Editorial

Team work: A problem for ergonomics?

In his editorial for the first issue of this journal, Alan Welford (1957:1) defined the core disciplines of ergonomics as `the biological sciences, especially anatomy, physiology, and experimental psychology'. Social psychology and sociology, if not explicitly ruled out, were generally thought of as comprising a separate discipline addressing a distinct set of problems, even those that are undeniably related to `the customs, habits or laws of work' (Welford 1957).Throughout much of the intervening four decades papers appearing in this journal have been primarily concerned with physical and psychological assets and limitations of the individual `human operator'.

Early text books in ergonomics rarely mentioned social factors. For example, the classic human factors handbook by Morgan et al. (1962: 321 - 362) has only one chapter on `the arrangement of groups of men and machines' and this is concerned largely with the layout of spaces used by more than one individual so as to minimize mutual interference and to facilitate communication and supervision. Even the chapter on communication is concerned principally with acoustic problems of different media and environments and not at all with the flow of information and ideas now regarded as essential to effective team work.

Organizational psychologists and industrial sociologists have, by contrast, been concerned with the functionality of working groups and have built up a considerable body of specialist knowledge on problems such as team motivation and social facilitation, and the effects of group norms and conformity on productivity and decision-making. These are relevant to many broad issues concerning effective management structures and industrial democracy. Whereas ergonomics has drawn heavily on psychophysics and cognitive psychology for both methods and concepts, organizational psychology has been more strongly influenced by theories of group dynamics, but as Sanders (1986) notes, the two superficially diverse traditions are by no means unrelated.

This special issue on Team Work has been put together in recognition of the fact that work systems are often based on teams of people and that the design of successful industrial and military systems must take into account the ways in which working groups and teams function. Teams, especially those operating in a highly technological environment, can sometimes fail disastrously and this fact has been the trigger for extensive research, some of it reviewed in this special issue.

The word `team' derives from the old English, Fresian and Norse word for a bridle and thence to a set of draught animals harnessed together and, by analogy, to a number of persons involved in a joint action. A set of definitions of related words is given in appendix 1. A group is `a number of persons or things in a certain relation or having a certain degree of similarity'. A team is a group, but not all groups are teams. The key distinction lies in whether or not the members share a common goal, which they pursue collaboratively. Members of a group may share a number of common features but do not necessarily share a common goal and may well be in competition with each other. A work team, on the other hand, not only collaborates but can succeed or fail as a whole and the members of the team share the benefits and costs of success or failure. Some problems with large interdisciplinary or inter-organizational teams undoubtedly relate to the question of shared goals. Modern information technology has favoured the development of teams comprising more or less specialized individuals contributing to a complex outcome and the central puzzle of team work is that the outcome is rarely, if ever, predictable from the sum of these individual contributions. Some of the emerging research themes that are of particular interest to ergonomists comprise analysing team tasks and measuring team performance, assessing the effects of team structure and roles, and evaluating workplace design and team workload.

Describing and analysing team tasks and measuring team performance are basic to any research programme. Early studies of team work, for example the layout of the combat information centre of the USS Louisville (Chapanis 1959) recorded the communication links between team members, but link analysis alone tells us little of the detailed nature of the team task. Most forms of task analysis aim to characterize the tasks of individuals but, with some modification, similar principles can be applied to the analysis of team tasks. A team task analysis has to illuminate what the team members have to do jointly to meet their common goals.

Performance measurement may focus on either team accomplishment, referred to as product, or the manner in which the team behaves, known as process. Among the most important questions that can be asked is how process relates to product in the accomplishment of team tasks. In the cognitive sphere communication between team members and the co-ordination of individual activities are generally regarded as crucial processes, or team skills, while in the affective sphere team spirit or cohesion may impact team performance indirectly through group processes such as social facilitation and group conformity. Distinguishing between and measuring these processes is fundamental to understanding team work but the techniques currently in use remain rather primitive, often depending on the use of questionnaires and observer opinion. Direct observation of large and busy teams, although possible with the use of video recording, is in practice both difficult and time consuming.

