An overview of cognitive skills and impairments for cognitive work

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Abstract

A practical taxonomy of IST functional requirements is developed here based upon occupational and cognitive factors to consider systematically:

- the IST requirements of individuals with different cognitive skills and impairments; and,
- the opportunities and solutions that IST developers can generate.

The focus is on functionality and accessibility to IST function in the work-place. Whilst vocational factors provide the context of use, cognitive notions proved more useful and precise when considering systematically the range of accessibility solutions that need to be developed in IST. Analysis shows that this taxonomy captures the range of potential accessibility solutions.

Introduction

The aim is to provide a basis for the following set of important questions and issues, and then to tackle them, in order to achieve at least some important theoretical and pragmatic insights into cognitive impairments at work. If we can achieve some significant conceptual innovations, we will then have a more advanced conceptual framework with which to identify eAccessibility solutions for eInclusion.

Conceptual instruments

These are tough questions, if they were not, they would have been put to rest many years ago. In fact, it is probably the case that we have only recently been able to formulate these questions clearly, as a prerequisite to formulating answers. If so, we will need a repertoire of powerful conceptual tools, to have sufficient understanding of crucial aspects of intelligent human behaviour. No one discipline is sufficient here. At least three perspectives, namely; occupational science, cognitive science and computing science are used here, since three should generate a reasonably accessible set of constructs with which to work.

Accessible cognitive IST resources can mediate between cognitive skills and the achievement enhanced performance levels and of work objectives. Powerful cognitive IST resources can even augment cognitive skills and boost work performance significantly. If so, then insights into vocational and cognitive factors will generate powerful, accessible design principles and IST solutions. This deceptively simple view will, as I hope to demonstrate, lead to some surprising and powerful conclusions. Inaccessible IST can create additional barriers which halt our personal skills and skills potential from being expressed by our work performance and achievements. Sometimes, IST is part of the solution, sometimes it is part of the problem.

To avoid overlap, for occupational science, only macro concepts which relate directly to the work place will be considered. For cognitive science, I focus on micro concepts and related approaches which underpin human, vocational behaviour. In the computing science perspective there, and only there, will I focus on technological design issues and solutions.

Perspective One: Occupational Science

We all transit through distinct stages and different roles, for example, getting a job. What are the demand characteristics of these transitions? What are the differential implications of these transitions for people who have different strengths and weaknesses, different abilities and impairments?

Key stages or roles in a person's lifespan development include:

- First age
  - education
- Second age
  - higher education
  - vocational training
  - employment
  - progression
  - promotion
- Third age
  - downsizing
  - retirement

At each stage, macro cognitive skills and impairments are differentially influential. For example, Sternberg's triarchic theory of human intelligence proposes that there are at least three types of intelligence; namely analytical, creative and practical. If it is the case that education and higher education focus on analytical thinking, rather than on creative or practical thinking (Sternberg and Bur-Zeev, 2001), then individuals with problems or impairments in analytical thinking skills will face difficulties even though they may be gifted elsewhere. Conversely, the arts may call for creative skills and vocational training for practical thinking. Of course, the absence of analytical skills does not in itself imply the presence of practical skills.

