Book Reviews

Cognitive Psychology

Visual Information Processing. Proceedings of a symposium, Pittsburgh, May 1972. WILLIAM G. CHASE, Ed. Academic Press, New York, 1973. xvi, 556 pp., illus. $17.50.

This volume, the eighth Carnegie Symposium on cognition, accurately reflects the paradoxical condition in which experimental psychology finds itself. An impressive number of talented people, including the contributors to this book, are doing work of great ingenuity and sophistication on visual information processing; new discoveries emerge from their laboratories in a continuous stream. Nevertheless it is not clear that we are moving in the right direction, or indeed in any single direction at all. In a remarkably frank central chapter, Allen Newell faces this question explicitly. As more and more phenomena are discovered, each one serves to stimulate further research. A flurry of experiments investigate it, establish its parameters, explore relevant variables, and relate it to other effects already known. Newell has no difficulty in listing 59 such phenomena of current interest: differences in physical and name matching, and continuous mental rotation, both treated in this volume, are among his examples. The list could easily have been made longer, and it will surely be lengthened by more discoveries in the years to come. After another generation or so of this, he asks, will we be any wiser than we are now? Will they add up?

Not unless something different begins to happen, says Newell, and I agree. Most contemporary theorizing integrates such effects only at a very low level, usually in terms of simple dichotomies (serial versus parallel, single memory versus dual memory, and so on). Newell has another expandable list of 24 such distinctions, which he does not find very useful. One reason is that human beings can handle a given task in so many different ways. "That the same human subject can adopt many (radically different) methods for the same basic task, depending on goal, background knowledge, and minor details of payoff structure and task texture—all this—implies that the 'normal' means of science may not suffice" (p. 299).

Newell suggests that we should be trying to formulate complete processing models, or single programs that can perform many tasks, instead of focusing on individual phenomena; he also suggests that the analysis of single complex activities in depth may be helpful. The models he advocates are "production systems," programmable control structures that are quite different from the flow charts and programming languages with which many psychologists are now familiar. In a subsequent chapter he describes one such system in detail, and shows how it would conduct memory searches in the Sternberg paradigm. Another chapter, by Klahr, elaborates a production system for subitizing and counting, which fits the data he obtained from human subjects in studies also reported here.

I am personally skeptical of unitary models, even those as sophisticated as Newell's. There is another research strategy we might pursue. Leaving our paradigms behind, we might try to understand how people function in the world at large: how they grow up, what skills they acquire, how they are influenced by society, what they care about. None of Newell's 59 phenomena is drawn from developmental psychology, cross-cultural psychology, differential psychology, or applied psychology; with the single exception of memory for chess positions, none is taken from any activity that occurs outside the laboratory. It may be more fruitful to strive for ecological validity than for theoretical inclusiveness and to study natural rather than an increasingly artificial intelligence.

Actually, one or two contributions to this book do move in that direction. A chapter by Bransford and Johnson, accurately described in Trabasso's discussion as "a brilliant *tour de force*" (p. 439), shows how thoroughly our comprehension and memory of prose passages depend on what we know about the world already. In previous work, Bransford and his collaborators have shown that memory for individual sentences depends on how the listener interprets them, which in turn is often governed by knowledge he acquired elsewhere. The present paper goes further to illustrate, with many ingenious examples, how the comprehension and memory of whole prose passages may also be altered by seemingly minor cues and by specific types of extralinguistic context. Moreover, readers and listeners often invent elaborate scenarios in their effort to grasp what was said: consider how we understand a sentence like "Bill is able to come to the party tonight because his car broke down." These invented scenarios have demonstrable effects on what is remembered later. Seen in this light, more limited and traditional studies of memory for words and sentences seem somewhat inadequate. Sentences usually are not, and often cannot be, understood in isolation, just as they often cannot be translated in isolation. This fact caused the failure of attempts at "mechanical translation" in the 1960's; Bransford and Johnson are, in effect, warning psychologists not to overlook it again in the 1970's.

Another fine chapter, by Chase and Simon, concerns chess-playing ability. It is the latest of the series of chess studies carried out by Simon and his collaborators over a period of years. This one, less computer-program oriented and richer in data than much of the earlier work, deals primarily with how board positions are matched and remembered by players of differing ability. The authors' analysis leads them to conclude that "the most important processes underlying chess mastery are . . . immediate visual perceptual processes rather than the subsequent logical-deductive thinking processes" (p. 215). They provide a detailed theory of the mechanisms and capacities involved. Though some aspects of the theory seem implausible to me (considerable effort is required to make the data fit a fixed-size short-term memory, for example), it is still impressive, perhaps the most significant accomplishment to date of the computer-program approach to cognition. Even if chess playing is not a biologically or socially crucial activity, it is at least something people do outside laboratories. I understand it better for having read this chapter.