Team processes are affected by team structure and role differentiation and these are determined, in part, by the nature of the team task, such as the requirement for specialized knowledge and skills, and in part by organizational considerations, especially questions of leadership and responsibility. Team training comprises a major tool of intervention and provides an important focus of practice and research. Some major issues that remain to be resolved include the relative importance of individual and team skills in team productivity and the question of whether there are generic or transferable team skills that can be taught out of context, for example in special team building exercise. Some teams appear to be more adaptive to adverse working environments than others and may perhaps have learned some kind of generic team skill over and above their individual skills.

Extraneous to these intrinsic characteristics but of considerable importance to team success and failure are the effects of workplace design and team workload. The effects of stressors, including both workload and danger, on team processes and product has inspired a substantial research effort (see Paris et al., this issue, and Cannon-Bowers and Salas 1998). The use of technological aids, especially computer-mediated communication and decision support systems, often introduced in an attempt to reduce workload and to facilitate key team processes such as communication and situation awareness, provide another significant focus for recent research.

Table 1 shows that a variety of research approaches are represented in this special issue, ranging from experimental studies conducted in the laboratory and the field to individual case studies of particular domains, and reviews of the literature. This range of approaches is indicative of the diversity of research methodologies in ergonomics. Application domains covered by the contributors include the main areas where effective team work is critical to success, such as command and control (including the military and emergency services) and process control, as well as more conventional work settings. Most of these themes are of common interest to the various work disciplines including organizational psychology and management science, but some have special relevance to human factors and ergonomics and are amenable to investigation by the methods of this discipline.

The team issues addressed by the contributors include stress, decision-making, mental models, workload, situational awareness, morale, cohesion, performance measurement, communication and team skills. The research reported has important implications for the way in which teams are designed, team training strategies, interface design, and for methodological aspects of team work research and development.

The paper by Paris et al. provides an excellent overview from which to consider the main issues. It is an authoritative review of the state-of-the-art, including the US Navy sponsored Team Decision Making Under Stress (TADMUS) programme. Assessing team requirements and the subsequent measurement of performance has to be one of the core themes to have dominated the past three decades of research. The paper by Annett et al. provides a set of procedures that draws these two particular themes together in an integrated methodology and applies it to a military command and control domain. Together the task analysis and team performance measurement methods (HTA (T) and TARGET, respectively) provide a solution to closing the loop between skills assessment and performance evaluation.

Team work in military domains places particularly high demands on people, owing to factors associated with hostile environments, high temporal demand, and threat of injury (McCann; Annett et al.; Artman; Paris et al.). The ways in which the team make, or fail to make, effective decisions, is one of the central topics to be considered. Jones and Roelofsama propose that the belief that shared mental models can always improve decision-making is misplaced; pathological biases in decision-making may result from incorrect shared models, or false consensus effect (FCE) by bolstering misplaced confidence. Their paper reviews processes that can affect decisions by team members as much as members of any other group, including the `false consensus effect', `groupthink', `group polarization' and `group escalation of commitment'. FCE clearly indicates the importance of `situation

Table 1. Thematic analysis of contributions to the special issue.

	Paris et al.	Annett et al.	McCann et al.	Artman	Jones & Roelofsama	Smith & Dowell	Rasker et al.	Stanton & Ashleigh	Sebok	Carletta et al.	Postmes & Lea
Research Style											
Review	•										•
Case Study						•		•		•	
Field Study		•		•				•		•	
Experiment			•				•	•	•		
Task type											
Process control								•	•		
Command & control	•	•	•	•	•	•	•				
Planning & Design										•	•
Research issues											
Performance measurement		•			•					•	
Communication		•		•		•	•	•		•	•
Situation awareness	•			•			•	•			
Mental models	•		•		•	•		•			
Decision Making		•		•	•	•	•	•		•	•
Workload								•			
Stress		•	•	•	•						
Design											
Team structure	•				•	•		•		•	
Training		•	•								
Interface					•	•	•	•		•	•

awareness' in ensuring that all team members have access to all the information necessary for their participation in making decisions with, or on behalf of, the team. In `groupthink' the need for consensus dominates and in `polarization' the consensus effect can be either towards risky or cautious decision-making. Although some potentially useful interim conclusions can be drawn, remarkably little research on these topics has been directed towards influences on the decision-making behaviour of teams, such as command and control teams.