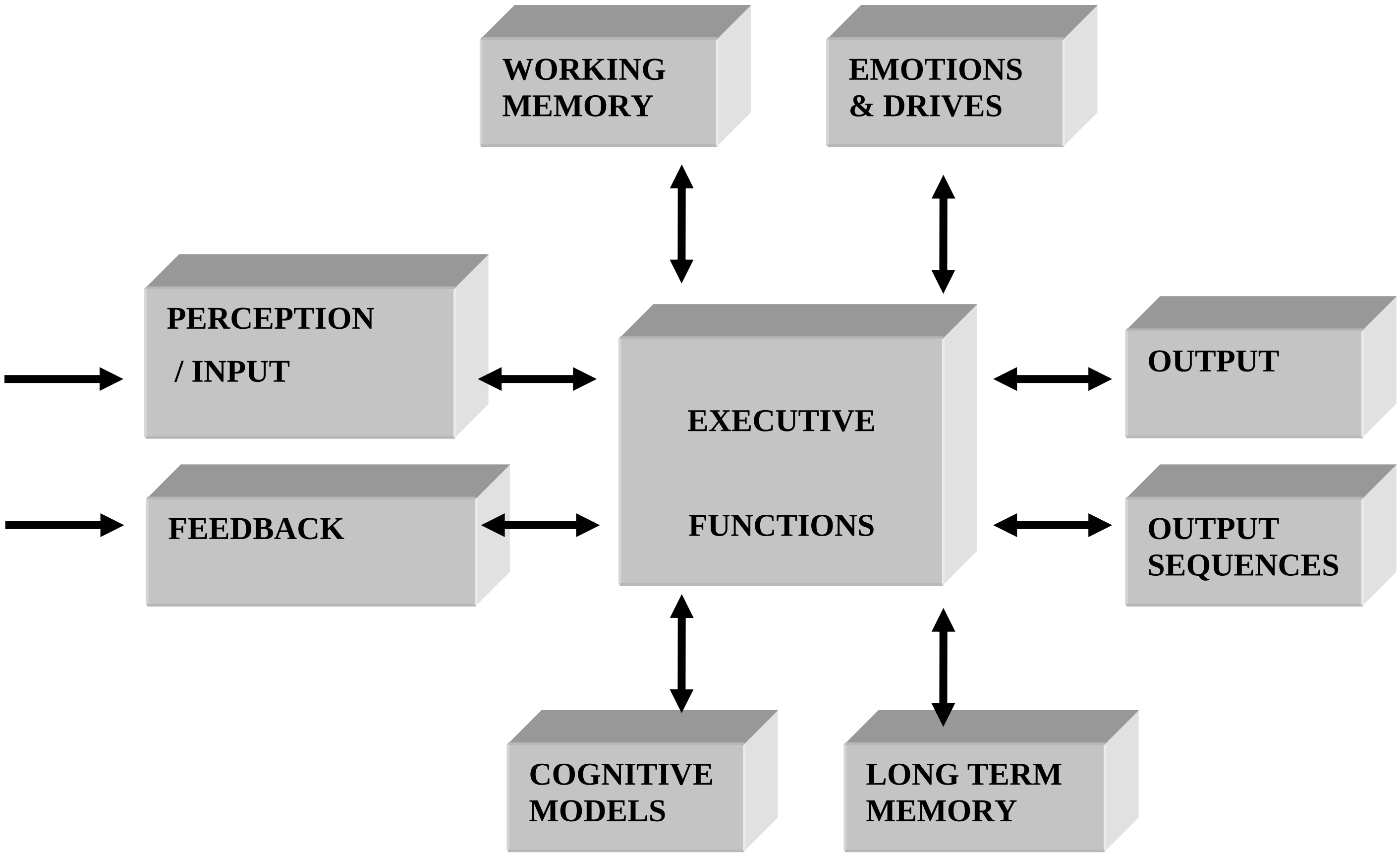

Figure 1. The Simplex 2 model

Perspective Two: Cognitive Science

However, vocational factors do not, by themselves, give us sufficient precision to identify design principles and IST solutions for eAccessibility for eInclusion. We need to specific skills and impairments. How can we capture current knowledge about cognitive skills and impairments? There are a number of options, which are reviewed elsewhere.

Our approach (Simplex 2 – see Figure 1) is a model which is intended as both a framework for researchers in universal access and for accessible systems design. It is a descendant of Broadbent's Maltese cross model which itself draws upon a considerable weight of research evidence. The benefits of this approach will hopefully emerge from this discussion.

On this view, there are five components of intelligent human behaviour i.e.:

- Input / perceptual processes
- Working memory processes
- Long term memory processes
- Output / response processes
- Executive processes

Based on further work with the cognitive science literature and with designers, we have identified a further four components:

- Feedback processing
- Cognitive models
- Emotions and motivation
- Complex response processes

Perspective Three: Computing Science

The aim is now to combine the vocational and cognitive processes to provide a solutions matrix for accessible IST solutions. Rather than start with a basic treatment of computing science, I begin with "*an evolutionary path from Assistive Technologies to Design for All and Universal Access to the Information Society, and more recently towards Universal Access to ubiquitous computing and Ambient Intelligence*" (Stephanidis, 2005).

Answering the questions

"What are the specific causes or conditions that lead to difficulties in securing and succeeding at initial employment?"

The individual with learning difficulties is at high risk of failing at this stage. Without additionally supportive resources, they are unlikely to acquire sufficient qualifications or complete an application form impressively without specific training. Here the importance of eLearning cannot be emphasized enough. The person with learning difficulties needs well structured and highly repetitive learning materials. They may need to learn in error free conditions. Conversely, the person with autistic spectrum disorders or Asperger's Syndrome without accompanying marked learning problems may do well at familiar examinations or selection tests, particularly if computerized. However, they will often do badly in interviews and other social settings without specific training

Cognitive deficits through brain injuries may often not be picked up at the selection stage but may rapidly become apparent in early performance at work. This is particularly relevant where frontal lobe injuries are associated with executive process malfunctions. Such individuals may offer appear to have typical cognitive processes but face substantial problems when given responsibility to organize and implement work tasks. Such people will often need IST systems which provide organisation and structure to their day, by prompting, provision of information etc. I have also had experience of individuals with head injury or medicated schizophrenia who started a new job well but who froze when confronted with apparently conflicting work requirements.

"What are the cognitive impairments that can cause functional limitations in the workplace specifically with relation to interaction with information technology systems?"

As discussed above, we believe that there are at least nine components of human cognition that can cause functional limitations in the workplace specifically with relation to interaction with information technology systems. They are:

- Input / perceptual processes
- Working memory processes
- Long term memory processes
- Output / response processes
- Executive processes.
- Feedback processing
- Cognitive models
- Emotions and motivation
- Complex response processes

It is vital to diagnose which of the above apply to a given individual. This simple cognitive architecture also has a message for the IST solutions developer, namely that there are at least nine types of technological solution to be develop for the inclusive society to be a reality.

