building on the best practice guidance discussed earlier in this paper, to match the modeled level of capability and needs for each action supported.

Table 3 shows a completed matrix for the "Lifelong learning and education" area of life endeavour.

4 Summary

This paper has shown that cognitive impairments, along with learning difficulties and behavioural disorders, can affect a person's quality of life. IT offers a potential means of assisting in a number of key areas of daily living and also areas of life endeavour. This latter concept is more useful when considering IT because it moves away from the more mundane issues of basic existence, which would most often benefit from "lo-tech" solutions, to considering more ambitious goals to which "hi-tech" solutions offer more appropriate solutions.

A basic framework for relating a person's cognitive capabilities to those areas of life endeavour has been presented and extended to identify possible design guidance for developing solutions.

5 Further Work

The most obvious conclusion of this research is to begin working on projects that take this framework as their inspiration, identify a clear need and develop a viable solution. It is expected that this will be the next phase of this work.

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