Smith and Dowell show that poorly shared models can lead to conflict in inter-agency co-ordination in dealing with disaster scenarios. Inter-agency teams may be particularly prone to this difficulty and it may well be that the problems exhibited by these emergency teams may also be relevant to composite design teams, for example the team designing the new Swanwick National Air Traffic Control system or the interface between different components of the privatized British railway system.

Other researchers have suggested ways for improving shared mental models, such as by improving feedback (Rasker et al.), the design of team structure (Stanton and Ashleigh), and presenting information serially without time stress (Artman). Sebock's paper illustrates an alternative approach to enhancing situation awareness and shared mental models, by using a large common display screen visible by all team members. The new advanced interface was found to support better team interaction and to improve performance, especially in smaller teams, but in this instance it could conceal significant detail and may even increase workload.

Rasker et al. show that intra-team feedback plays an important role in developing and maintaining shared mental models and situational awareness. This can be improved through informal communications channels and enabling free communication throughout the duration of the task. Stanton and Ashleigh show that a flatter team structure also enables better sharing of information when compared to a more hierarchical structure, and this seems to foster a greater feeling of a collaborative endeavour. Presenting information to individual team members in series can lead to improved communications and sharing of information and higher levels of situational awareness (Artman). It also leads to higher levels of reliability than parallel information presentation, but again it has a time cost and is best suited to lower workload situations.

Team training strategies also seem to have an effect on the degree to which shared mental models assist team performance. McCann et al. report that when team members are cross-trained in each other's tasks they perform better under circumstances of dynamic team reconfiguration. This may also help to develop alternative perspectives and to assist in building a common frame of reference when working with other team members. However, cross-training exacts a cost in team performance that was not recovered within the context of the relatively short training period.

Technology may assist team performance, particularly where geographical factors make face-to-face meetings difficult. Carletta et al. argue that, despite the temptation to seek the most technically advanced solution, modest desktop technology will probably suffice for most of the time. Some problems of `virtual' team meetings to be resolved include practical issues such as turn taking in verbal exchanges and more intangible problems such as the effects of `social presence'. Carletta et al. show that `virtual' team meetings affect the group dynamics and the manner in which meetings are conducted. Postmes and Lea argue that anonymity of team members may improve decision-making by reducing the pressure to conform, but there are concerns about accountability and the negative effects of depersonalization. Research evidence to date shows that anonymity leads to more contributions from team members, but this in itself does not guarantee improved performance. There may be some circumstances where virtual teams are best made aware of the identity of other contributors, for example where commitment is especially important, but others where anonymity may be preferable, for example when making apparently divergent suggestions may be helpful in avoiding `groupthink'.

This collection of papers provides a snapshot of a currently developing field without pretending to be a comprehensive overview. While some of the major research themes are exemplified it is clear that many of the key issues remain unresolved. These issues often call for the use of advanced research methods to overcome the difficulty of recording and measuring the processes by which teams achieve or fail to achieve their goals. Team work research also calls for a careful balance between case and field studies on the one hand and controlled experiment on the other. Case and field studies are often limited by the number of teams available for study with consequent limitations on the statistical analyses that can be used. Laboratory teams are typically much smaller than `real' teams but, what is more important, real teams may display emergent qualities only after days or months of working together. For these reasons progress may seem to be slow. The editors hope that this special issue may at least serve to enhance the visibility of this increasingly important area of ergonomics research and serve to stimulate further scientific endeavour in this field.

