MAN-COMPUTER PROBLEM SOLVING

EXPERIMENTAL EVALUATION OF
TIME-SHARING AND BATCH PROCESSING

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PREFACE

THIS book is concerned with the growing experimental evidence on man-computer problem solving, particularly in the competition between time-sharing and batch-processing computer systems. The concept for the book emerged in response to strong and continued demand from the computer world, and from users in related scientific, educational, and technological areas as well, for scientific data on the dynamics of man-computer problem solving and on the associated comparative merits of time-sharing and batch systems.

When time-sharing was first pioneered in the early 1960's, the initial controversy between online and offline systems was a speculative, armchair affair, marked by partisan heat rather than scientific light. This predisciplinary controversy gave way to applied scientific studies as soon as significant experimental data became available. Since investments in computer systems run into billions of dollars, and since the annual gross product of computer goods and services is at the 10 billion dollar level, the interest in comparative experimental findings on man-machine effectiveness between online and offline systems has become intense.

The author—who has worked in this field since the emergence of the first real time command and control systems in the mid-1950's—received many requests for available publications, talks, and specially written papers on different aspects of the comparative cost-effectiveness of online and offline (time-sharing vs. batch) problem solving. Inquiries have come from government agencies, universities, commercial computing centers, engineering and computing groups, large and small business firms, professional and

trade journals, and from individuals in the United States and abroad. With the conclusion of his most recent and comprehensive research in this area, a large-scale study at the United States Air Force Academy, it became clear that the dispersed research had reached the point where it should be brought together and integrated into book form for the convenience of all interested parties. The book thus includes all relevant research to date on man-machine cost-effectiveness for man-computer problem solving in time-sharing and batch processing—its early development, method and findings, limitations, and prospects.

The orientation of the book and its organization follow established scientific guidelines. Relevant literature is reviewed, hypotheses are operationally formulated, methodology is carefully described, quantitative procedures are made explicit, empirical results are presented in detail, and interpretations are tied to statistical findings. The more technical aspects are explained for the lay reader as they occur.

The focal audience is the computer world—managers, programmers, systems analysts and users of computers in government, education, scientific, engineering, and business applications. This audience is expected to grow with the steady extension of computers throughout society, and with the imminent rise of mass information utilities. The experimental orientation of this book should make it especially useful to the various scientific disciplines that have some stake in man-computer problem solving and the online/offline controversy. These include the computer and information sciences, engineering and operations research, management science, and, for human creativity and problem-solving in a computerized milieu, the social sciences.

The book is divided into four parts. Part I essentially consists of an introduction to time-sharing and batch processing, the historical background of the scientific study of the human use of computers, and summary accounts of exploratory online/offline studies that preceded the comprehensive studies described in Parts II and III.

Part II covers the collaborative work of the author and M. Gold, based on follow-on analyses of the extensive data from Gold's original doctoral dissertation at Massachusetts Institute of Tech-

nology. The original and the follow-on studies represent a breakthrough in the field; they cover numerous performance variables for an open-end problem which permits measurement of the excellence of the solution. The reported study was jointly sponsored by System Development Corporation and Carnegie-Mellon Institute.

Part III is concerned with the largest and most comprehensive online/offline study of man-computer problem solving to date. It was conducted by the author on a sample of 415 cadets at the Air Force Academy. This experiment was performed under the joint auspices of System Development Corporation and the United States Air Force Academy to test the effectiveness of time-sharing and batch processing in teaching introductory computer science, and to gain new insight into leading issues on the dynamics of man-computer problem solving. A wealth of new data and new hypothesis was generated by this recent study, which is described in Part III.

The epilogue, Part IV, was designed to pull together and summarize the various strands of research on man-computer problem solving under online and offline conditions as reported in this book. Special emphasis is placed on the interface between these online/offline studies and the mainstream of the behavioral literature on human problem-solving in such areas as: massed vs. spaced learning, insight vs. trial and error, and the structure of human skills and traits in man-computer communication. The book concludes with a preview of mass computer utilities, and a plea for cooperative interdisciplinary research on experimental community prototypes to meet the challenge of the public interest in the computer-serviced society of the future.

I am deeply indebted to System Development Corporation which has generously provided funds and resources in supporting various studies reported in this book and in the preparation of the manuscript. In particular, I am most grateful to Kenneth W. Yarnold and Lorimer F. McConnell for their administrative support, and to Clark Weissman for his technical support. I owe a major intellectual debt to Dr. Michael M. Gold whose influence is manifest throughout this book, particularly in the collaborative study we performed, as reported in Part II.

The author would like to thank Colonel Roger R. Bate and

Lieutenant Colonel Monti D. Callero for their authorization and support of the reported experiment at the Air Force Academy. I am especially grateful for the steadfast cooperation of instructors and cadets throughout all phases of the pilot study and the main experiment. Special thanks are owed to Captain Duane A. Adams who educated the author in the ways of the Academy, provided extensive administrative and technical support throughout the design and implementation of the study, and contributed to the interpretation of the results. I would like to thank Dr. Lee S. Christie of System Development Corporation for urging me to become involved in this project, and also Dr. Miles S. Rogers there for statistical services.

I owe a continuing debt to Catherine E. Perrone for her endless pursuit of secretarial excellence, not only for all phases of the manuscript, but also for the main studies reported in this book. In closing, I must express my affectionate appreciation to my wife Kathleen, and my children, Jeffry, Sharon, and Amy for their patience and forbearance over the demanding course of work that made this book possible.

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PART I

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THE EXPERIMENTAL LAG IN MAN-COMPUTER COMMUNICATION

1.1 INTRODUCTION

MUCH has been written about the enhancement of human intelligence through the aid of computers. Elysian visions have been projected portraying man attended by his computerized robots, living the good life with boundless leisure to pursue his creative bent. A few, such as Wiener (1964), have been alarmed by humanistic neglect in the development of computerized systems, and they have warned us that human responsibilities will grow more difficult and more complex, that the enormity of the challenge for the "human use of human beings" could eventually overwhelm humanity.

Although the enhancement of the human intellect with computers has been the subject of much speculation, remarkably little solid scientific work has been done in man-computer problem-solving. The humanistic lag in the application of computers to social affairs goes hand in hand with the experimental lag in man-computer communication. This chapter outlines the scope and nature of this unfortunate situation. Succeeding chapters review and evaluate the significant studies that have been done to date and spell out leading implications for future scientific work.

Primary emphasis is placed on comparative evaluation of