

Preface

These research reports and discussions are concerned with the information processing activity that underlies intelligent behavior in human beings and computers. We were motivated to prepare such an anthology for three reasons.

First, since the topic is of general interest, controversial, and of potentially great scientific and social significance, we wished to make available to a wide audience a collection of the significant research papers. Most have been available only in relatively inaccessible technical journals, and most are reprinted here just as they originally appeared.

Second, we felt it important to make these particular readings easily available for use in graduate-level and undergraduate courses being offered (or planned) at many colleges and universities.

Third, we wished to provide a convenient reference volume for researchers working in or entering the fields of artificial intelligence and simulation of thought processes. An invaluable component of such a reference volume is a good bibliography. We believe that Minsky's descriptor-indexed bibliography will be a particularly useful tool for the researcher.

The lot of the anthology editor is not a happy one. He may be damned not only for presumed sins of commission but also for sins of omission. When the anthology is the first in an area as ductile as the one we are labeling *Computers and Thought*, the problems of selection are compounded.

In the introduction to Part 1 on artificial intelligence, we present our understanding and interpretation of the goal of this research. We have selected reports of research efforts which we feel outdistance all others in advancement toward this goal. Such a criterion, as we see it, gives high priority to a particular brand of research, loosely labeled "cognitive models." An opposing school of thought, sometimes called "neural cybernetics" or "self-organizing systems," has intrinsic fascination and has produced a considerable number of particular projects. Neural cybernetics approaches the problem of designing intelligent machines by postulating a large number of very simple information processing elements, arranged in a random or organized network, and certain processes for facilitating or inhibiting their activity. Cognitive model builders take a much more macroscopic approach, using highly complex information processing mechanisms as the basis of their designs. They believe that intelligent perform-

ance by a machine is an end difficult enough to achieve without "starting from scratch," and so they build into their systems as much complexity of information processing as they are able to understand and communicate to a computer (using their programming techniques).

The cognitive models approach has led to tangible progress (displacement toward the ultimate goal) in the field of artificial intelligence, while the progress to date in the neural cybernetics approach is barely discernible. On this basis, we feel that there is reason for our bias in favor of cognitive models, though of course there are other dimensions along which to evaluate the research.

We have tried to focus on papers that report *results*. In this collection, the papers that deal with specific projects describe actual working computer programs that produced interesting and significant behavior. Because of the limited space available, we chose to avoid the more speculative, albeit stimulating and thought-provoking, pieces that have been written on intelligent machines. It is for this reason that the writings of some of the well-known theorists in the area are not included.

Related research areas, such as machine translation of languages, automatic information retrieval, and automata theory, were not treated, since they constitute separate subdisciplines of the computer sciences and deserve full treatment in their own right.

Many papers in psychology and the life sciences are relevant to an understanding of information processing in human thought, but we did not include these, because we wished to keep a sharp focus on computer processes and techniques.

For reasons of sharp focus also, we have not included a paper on an important topic, the social implications of intelligent machines.

We have used the papers here collected for a graduate-level course in artificial intelligence and computer simulation of cognitive processes, in which we have had students from business administration, psychology, linguistics, philosophy, biology, physics and biophysics, and electrical engineering. The course has no mathematics prerequisite, but some knowledge of mathematics is helpful (e.g., in understanding Slagle's work on integration). An introductory course in psychology would also be helpful to the student, but it is not required. We have required some elementary knowledge of computers and an ability to program a computer, preferably in one of the list processing languages, e.g., Information Processing Language V (IPL-V), FORTRAN List Processing Language (FLPL), COMIT, or LISP. For students who have not had this preparation, we have provided extra instruction in IPL-V.