References

ARGYLE, M. 1974, The Social Psychology of Work (Harmondsworth: Pelican).

BOGUSLAW, R. and PORTER, E.H.1962, Team functions and training, in R. M. Gagně (ed.), *Psychological Principles in System Development* (New York: Holt, Reinhart & Winston).

CANNON-BOWERS, J. A and SALAS, E. 1998, *Making Decisions Under Stress: Implications for Individual and Team Training* (Washington,DC: American Psychological Association).

CHAPANIS, A. 1959, *Research Techniques in Human Engineering* (Baltimore: The Johns Hopkins Press).

MORGAN, C. T., CHAPANIS, A., COOK, J. S. and LUND, M. W. 1962, Human Engineering Guide to Equipment Design (New York: McGraw Hill).

REBER, A. S. 1985, *Dictionary of Psychology* (Harmondsworth: Penguin Books).

SANDERS, A. F.1986, Contexts and conflicts between ergonomics and industrial psychology, in G. Debus and H.-W. Schroiff (eds), *The Psychology of Work and Organisation* (Amsterdam: Elsevier Science), 7-13.

The Shorter Oxford English Dictionary 1972, 3rd ed. (Oxford: Clarendon Press).

WELFORD, A. T. 1957, Editorial, *Ergonomics*, 1(1), 1-3.

JOHN ANNETT
University of Warwick, UK
NEVILLE A. STANTON
Brunel University, UK

Appendix 1 Teams and groups - some definitions and etymological sources

Team

'1. A set of draught animals; two or more oxen, horses, dogs, etc. harnessed to draw together (OE).

2 a Applied to persons drawing together;
b A number of persons associated in some joint action' (The Shorter Oxford English Dictionary 1972: 2251).

`...the word `team' should be used to encompass human beings, work procedures, machines and machine procedures as they interact in contributing to, or detracting from, the accomplishment of the defined goals of a system or subsystem' (Boguslaw and Porter 1962: 390).

`Teams are groups of people who cooperate to carry out a joint task' . . . (Argyle 1974: 110).

Group
`A number of persons or things in a certain relation or having a certain degree of similarity' (*The Shorter Oxford English Dictionary* 1972: 896).

`1 A collection or assemblage of `things'... people, animals, events, objects ... 2 A social group; a group in sense1butin which the members are all persons who are classified together on the basis of some social/psychological factor(s)' (Reber 1985: 310).

Committee
`A body of persons appointed or elected for some special business or function' (*The Shorter Oxford English Dictionary* 1972: 377). (Each person was originally called a committee.)

Crew
`An augmentation or reinforcement of a military force; hence a company of soldiers' (*The Shorter Oxford English Dictionary* 1972: 455). Derived from Latin crescere to grow.

Gang
`A set of tools arranged so as to work simultaneously (old Danish set of knitting needles)' ... `any company of persons who go about together . . . '(*The Shorter Oxford English Dictionary* 1972: 830). Derived from the Old English `gangan', to walk or go.

Syndicate
`A combination of capitalists or financiers entered into for the purpose of prosecuting a scheme requiring large resources of capital . . . ' (*The Shorter Oxford English Dictionary* 1972: 2224).

Symposium
`A drinking party; a convivial meeting for drinking, conversation and intellectual entertainment' (*The Shorter Oxford English Dictionary* 1972: 2222).

Quality circles
A small group of departmental work leaders and line operators (originally management only) who have volunteered to spend some time outside their regular hours to help to solve departmental quality problems. Developed in Japan after World War II (but with earlier origins in the human relations and humanistic management movements).

Semi-autonomous workgroups
Permanent group given responsibility by senior management to arrange their own working methods.

Task force - A temporary group of specialists charged with working on a pre-defined problem.

Lernstatt - A group dedicated to the integration of working and learning (German).

Werkoverleg - A consultative group of workers and managers, legally required in the Netherlands.