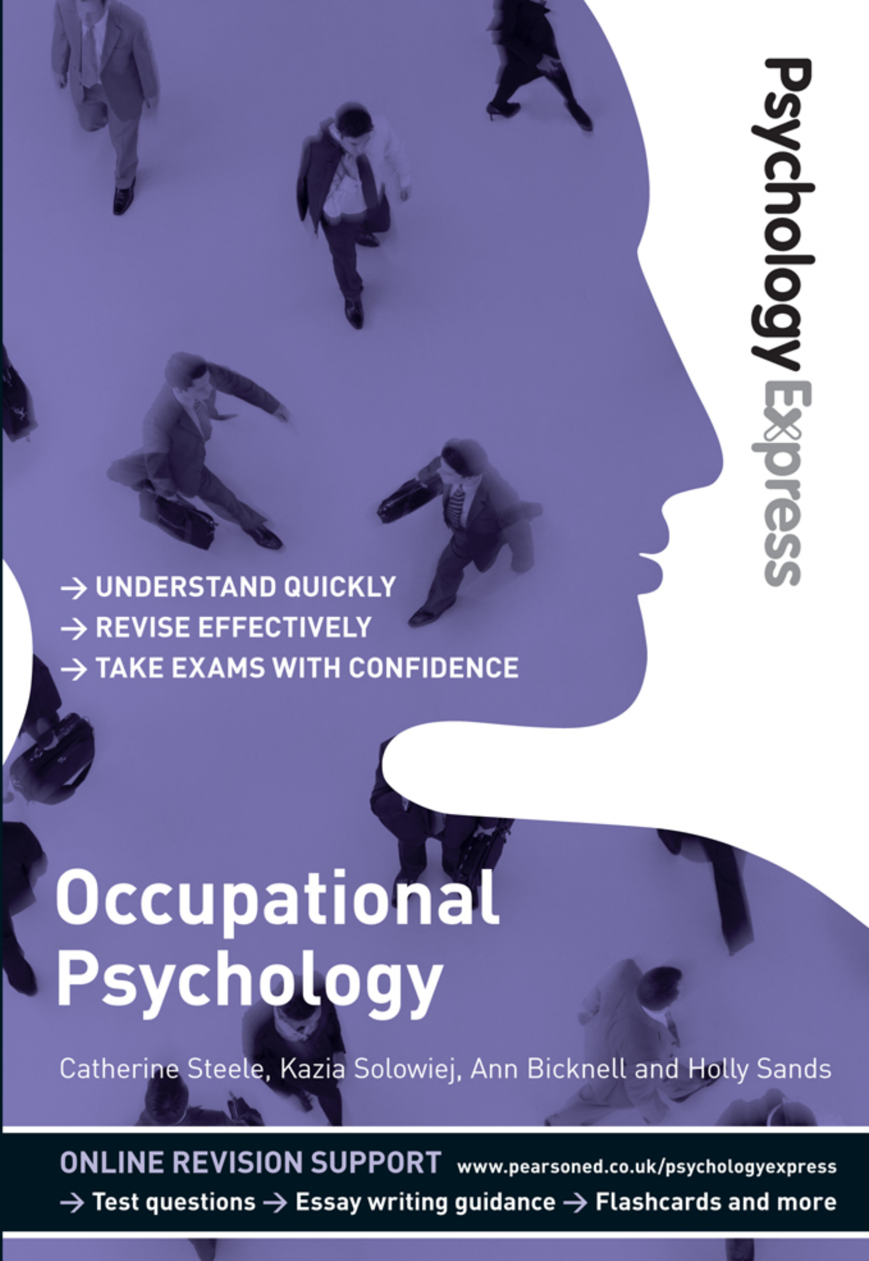

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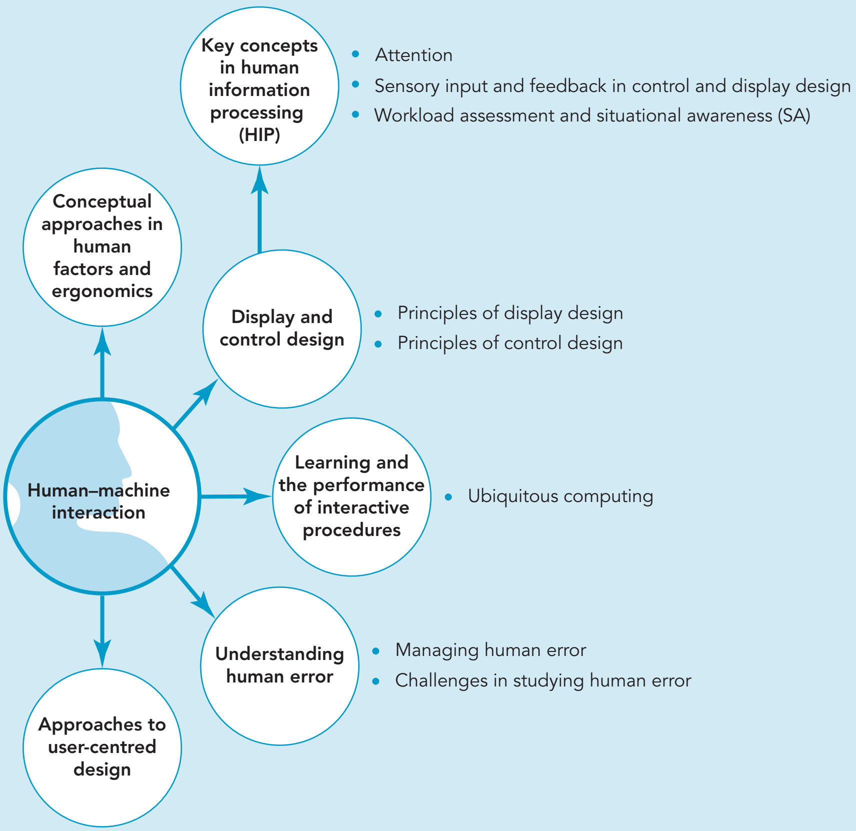
Human–machine interaction



A printable version of this topic map is available from **www.pearsoned.co.uk/psychologyexpress**

Introduction

'Human factors' and 'ergonomics' are terms used often interchangeably, as indicated in the title of the United Kingdom's governing body: the Institute of Ergonomics and Human Factors (IEHF). The practitioner may be an ergonomist, a psychologist or in a related field (physiotherapist, occupational safety representative and so on). What is important is the application of transparent methodologies, such as task analysis and human error analysis, by which human performance data are gathered and interpreted against standards and guidance from an experimental evidence base. This is the case for human–machine interaction (HMI) and facilitates the identification of performance problems and sources of error, and the recommendation of 'usability' improvements towards the optimal human–machine interaction.

Revision checklist

Essential points you should know by the end of this chapter are:

- ❑ The concepts of human factors and ergonomics
- ❑ The issues in display and control design that contribute to human performance
- ❑ How to describe learning in the context of performance of interactive procedures
- ❑ The main approaches to understanding human error in HMI
- ❑ Demonstrating an awareness of approaches to user-centred design

Assessment advice

Assessment questions on this topic are likely to take the form of either an essay-based question or a problem-based learning task. Whichever form of assessment you complete on this topic, it is important to remember that there are many factors that influence human–machine interaction (HMI) beyond those covered in this chapter. Good answers to either type of question will draw upon issues covered in other chapters in this revision guide.

Typical *essay questions* on this topic will require you to be evidence-based in your answers, by considering theoretical, research and practical issues surrounding this topic. You will need to think about how theories of HMI can be applied at the design stage to improve the experience of the user-operator. For example, you may be asked to critically evaluate how theories of human information processing have been applied in the workplace to improve control and display efficiency and operator productivity, or how effective systems can be designed to reduce the potential for human error.

Problem-based questions in occupational psychology often take the form of a case study that requires you to apply your understanding and creativity based on the topics covered in this chapter. You will need to think critically about how to address issues including problems in HMI and principles by which to do this, in order to make recommendations for improving the utility of the human–machine interface and business productivity.