"What are the specific causes or conditions that lead to difficulties in long-term employment and "ageing in place"?"

We all change over our life-spans. Here the perspective or evolutionary psychology is insightful i.e. what skills do we need to survive and how do our requirements change with age? In initially, we tend to be focused on the outside world, with relatively fast reflexes but relatively low background knowledge. As we mature, we gain more and more knowledge which builds up over time. Our survival depends less and less on responding quickly unusual events or threats in the environment and more and more on using our past knowledge and experience to solve the problems and challenges of life. Whilst, in principle, any of the nine cognitive functions can show decline, in practice we can categorize them as (a) executive functions and (b) non-executive functions. Individuals in category (a) need support with self-organization and maintaining structure in their lifestyles. Such difficulties may not be apparent in a standard psychometric assessment, since basic skills like, for example, working memory, can remain unimpaired. They will need IST solutions which support self-organization and maintaining structure. There is always the risk, however, that they will decline to use their cognitive skills appropriately unless monitored. Conversely, individuals in category (b) will have good organizational, task learning and structuring skills. In many cases, where they face a decline in specific cognitive skills e.g. acquisition of new knowledge, they may be able to fall back on effective strategies like making analogies with prior knowledge and tasks. Executive functions are, however, limited in their capacity to compensate for cognitive deficits. Once such individuals are comfortable to accept their skills deficits, then they can be given IST to support those functions that need it. Perhaps in the future, better methods and better ways of restoring such deficits will be found.

“What types of assistance are available today and what types of workplace issues do they address? Why these difficulties and not others?”

Looking at IST, there are, of course three types of solution for eAccessibility for eInclusion, namely

- assistive technology which augments mainstream technology;
- accessible systems which follow Design for All principles to make systems accessible for all; and,
- universal access which takes DfA and adds adaptability and adaptivity.

It is noticeable that for systems which support performance rather than learning, the majority of solutions are still aimed at input (senses and perception) and output (psychomotor and verbal responses).

- It is now recognized by the European Union’s Framework Program Six that cognitive disabilities and cognitive technology constitute the one area where much could be done to improve eAccessibility.
- **Cognitive impairments are the least well known, the most complex to understand and the most difficult to resource**
- One promising approach to cognitive deficits is through “Universal Access to ubiquitous computing and Ambient Intelligence” (Stephanidis, 2005).
- A second, related approach is based upon the development of cognitive user models as bases for understanding user requirements and where accessible solutions can be found.

Examples of solutions

Example One: Education / processes

Beekman (2005) gives the example of a very able student (Patricia Walsh) who lost her sight when 14 years of age. She had learned Braille but needed a way of depicting equations for her studies. Fortunately, John Gardner, a blind physics Professor at Oregon State University was developing maths and science tools for people with visual impairments. Patricia now uses his Tiger Tactile Graphics and Braille Embosser. She can now print equations, graphs and emails as raised patterns, so she can now read her class notes again. Incidentally, she is now a computer science major at OSU.

References

1. Beekman, G. (2005). Computer confluence. Upper Saddle River NJ: Pearson Education International.

2. Stephanidis, C. (2005). Personal communication by email.

3. Sternberg, R. J. and Bur-Zeev, T. (2001). Complex cognition: the psychology of human thought. Oxford. OUP.

APPENDIX

Example Two: Employment / executive functions

In the increasingly complex world of work, and for working conditions that are downright dangerous, virtual reality offers the prospect of a dry run of complex scenarios to facilitate planning and preparation. This approach can be particularly helpful for the stroke victim who has frontal lobe damage and perhaps also has sustained physical deficits. They are enabled to go through potential scenarios over and over until they are well planned and prepared.

Example Three: Education / executive processes

Inspiration is a software tool that facilitates the organisation of concepts to support the clarification of thinking and long term planning. Concepts are represented by a range of visual techniques to portray ideas visually and make them accessible to critical inspection and reorganization.

Example Four: Employment / working memory

NeuroPage is a telephone pager system which alerts the user by an auditory signal or vibration when a scheduled message is received. This device is increasingly used to circumvent prospective working memory errors and so support users with memory problems to live a normal life as far as possible (Inglis, E., Szymkowiak, A., Gregor, P., Newell, A.F., Hine, N., Wilson, B.A. and Evans, J., 2002).

Example of Inclusion

It may have once been true that every one who uses a computer is a nerd or a hacker, but that is not now correct. In the past, people without the traditional IST skills or resources were excluded. Beekman (2005) reports the case of Vaughn Rogers who was into art rather than programming. Rogers discovered the Computer Clubhouse in Cambridge Massachusetts where he learned to use computers to create his art. Now he has crossed the digital divide of eExclusion and is studying visual communication and animation at College. At the same time he is now assistant manager at the Computer Clubhouse, enabling others with creative skills to deploy computers in their work.