Setting an Agenda for Research on Ageing

Peter G Higgins
Faculty of Engineering and Industrial Sciences
Swinburne University of Technology
Hawthorn 3122, Australia
+61 3 9214 8029
phiggins@swin.edu.au

ABSTRACT
Physical and cognitive aspects of ageing affect people's interaction with the environment.

Categories and Subject Descriptors
H.1.2 [**User/Machine Systems**]: Human factors. H.5.2 [**Information Interfaces and Presentation (e.g., HCI)**]: User Interfaces – *Ergonomics*, *User-centred design.* K.4.2 [**Social Issues**]: Assistive technologies for persons with disabilities

General Terms
Design, Human Factors

Keywords
Older people, cognitive work analysis.

1. INTRODUCTION
Most engineering products are designed for an 'able' body. However, the ability of the body changes with age. Sometimes the senses fade and/or the brain looses short term memory, affecting the perception of the surroundings and the person's ability to interact efficiently with day-to-day products. The schematic in Figure 1 explains this process. The quality of life deteriorates and in many cases the person requires care. The rapid deterioration in later years of life means that this problem is becoming increasingly acute.

Consequently, Swinburne University of Technology is developing a centre for research into ageing with a focus on older people relationships to products they use. As well as the physical aspects of usage, consideration will on how products develop and reinforce in aged users appropriate mental models of how "things work." That is, the study of how physical affordances and cues within a design affects people's conceptions of the design and thus its usage. What visual cues should a product propagate for users to perceive its range of functions and hence whether people can work out how to use it easily?

An objective of the proposed centre is the development of analytical tools that represent the physical and cognitive aspects in the usage of products may bolster the design of intelligent products suitable for persons with 'less-able' bodies.

2. PHYSICAL AND COGNITIVE FACTORS
One aim of our research is to reveal the internal (i.e., biological and physiological) and environmental information used by humans to carry out complex or time-critical activities. In particular, research on human timing has shown that people possess temporal acuity substantially greater than long-assumed experimental limits. Significant advances in this area require extremely precise control over experimental stimuli and the ability to record a wide variety of response variables with high levels of accuracy. Through simulation, new forms of interaction between human and machine can be investigated, and hence the forms that best help people integrate this information can be chosen. An example comes from research by the author on drive-by-wire cars, in which conventional linkages between controls — steering wheel, brake and accelerator pedals — and actuators are replaced by digital electronics. This decoupling allows the exploration of human responses to various forms of feedback: for example, instead of the force at the brake pedal reflecting the force on the brake discs, it can correspond to the dissipation of a car's kinetic energy instead of the force exerted on brake discs. What is the efficacy of these forms of feedback? Does age affect performance?

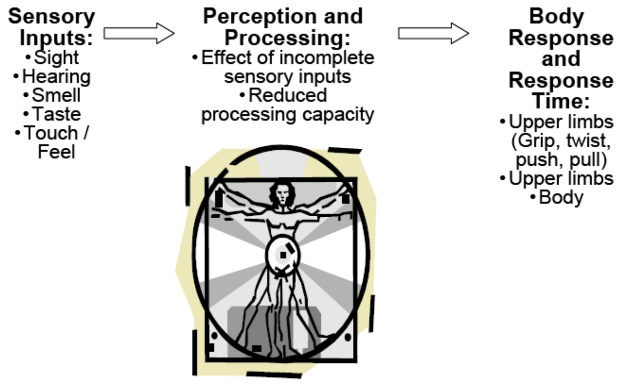

Figure 1. Human physical and cognitive processing system

3. Feedback in Machine Control
The physical and cognitive functions of persons change as they age. Changes in behaviour may clearly affect performance in situations where persons interact with physical objects such that they close the loop of an otherwise open-loop system. For example, automotive control has many forms of human response to various forms of feedback. A particularly important feedback is the force on displacing a brake pedal (i.e., the feeling of effort when you push the brake, which usually occurs because of a direct mechanical linkage). Thus, there is an interaction between the physical properties of the machine and

humans, as well as an interaction between the mental processes of humans and machines, and this process is very important for driving. To examine such an effect, it is necessary to consider psychological research on human coordination, cooperation and interaction with machines. System control is also affected by behaviour. Crossing intersections, older drivers tend to cross towards the centre of the road due to the higher level of defensive behaviour among older than younger drivers [4].

There is a link between cognitive performance and the physiology of visual information processing [5]. Impairments in receptor-effector organs affect cognitive functioning, particularly attention [1]. As vision decreases with age so does cognitive performance, irrespective of age-related cognitive decrement. A decline in physiological performance exacerbates the effects of aging on cognitive functioning. The combination of deterioration in perceptual, cognitive, and motor functions affects task performance. Brouwer elucidated this using an example of older drivers merging with motorway traffic [1]. Judging speed and distance are perceptual processes. The ability to look over the shoulder for oncoming traffic concerns motor control. Restrained by neck movement, older drivers are more reliant on rear-vision mirrors. However, capability to mentally rearrange and rotate objects spatially in the visuospatial sketchpad of working memory also reduces with age. This affects their perception and interpretation of mirrored scenes [5]. Deciding when and how to merge is a cognitive function, which depends on attention and performance of working memory.