Sample question

Could you answer this question? Below is a typical problem question that could arise on this topic.

> ✱ *Sample question* — *Problem-based learning*
>
> You have been asked to consider the factors that led to a breakdown in production at a Chinese automotive manufacturing plant which has recently adopted new technology and machines from the United Kingdom. This was the result of a technology transfer agreement with a major UK manufacturing company seeking to enter new markets and become a global producer of vehicles that are too expensive to build and export from the United Kingdom.
>
> As a result of the breakdown in production, the company has temporarily suspended the local management pending review of operating procedures and staff training. An emergency team of UK plant managers and human factors professionals has been flown out to assess the situation. Early reports have indicated that a number of local employees have expressed their anger and dissatisfaction as a result of unfamiliarity with new machine technology and an increased workload. Newly appointed local managers are also concerned that their teams appear unhappy and fear that quality of outputs and wages will drop.
>
> Outline the possible approaches you would take to understand the reasons for the breakdown in production at the Chinese automotive manufacturing plant since the new machines arrived. Provide a transparent justification for your recommendations to resolve potential issues.

Guidelines on answering this question are included at the end of this chapter, whilst guidance on tackling other exam questions can be found on the companion website at **www.pearsoned.co.uk/psychologyexpress**

Conceptual approaches in human factors and ergonomics

Differences in use of ergonomics/human factors (EHF) terminology continue to reflect the training of the practitioner as well as the overall roots of the discipline in engineering and industrial psychology. Its heritage is a domain born of the Second World War (Wickens, 1992). At this time the focus was on a contingency approach (specifying, measuring and standardising detailed components such as displays and control design) to produce performance criteria from which learning and training content could be specified for the operation of, for example, machinery, artillery or aircraft. This was about fitting the human to the task.

Today, the concern is equally with how the task is designed to fit the human and how the human psychologically constructs their task. This reflects a shift to include both a contingency and a constructivist approach to understanding how technology transforms the way work is done (Sonnentag, 2000; Symon, 2000) and includes the psychological and cultural factors that effect optimum performance in the workplace. The task then becomes an output of a broader system of interacting factors and decisions as to the allocation of functions between the machine or the human, based on optimal use of each (Jewell, 1998; Oborne, 1992). This is of great importance to the ultimate productivity and safe operation of a 'system of systems', such as a manufacturing plant or nuclear power station.

EHF professionals follow the bio-psycho-social approach (Quick et al., 1997) to understanding human behaviour. In the case of HMI this acknowledges that interfaces should be designed with these elements in mind to facilitate optimum task performance, to direct attention appropriately for system maintenance and in particular to respond to system problems (e.g. correctly interpreting warnings, signs or alarms to alert the human operator to imminent component or system failure). It is not overly inclusive to say this is of critical importance, as human error from poorly designed interfaces has been identified as a significant contributory cause of both minor and major industrial incidents, such as the Three Mile Island nuclear power plant disaster in 1977. The investigating body at that time concluded that, whilst human error was causal, fault could not be attributed to the humans involved, precisely because of the misleading and overwhelming task environment that the displays, controls and warning signs produced.

In any environment where the costs of user-centred design are constantly being debated against lost productivity, increased time to market or longer production cycles, there will be a tension between what can be done and what should be done (Harris & Harris, 2004). In an HMI context, these interactions are ably represented by the 'five Ms model' (Harris & Harris, 2004) which reflects the contemporary systems-based approach taught in EHF courses as a sociotechnical system which is simply the interactions between the physical, psychological and social aspects of the work environment and how they support or inhibit optimum performance. The five Ms are therefore: (hu)Man, Machine, Mission (task or goal), Management (supervision and established procedures) and Medium (separated into capacities of the end user as the physical medium and the individual expectations and assumptions from the cultural norms as the societal medium).