As a road map to the collection we offer the following guidelines:

For the general reader: The major introductions to Part 1 on artificial intelligence and Part 2 on simulation of cognitive processes, the intro-

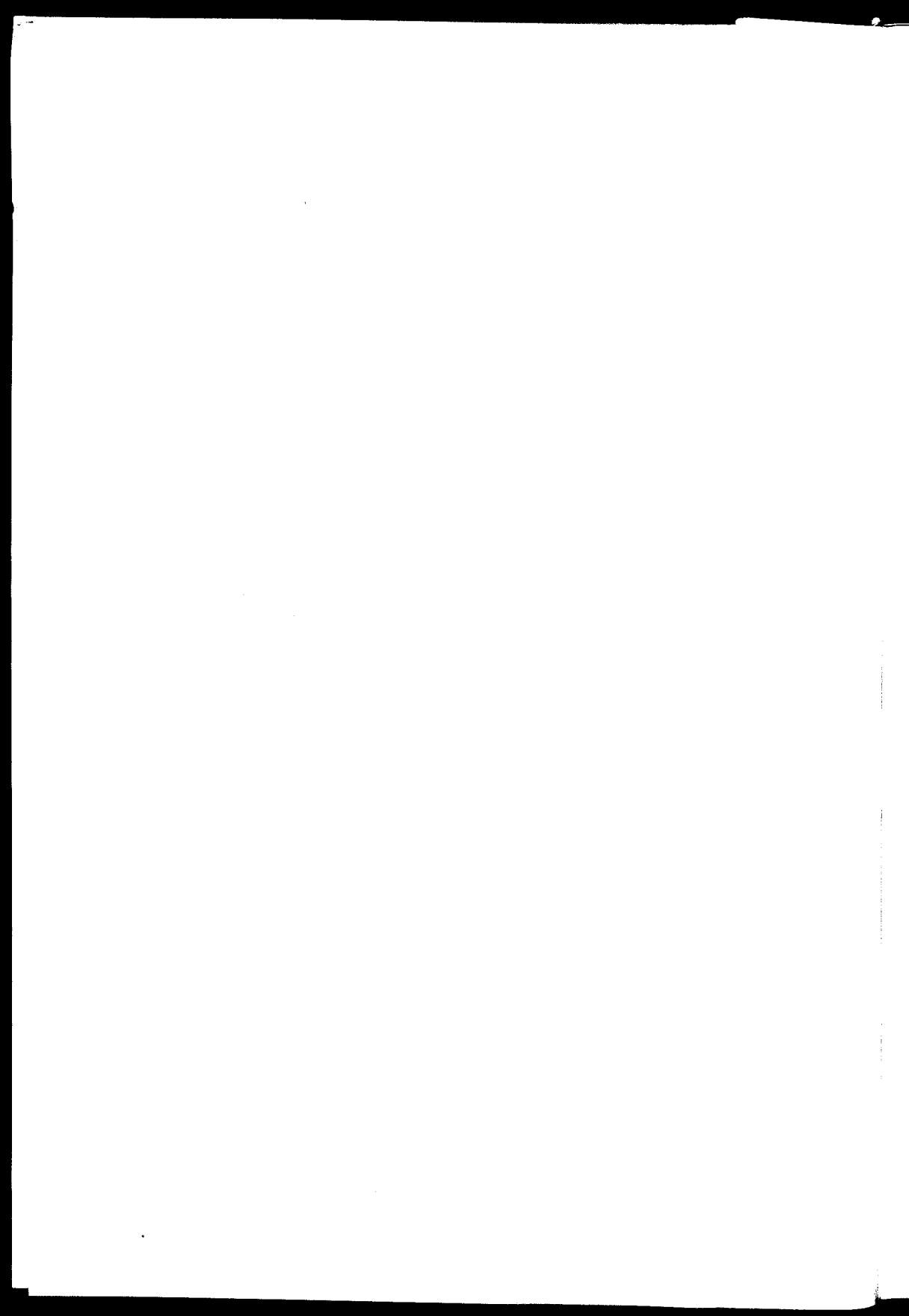
ductory article by Turing, followed by the other articles in a sequence dictated by the tastes of the reader and his competence in the subject matter discussed, and finally the summary and review articles by Armer and Minsky. The Minsky critical review might also usefully be the midpoint in a reading of this collection.

For the computer scientist and the management scientist: The major introductions, followed by Minsky's critical review. Perhaps of highlighted interest, Samuel's treatment of learning programs, Tonge's management science application, and the research on theorem-proving programs (Newell, Shaw, and Simon, and Gelernter).