Although the Chase-Simon and Bransford-Johnson papers may have more face validity than the rest of this collection (except for John Hayes's startling examples of the use of visual imagery in mathematics), they are almost overshadowed by Cooper and Shepard's elegant 100-page study of mental rotation, which goes far beyond Shepard's earlier and already influential work. Among its findings are that subjects cannot rotate an abstract frame of reference, but only an image of a concretely specified form; that certain well-defined circumstances yield nonlinear rotation-time functions; and that people can be induced to rotate a mental image continuously at a regular rate, with predictable effects if a comparison stimulus suddenly appears in the field. At all levels—ingenuity of design, sophistication of analysis, thoughtfulness of presentation—this is an outstanding piece of research.

The book offers two other very competent papers, both using judgment latencies to analyze complex processes. Posner continues to develop his notion of internal "codes," or modes of representation; Clark, Carpenter, and Just study the verbal statements which people find acceptable as descriptions of schematic drawings. In summary, whatever doubts one may have about the ultimate future of experimental psychology, there is no doubt that this volume includes some impressive examples of the present state of the art.

ULRIC NEISSER
Center for Advanced Study in the Behavioral Sciences, Stanford, California

A.I. in EASEy

Pattern Recognition, Learning, and Thought. Computer-Programmed Models of Higher Mental Processes. LEONARD UHR. Prentice-Hall, Englewood Cliffs, N.J., 1973. xxii, 506 pp., illus. $13.95. Prentice-Hall Series in Automatic Computation.

No matter what its ultimate definition, in practice "artificial intelligence" (A.I.) deals with computer programs that can be said to learn, recognize patterns, and solve problems. One usually teaches A.I. by discussing programs that appear to be especially good examples of machine thought. A few authors have tried to develop general principles about the capabilities of classes of algorithms used in A.I. Here Leonard Uhr, one of the major contributors to A.I. research, has tried yet another approach, a guide to the creation of A.I. computer programs. To be sure, Uhr interleaves mentions of general problems with his discussion of specific programming examples, but he usually does not go much beyond a brief aside on a general problem that a sample program illustrates. His asides are not reasoned arguments; his programs are.

Uhr discusses four subfields of A.I.: pattern recognition, game playing, problem solving, and learning. In each case he first presents a rudimentary program to do a simple illustrative task and then complicates it in order to execute more complex varieties of "intelligent action." There are numerous asides about the programs but, as noted, no formal analyses. Neither is there very much coverage of the literature, although there is a good bibliography, divided into topical sections. The programs themselves are written in EASEy, a simplification of the SNOBOL programming language, which Uhr hopes can be read like text. Fortunately, Uhr also offers clear English-language précis of the various EASEy programs. He seldom uses flow charts, and I, for one, missed them.

In evaluating Uhr's work we must distinguish both how well his aims are met and how well they have been chosen. Uhr himself says that the book is unevenly written. The discussion of pattern recognition is quite good, both in the choice of programming examples and the philosophical asides. I recommend this section to anyone who must actually program a pattern recognizer. The chapters on game playing do not contain clear-cut discussions of the various algorithms that have been developed for board games. Uhr has chosen to spend a great deal of time on a general discussion of the game GO, rather than the much more studied chess; his discussion is interesting, but it shortchanges the student who has not already examined the uncited literature. In discussing problem solving Uhr does not explain the basic ideas behind the resolution principle and graph searching. Finally, the most difficult section to evaluate is the one on learning. The examples of learning programs appear, at first glance, to be a collection of useful but ad hoc tricks. Uhr clearly feels that they represent much more. Unfortunately, his failure to carry his asides to the point of formal analysis leaves me unclear about the real implications of the programming devices illustrated. Uhr certainly recognizes the need to trace a connection between learning and pattern-recognition programs. He tries to do this by cross referencing from a discussion of learning to pattern-recognition programs presented earlier, but the effort seems to me to be of limited success.

Uhr's approach to instruction via programming example will probably be very useful in engaging the beginning student in a concrete discussion of A.I. This is good pedagogy and, especially at the undergraduate level, it should be much more effective than reliance upon the more formal, analytic, "removed from the real computer" approaches taken in several other texts. The disadvantage is that students may learn to plunge forward with clever programming solutions without analyzing their algorithms in any formal way. This encourages the software-engineer approach to A.I.—"can I program the machine to solve the problem at hand right now?"—and discourages the search for *proven* general solutions, even though Uhr stresses the need for such solutions in his discussion. The student is likely to heed the examples more than the cautions.

This book is an interesting adjunct to other A.I. texts. At the least it could serve as a second text in a course in which students discussed general principles and, using Uhr's book, worked on concrete programming problems. (A revised edition, written specifically for this purpose, could be much shorter.) A Compleat Artificial Intelligencer will have to contain serious discussions in mathematics, engineering, psychology, and programming. Only the last is given here. Uhr, too, is human. To give four would be divine.

EARL HUNT
Departments of Psychology and *Computer Science, University of Washington, Seattle*

The Physics of Bonding

Bonds and Bands in Semiconductors. J. C. PHILLIPS. Academic Press, New York, 1973. xii, 288 pp., illus. $18.50. Materials Science and Technology.

During the past six years, J. C. Phillips has worked on modernizing and generalizing the outlook on chemical bonding begun by Linus Pauling, now possible because of the immense increase in factual knowledge about covalently bound solids. The theoretical calculations of conventional solid state theory can be long on computer time