4. Cognitive Work Analysis

Analysis of the cognitive behaviour of users will be instrumental in laying the groundwork for better and more appropriate products and aids for older people. Cognitive Work Analysis (CWA) provides a means for representing the *cognitive* and *environmental factors* found through a combination of ethnographic research and laboratory testing. The perceptual, cognitive, and ergonomic attributes of persons performing tasks within a specific environment are analysed using a framework that integrates physical and cognitive elements [2]). CWA provides a framework for generating descriptions of system purpose and form, explanations of system functioning and observed system states, and predictions of future system states.

There are two separate types of analysis in the standard form of CWA: Work Domain Analysis (WDA) and Cognitive Task Analysis (CTA). WDA describes a system of resources in a way that distinguishes its purposive and physical aspects; its concern is "what" is being acted upon. WDA describes the operational constraints of the physical system and is independent of any specified events. WDA represents the constraints imposed on persons by the devices they use, such as decision tools and communication systems. CTA is the component of CWA that represents the events associated with decision-making. It charts the decision-making activities leading from specified inputs (e.g., information) to specified outputs (e.g., an action) [8]. It describes the activity itself, which must be within the bounds of the physical system. It is an event-*dependent* analysis that shows how activities are directed towards specific goals. These control activities correspond to "how" relationships.

Salmon et al. discussed the use of WDA for analysing the problem-solving trajectories by novice, expert and elderly drivers [7]. Their recognition that different drivers may adopt different trajectories raised implications regarding the design of technology and artefacts to support different approaches and mental models of task. That is, CTA for different classes of persons differ. Consideration of the links between the WDA of a device and the difference in CTAs for the dominant user populations and a population of older users may be useful. In their discussion, Salmon et al. saw the potential of applying CWA to explain the differences in behaviour of different driver groups (e.g. elderly, young, expert drivers). A coherent theoretical and methodological approach for WDA for analysing competing designs has been developed by Naikar, Hopcroft and Moylan [6]. Their success in applying CTA to restricted class of users has lead to them to work on advancing a coherent approach.

Higgins extended CWA to include a goal structure to represent multiple goals of complex decision environments [3]. The aim now is to include in CWA a means for representing the cognitive and physical constraints as experienced by older persons in links between CTA and WDA.

5. ACKNOWLEDGMENTS

I wish to acknowledge the work of Prof Ajay Kapoor and Dr Soullis Tavrou, in establishing research on ageing.

6. REFERENCES

[1] Brouwer, W. H. Older drivers and attentional demands: consequences for human factors research. In K. Brookhuis, C. Weikert, J. Moraal, D. de Waard, *Proceedings of the Human Factors and Ergonomics Society-Europe* Chapter on Aging and Human Factors, Soesterberg, Netherlands, 1993, 93-106

[2] Fidel, R ,and Pejtersen, A. M. Cognitive Work Analysis. In K.E. Fisher, S. Erdelez, & E. F. McKechnie (Eds.). *Theories of information behavior: A researcher's guide*. Information Today, Medford, NJ., 2005, 88-93.

[3] Higgins, P. G. Architecture and Interface Aspects of Scheduling Decision Support. In B. MacCarthy and John Wilson (Eds.) *Human Performance in Planning and Scheduling*. Taylor and Francis, 2001, 245-281.

[4] Kloeppel, E., Peters, R. D., James, C., Fox, J. E. and Alicandri, E. *Comparison of Older and Younger Driver Response to Emergency Driving Events*. FHWA-RD-95-056, Office of Safety and Traffic Operation Research & Development, Federal Highway Administration, 1995.

[5] Mouloua, M., Smither, J., Hancock, P.A., Duley, J., Adams, R., and Latorella, K. Aging and driving I: Implications of perceptual and physical changes. In: D.A. Vincenzi., M. Mouloua., and P.A. Hancock, (Eds.) (2004). *Human performance, situation awareness and automation: Current research and trends*. Erlbaum: Mahwah, NJ. 2004, 315-319.

[6] Naikar, N., Hopcroft, R., and Moylan, A. Work Domain Analysis: Theoretical Concepts and Methodology. DSTO-TR-1665, Air Operations Division, DSTO Australia, 2005

[7] Salmon, P., Stephan, K., Lenné, M., and Regan, M.. Cognitive work analysis and road safety: potential applications in road. Australasian road safety research, policing, education conference, 14-16 November 2005, Wellington, New Zealand.

[8] Vicente, K. J. *Cognitive Work Analysis: Towards Safe, Productive, and Healthy Computer-based Work*. Hillsdale, NJ: Lawrence Erlbaum Associates, 1999