For the psychologist and the philosopher: The introduction to Part 2 on simulation of cognitive processes, the articles on problem-solving, verbal learning, two-choice behavior, concept formation, social behavior, and decision-making, in a sequence dictated by the interests of the reader, and finally the papers on artificial intelligence research.

We should like to express our gratitude to the authors who graciously allowed us to reprint their articles; to those who advised us on the selection problems; to Robert Lindsay, Leonard Uhr and Charles Vossler, John and Jeanne Gullahorn, and Geoffrey Clarkson, who prepared articles or revisions specifically for this collection; to Arthur Samuel for service beyond the call of duty in arranging and running the 7090-Nealey checker game; and especially to Marvin Minsky for the time and energy he spent in preparing a revision of his earlier bibliography. We owe a special debt to A. Newell and H. A. Simon for their guidance and research collaboration over the years. Our final expression of appreciation is to Mrs. Pamela Tellefsen, who offered this manuscript her toil, patience, and care over many months, and to Rita R. Feldman, who compiled the Index.

*Edward Feigenbaum
Julian Feldman*



Acknowledgments

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- A. Newell, J. C. Shaw, and H. Simon, Chess playing programs and the problem of complexity, by permission from the *IBM Journal of Research and Development*, October, 1958, **2**:320-335.
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Many different people have contributed to these studies through stimulating discussions of the basic problems. From time to time the writer was assisted by several different programmers, although most of the detailed work was his own. The forbearance of the machine room operators and their willingness to play the machine at all hours of the day and night are also greatly appreciated.

- A. Newell, J. C. Shaw, and H. Simon, Empirical explorations with the Logic Theory Machine, by permission of the authors from the *Proceedings of the Western Joint Computer Conference*, 1957, **15**:218-239. This research was part of a project conducted jointly by Newell and Shaw of the RAND Corporation, Santa Monica, and H. Simon of the Carnegie Institute of Technology.
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The technical and programming assistance of J. R. Hansen and D. W. Loveland has been indispensable to the success of this project. N. Rochester and J. McCarthy contributed much to the early development of ideas, and Rochester supplied the necessary administrative support as well. Other members of the Information Research Department of IBM, and W. G. Bouricius, P. C. Gilmore, J. P. Lazarus, and P. D. Welch, in particular, contributed to the author's understanding of the problem in his conversations with them.

The research project itself is a consequence of the Dartmouth Summer Research Project on Artificial Intelligence held in 1956, during which M. L. Minsky pointed out the potential utility of the diagram to a geometry theorem-proving machine.

X ACKNOWLEDGMENTS

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We would like to express our indebtedness to J. C. Shaw, who has been our colleague in most of our research into complex information processes, including the GPS program which forms the basis of this paper.

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I am deeply indebted to H. Simon for his past and present collaboration in this research. This research has been supported by the Computer Sciences Department, the RAND Corporation, and the Ford Foundation. I wish to express appreciation for the help and critical comments of J. Feldman, A. Newell, J. C. Shaw, and F. Tonge.

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The work reported in this paper was supported by a grant for the study of concept learning from the Ford Foundation to C. I. Hovland. The computational work involved was supported, for the most part, by the Computation Center, Massachusetts Institute of Technology. B. F. Green, Jr., and A. Wolf, of Lincoln Laboratory, M.I.T., made available the 709 version of the IPL-V interpreter and instructed Hunt in its use. The aid received is gratefully acknowledged.

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Thanks are also due the Committee on Simulation of Cognitive Processes of the Social Science Research Council for support during the early phases of this research at the School of Business Administration, University of California at Berkeley, and to the System Development Corporation, Santa Monica, for continued sponsorship of the project.

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I would like to express my gratitude for many long discussions of this topic with W. H. Ware, M. E. Maron, F. J. Gruenberger, E. A. Feigenbaum, A. Newell, J. C. Shaw, and H. A. Simon, and the influence of the research efforts of the latter four on my thinking. In

this paper I have quoted many people. In so doing I have strived to avoid quoting out of context. However, one runs this risk when only a portion of a man's statement is repeated. If I have misrepresented the intended meaning of anyone in this paper, it has been accidental.

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