CRITICAL FOCUS

The application of EHF in practice

The very existence of EHF as a discipline acknowledges that the engineers and designers can 'get it wrong' or overlook the human involved in the safe and efficient operation of tasks such as the design and build stages of, for example, a machine or control room. They may not be involved at the design stage and so arrive later, to compensate for these oversights. Worse still, they may arrive after personal injury or some form of harm has occurred. In this context, it is not surprising that the presence of an EHF professional may provoke conflict as well as clarity.

As with so many things in life, EHF issue prevention is better than cure. A current hot topic in the discipline is to develop cost models and communicate the increasing evidence base as to the financial benefits and through-life cost savings that can accrue from EHF interventions in the process of human systems integration. In the editorial of a journal special issue on this topic, Stanton (2003) concluded that there was sufficient evidence available to present such business cases and that EHF interventions typically delivered returns on their investment in periods of less than one year, citing problems with transferable, usable methodologies as the main reason why this was not widely done. It is likely, however, that the current economic climate will demand it.

Display and control design

Both display and control design are large research and practice areas. This chapter necessarily contains an overview of the important contribution that an awareness of issues in control and display design makes within the field of EHF, such that a human-centred design (HCD) process is possible. HCD facilitates human systems integration: that is, integration such that poor design (e.g. ambiguous display notation or symbols) is avoided and total system performance is enhanced. An EHF professional may choose to specialise in, for example, cockpit design and layout for military fast jets, the design of a hydroelectric dam control room layout, or the design of the dashboard inside a standard road car. This section will provide an overview of some of the main design principles and associated challenges. Returning to the bio-psycho-social approach then, it is necessary to be aware of the boundaries within which designers of display and control systems are free to vary. These include the limitations of human cognition, which are central to human information-processing (HIP) approaches to display and control design.

Key concepts in human information processing

Attention

As impressive as the human brain is, it has limited capacities of attention, perception, memory, thinking and decision making. These abilities shift according to physiological states (e.g. arousal and wakefulness) as well as in response to environmental conditions (e.g. changes in temperature, lighting, noise or vibration or the sudden presence of novelty or hazard). The classic study by the cognitive psychologist George Miller in 1956 suggested that most humans have a working memory capacity for seven discrete units of information to be processed at any one time (±2 to cover individual differences).

A number of different theories exist for how this limited resource is meted out. For HMI purposes, malleable or multiple resource theory (Wickens, 1992) holds merit in application to EHF issues. This proposes that attention is a more dynamic resource than Miller would have suggested and that, by making judicious decisions between the use of different sensory modalities (e.g. vision, audition, smell, touch and taste), it is possible to move attention around to where it is most needed: for example, an audible rear parking sensor is processed faster and more effectively than the feedback from a rear-view mirror in the context of two or more tasks being undertaken simultaneously, as it enters awareness through a different sensory modality. This demonstrates the benefit of theory to EHF professionals. Theory makes predictions which can then be tested through controlled research design such as experiment, and can generate data to create an evidence base for safer human systems.

Sensory input and feedback in control and display design

The visual and auditory senses tend to dominate in the presentation of information for displays and warnings respectively, with the addition of kinaesthetics, the sense of movement (mechanoreception – awareness of pressure and distortion) and equilibrioception (the sense of balance, linked to proprioreception, the sense of the relative position of parts of the body) to provide feedback in the signalling of alterations having been made in controls.

Workload assessment and situational awareness (SA)

In HMI terms, this can be seen as optimising human performance through balancing the demands or mental 'workload' required by the task. However, too light a workload has been found to be unsafe or error-prone in maintaining situation awareness (SA) or the dynamic nature of past, current and predictive future awareness of a task (Endsley, 2000). In conditions of under-load and/or high automation, but which still require a human to be in the 'cognitive loop' (e.g. in a supervisory role), the risks are boredom or 'labile' mental functioning from an essentially passive state.

There are a number of approaches to workload measurement and SA, characterised as physiological, behavioural, subjective and analytical. Each of these has associated advantages and disadvantages as indicated in Table 5.1. There are always trade-offs to be made in measurement scenarios and careful consideration must be given to real-time metrics, which are preferred for their validity, but incur additional safety risks: for example, a secondary peripheral