graphs pass Barry's test for ball lightning, and I invite you to pick those three before reading Barry's explanation in the text. You may conclude, as I have, that obtaining the first photograph of ball lightning remains one of the greatest challenges to the amateur, professional, or scientific photographer.

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Cognition

The Nature of Thought. Essays in Honor of D. O. Hebb. PETER W. JUSCZYK and RAYMOND M. KLEIN, Eds. Erlbaum, Hillsdale, N.Y., 1980. xx, 256 pp., illus. $24.95.

As the authors of this collection acknowledge, Hebb's *Organization of Behavior*, published in 1949, gave a sense of new direction in experimental and physiological psychology. Its centerpiece was the proposal of redundant, spatially distributed cell assemblies to explain the flexibility of mental operations, our abilities in learning to perceive the world, and the brain's resistance to damage.

This collection includes both the bringing up to date (by Goddard) of Hebb's neuronal concepts in terms of recent findings concerning synaptic potentiation and a description by Nadel of the discovery of neural bases of cognitive maps, one of the most interesting recent developments in physiological psychology.

The main part of the book, however, is on human cognitive psychology, with chapters on the language of thought (by Jusczyk and Earhard), on the psychology of structural simplicity (by Krueger and Osherson), and on the information processing approach (by Simon, Bever *et al.*, Paivio, and Posner).

It was some ten years after the publication of Hebb's book, influential though it was, that this other and stronger current of cognitive psychology began to flow. Perhaps the most provocative essay in this collection is by Neisser, whose *Cognitive Psychology* in 1967 marked the swelling of this current in the mainstream of academic psychology. In a way Neisser in his chapter "The limits of cognition" has reversed his former allegiance and sides here with the early Hebb, in spirit if not in detail.

A major preoccupation of the information processing approach to cognition is to inquire what are *the* specific characteristics of the recognition of letters, *the* capacity of memory, *the* speed of this piece of processing, *the* limits of that mental performance, and so on, as if the brain were a machine with fixed characteristics.

In his chapter, Neisser now doubts the correctness of this assumption of measurable fixity. He shows with some apposite demonstrations that human capacity is flexible rather than having rigid limits.

Posner's position in his chapter is directly opposed to Neisser's. He argues for mental chronometry as "the effort to observe the time course of information flow in the nervous system," by measuring reaction times and the like. Neisser has the more convincing case here. The effort to capture some essence of cognition in measurements such as reaction times that assume fixed mechanisms of processing is a direction taken because of seductive qualities of what can be experimented upon rather than because of what is characteristic of mental life.

With this in mind it is appropriate that Hebb's own essay here culminates in some speculations on creativity in terms of the simultaneous activation of cell assemblies (or, as I should prefer to say, of cues capable of addressing schemata). Though experiments might be more difficult, demonstrations are possible as Hebb shows; and it is more likely that here is to be found something closer to the nature of thought.

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Computer Work Remembered

A History of Computing in the Twentieth Century. A Collection of Essays. Papers from a conference, Los Alamos, N.M., June 1976. N. METROPOLIS, J. HOWLETT, and GIAN-CARLO ROTA, Eds. Academic Press, New York, 1980. xx, 660 pp., illus. $29.50.

Despite the impact computers have had on society, accounts of their development have been lacking. Many of the pioneers of computing are approaching advanced age, and the present volume is the result of a timely attempt to record their recollections and perspectives on past developments.

The book includes over 30 papers that focus on most of the major computer and programming developments in the United States and abroad from 1935 to 1955. There is appropriate attention to British, German, Japanese, and even Russian work, and, although several American computing projects such as Harvard's Mark I and Eckert and Mauchly's UNIVAC are not specifically included, overall the book has a fair cross-section of topics.

In addition to the papers by the computing pioneers, there are papers by historians like Henry S. Tropp and Kenneth O. May describing historiographic problems associated with writing contemporary history; Brian Randell and Simon Lavington, although not historians, have researched various aspects of British computing history and have also contributed historical papers. Several papers that were not presented at the conference that gave rise to the book, including one on programming in the U.S.S.R., have been added. Despite significant contributions by women during the period covered, particularly in programming, there is not one female-authored paper. The book concludes with an annotated bibliography by Randell that supplements his excellent bibliography that appears in *The Origins of Digital Computers* (second edition, Springer-Verlag, 1975). The lack of an index to the book is a serious deficiency.

