MENTAL WORKLOAD

Its Theory and Measurement

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MENTAL WORKLOAD

Its Theory and Measurement

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PREFACE

Early in 1976 a conference sponsored by the NATO Human Factors Special Panel was held at Berchtesgarden on the topic of "Monitoring Behaviour and Supervisory Control". It attracted a large number of participants: Psychologists and engineers, both theoretical and applied. Topics which were addressed included vehicular control, vigilance, process control, monitoring of plant, instrumentation and optimisation of man-machine interfaces, attention, and ergonomics. Repeatedly the authors of papers and discussants made reference to "mental workload" and problems associated both with too heavy and too light a load. Furthermore, in workshop discussions the same topic appeared. It became evident that almost everyone needed the concept. In particular the designers of man-machine systems badly wanted a measure which would allow them to predict whether a new system would be satisfactory for human operators who would have to use it.

In one of the discussions someone remarked that we have an enormous amount of knowledge about workload, and many models for it: surely it would now be possible to synthesize that knowledge into a coherent summary which would be both theoretically sound and practically useful. Perhaps what was needed was not a conference on workload, but some kind of intensive workshop at which such a synthesis could be attempted, gaps in our knowledge identified, research planned, and areas where our knowledge was adequate defined. This book is the outcome of that suggestion.

In 1977 the NATO Special Panel on Human Factors sponsored a small workshop. A few experts from each of several disciplines were invited, chosen largely in the light of discussions at Berchtesgarden. It was clear that research into Mental Workload was being done by engineers - particularly control engineers - by physiological psychologists, and by experimental psychologists. In addition, since measurement theory and problems of probability, prediction and time series analysis might be expected to be prominent, some people working on mathematical models of human behaviour were invited. Finally, a group of non-academic human factors specialists, all active in the application of workload concepts to

the solution of problems of systems design in the real world were added to prevent the discussions becoming theoretically elegant but of little practical value.

Each participant was asked to submit a "position paper" summarizing his views about mental workload. He was asked to define the concept, to say how he found it useful, how he measured it, what he would like to know about it, and the boundary conditions within which he considered it applicable. The papers - which appear in this volume - were circulated to participants in advance of the opening of the symposium.

At the symposium, the first day was spent in disciplinary discussions. The psychologists discussed their own position papers with each other, as did the engineers with the engineers, etc. On the basis of these discussions each discipline presented a summary of their (more-or-less) agreed joint position, and then the discipline groups, for two days, met in pairs. The physiological psychologists met first with the mathematicians, then with the experimental psychologists: the engineers met the applied group, then the psychologists, then the physiologists; and so on. New groups were then formed, each containing one member from each discipline, and discussion continued for a day. Finally, the original single-discipline groups met again as on the first day, and wrote a single position paper putting forward the agreed, common opinion of the group, together with suggestions for future research. This final paper was edited in each case by the chairman of the group and appears in this volume as the "Final Report" of each discipline.

What has been gained by this procedure? There is a certain amount of redundancy in the initial position papers. For example the physiological psychologists all tend to discuss the same measures, and several of the experimental psychologists deal at length with "secondary tasks". Such redundancy however reflects the degree of interest in such topics and measures among leading research workers, and there are important qualifications and nuances of emphasis which only become apparent when several such papers can be compared. Indeed, it is both surprising and somewhat worrying to see how many people can discuss a single methodology without exhausting the topic. What is perhaps more surprising is the extent of consensus across disciplines. The accepted wisdom of approaches and concerns is emphasised when workers with interests as diverse as control engineering, academic psychology, and physiology of the metabolic effects of them all agree on the value (or lack of it) of particular approaches.

Secondly, at least for those who were present at the conference, there was a real rapprochement between disciplines. Technical terms which are commonplace within a discipline may be

extremely difficult for workers with a different background to understand. Intensive interaction in pursuit of an agreed set of definitions and rules for translation from one discipline to another "concentrates the mind wonderfully", and the participants undoubtedly left the conference with a greatly improved understanding of the value and difficulties of alternative approaches.

These proceedings are possibly unique in the extent to which multidisciplinary approaches to a single topic are not merely available, but stated with sufficient clarity and interrelationship for one really to grasp the relation between the techniques used by the different disciplines.

The very ambitious aims of the symposium are summarised by Johannsen's remarks in the first paper.

"In this workshop, we should therefore try to -

- (1) find a consensus among all attendees of a strong definition of workload;
- (2) form an application-oriented theory or procedure of workload assessment which integrates all known aspects; and
- (3) find relationships between measurement techniques or applicable combinations of them corresponding to the theoretical concepts."

How far the participants fell short of those aims is perhaps equally well summarised by some remarks of Hopkin in the final paper.

"As of this point in time, theory has not produced an umbrella technique to partition, predict or measure the multitude of variables in an operational field problem. It is difficult to distinguish ... concepts, and no single individual can hope to have the breadth and depth of knowledge to accomplish the interdisciplinary integration of information that appears to offer significant advancements for applied settings".

Hopkin's point is underlined by the enormous list of "problems for future research" produced by the different groups. However, three things stand out. The first is that regardless of the groups to which participants belonged, they left the conference with a firm conviction that interdisciplinary co-operation is absolutely mandatory for progress. More: that in any single investigation or project the simultaneous application of methods from several disciplines will be mandatory. The other side of the coin is, however, that there is a remarkable degree of consensus among

the final reports. Regardless of discipline or approach, participants came to very similar conclusions about the validity, usefulness, and promise (or lack of each) for a wide variety of methods for approaching the assessment of workload in the human operator. The careful reader will find a rather clear picture at least of the pitfalls involved in many techniques which are often assumed to be "standard". On the other hand, he will equally well notice that in certain specific areas, and for problems of certain kinds, substantial success is even now possible. Thirdly, it is of interest that since the conference, several interdisciplinary projects, and indeed international projects, have resulted from co-operation between participants.

As editor and convenor of the symposium, it remains for me to make the acknowledgments to those who made the symposium possible. Thanks are first due to the Special Advisory Panel on Human Factors of the NATO Science Committee for supporting the Symposium. Secondly, I must thank H. Ursin and H. Stassen for their help in organising the conference, and all the Group chairmen for preparing the Final Reports of their Groups. Particular thanks are due to Dr. Mary Vakali of the Department of Psychology of the University of Thessaloniki for her untiring work as liaison officer in Greece; and to N. Durham and his staff at Condor Travel, Athens and T. Shakalis of Grecian Holidays, London who dealt with considerable problems caused by an air traffic controllers' strike at the time of arrival and departure of participants. The preparation of the typescript gave an added burden to our secretaries, Gill Johnston and Ina Mack, which they bore with their usual fortitude, and Donald McLeod proof read with skill and ingenuity. Finally, I would like to thank all the participants for the exceptionally hard work they put in both before and during the conference. Several of the position papers deserve to become classical references of the state-of-the-art in 1977, and in the light of the discussions give one hope that a significant break through in applied psychology may be possible: one moreover which may significantly contribute to what Norbert Wiener called "the human use of human beings".

N. Moray
Stirling 1978.

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