As a collection the essays are rather disjointed. They are grouped into several units—The Human Side, The Languages, The Machines, and The Places—but with the exception of the unit on languages the groupings seem somewhat arbitrary. Papers on ENIAC, for example, are included under The Places, and one entitled "Early programming developments in Cambridge" is included under The Machines.

Some of the contributors set out to provide as unbiased accounts as they can. Others are more polemical. Most of the pioneers tend to focus on the priority issues that were the subject of bitter disputes at the time of the events and that remain controversial. For example, J. Presper Eckert, the coinventor of numerous "firsts" in electronic computing, including the ENIAC and the UNIVAC, focuses on his contribution to the stored-program concept: "My best computer idea, today briefly called 'stored program,' became to us an 'obvious idea,' and one that we started to take for granted. It was obvious that computer instructions could be conveyed in a numerical code" (p. 531). In this paper, Eckert argues against those who credit John von Neumann with this concept.

Similarly, Maurice Wilkes attempts to establish his priority regarding the devel-

opment of subroutines: "From the very first, I had seen the establishment of a library of subroutines as being of prime importance" (p. 499).

John Mauchly focuses on perhaps the most controversial priority claim of all: who invented the United States' first electronic digital computer? He addresses himself to the *Honeywell* vs. *Sperry Rand* decision of 1973, which invalidated the ENIAC patent, in part because of the prior invention of John Atanasoff: "Because I visited J. V. Atanasoff for just two or three days in 1941, the 1974 [sic] decision of Judge Larsen was that I derived all my notions about building electronic computers from Atanasoff" (p. 549).

Individual points of view are of course important, but the reader must be aware that the presentations are frequently highly subjective and that recollections of events that occurred more than 30 years ago tend to be selective. There is also a tendency to focus on the past from the vantage point of the present, to emphasize decisions and developments that today are considered "correct," without paying adequate attention to the opinions held at the time, the norms that prevailed, and the decision-making process itself.

For example, Robert R. Everett states the following about the critical decision to convert Project Whirlwind from an analog to a digital machine: "In 1945, Jay Forrester began looking at the new digital computers, talked to a number of people, attended a computer conference, and as I recall it, late that year came back and said 'We are no longer building an analog computer; we are building a digital computer' " (p. 365). Such a critical decision requires far more analysis than this one simple statement.

Similarly, James E. Robertson writes of the ORDVAC: "Although it was first planned to build ILLIAC and ORDVAC from circuit drawings obtained from the Institute for Advanced Study, this intention was later changed, and most of the computers were constructed from circuits designed at the University [of Illinois]" (p. 348). One wonders why the change was made and what effects it had on the design of the ORDVAC. Similar examples appear throughout the book.

There are, however, several papers that demonstrate sensitivity to historical issues and skill in writing history: "The early development of programming languages" by Donald E. Knuth and Luis Trabb Pardo, "From ENIAC to the stored-program computer: two revolutions in computers" by Arthur W. Burks, and "The start of an ERA: Engineering Research Associates, Inc. 1946–1955" by Erwin Tomash. These authors give some attention to the economic, administrative, institutional, political, and social factors that relate to those developments. Tomash notes, for example, that "1946 was . . . a year of change and movement and new beginnings all across the United States. Engineers and scientists who had worked in war plants or served in the Armed Forces came back to their homes and started looking for work" (p. 488) and that "under the frugal defense funding of the Truman administration before the Korean War, revenues and profits [of ERA] declined" (p. 491). And, as Burks states: "In evaluating ENIAC, one should keep in mind that it was developed during World War II. The immediate goal was to calculate firing tables. . . . Moreover, because of the emergency character of the war, ENIAC was developed very rapidly" (p. 334).

In summary, *A History of Computing in the Twentieth Century* is worthwhile reading for anyone interested in the subject. The chatty, anecdotal style of many of the authors may not give rise to the sort of objective, professional account preferred by historians, but it lends a dimension to the study of history that is not prevalent in more conventional works. The personalities of the pioneers and the issues they currently regard as most important clearly emerge, providing the reader with an understanding of some of the major controversies.

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