Book Reviews

Human Information Processing

Decision and Stress. D. E. BROADBENT. Academic Press, New York, 1971. xiv, 522 pp., illus. $21.

Man's behavior may be characterized by the information-processing operations that he performs on environmental stimulation and internally stored data. From this perspective, sometimes considered a cybernetic framework, research is directed toward elaborating the functional information-handling capabilities and limitations of man. It seeks to specify the operational constraints within which human behavior evolves and to pin down in as much detail as possible the elemental processing operations that eventuate in observable behavior. The most direct analogy is with computer systems. Specialists in human information processing seek to specify these operations in the form of functional flow charts that represent the computer software of the system. They want to elaborate processing algorithms that will account for the behavior they observe.

This approach has several attractive features. (i) It provides a structure from which such classical concepts as attention, mental act, and memory can be investigated with a scientific rigor not attainable through the earlier, introspective attacks on these problems. (ii) It is congenial to currently popular kinds of formalism such as mathematical or computer modeling. (iii) With the growth in understanding of computer programing systems it becomes intuitively reasonable to think of encoding, transformation, and choice as fundamental aspects of behavior and yet to have a language and structure with which to communicate the incredible complexity of behavior that can result from such simple processes. Both Neisser in his *Cognitive Psychology* (Appleton-Century-Crofts, 1967) and Broadbent in the present volume make the point, expressed impudently by Neisser, that from this perspective "psychology is not just something to do until the physiologist comes." There are aspects of behavior calling for explanation at a level removed from physiology or biochemistry. (iv) Many detractors think this kind of theorizing conceives of man as an overgrown automaton. Actually, the converse is true. Sophisticated programing systems provide their own management and control functions and provide algorithms for the creation and elaboration of operational procedures. Thus the state of a system is always undergoing change, and a sophisticated user will create a configuration of the system that is uniquely suited to his own computational purposes. In short, there is room for both conformity and individuality within a framework that can sustain relatively rigorous specification.

Donald Broadbent, psychology's only Fellow of the Royal Society since Sir Frederick Bartlett, was at the leading edge of this movement with the publication of *Perception and Communication* (Pergamon Press) in 1958. In 1969 he presented the first Paul M. Fitts Memorial Lectures at the University of Michigan, and *Decision and Stress* fleshes out those lectures, giving an account of his subsequent quest for integration in this fragmented field of research. Inasmuch as the book is organized around the chronological development of the author's thinking since his 1958 work, it is appropriate to ask, "What's new?"

Experimental psychologists tend to generate "small world" theories having limited generality and to beat a problem into submission with data from every imaginable variant of a given experimental paradigm. Broadbent is a very able experimentalist himself and reports noteworthy experiments of his own on virtually every topic he discusses, but the most important thing that is new is his success in finding concepts that span the diverse areas of research to which this cybernetic approach has been applied.

The idea of a limited-capacity information channel is still fundamental to his view, as it was in 1958. Given limited capacity, the system needs means of economizing and sifting the information dealt with by this channel. In 1958 he relied almost entirely on the concept of "filtering"—the selective rejection of all but those aspects of environmental stimulation that are demanded by the current processing task. In *Decision and Stress*, he expands the means of economizing to include a redefinition of filtering and two additional, closely related mechanisms—"categorizing" and "pigeonholing." Defining these processes entails the further concepts "stimulus event," the set of features of external environmental stimulation; "state of evidence," an internal and possibly "noisy" representation of the crucial aspects of the stimulus event; and "category state," the representation of information at the output end of the limited-capacity system. Filtering is the process by which some aspects of the stimulus event come to be represented in a state of evidence, others to be omitted, and still others to be represented erroneously. In filtering operations there remains a one-to-one mapping between states of evidence and category states. However, when the selection is accomplished by categorizing instead of filtering there is typically a many-to-one mapping of stimulus events to category states directly that implies classification, decision, and choice. Finally, the organism adjusts the distribution of information assigned to various category states by the operation of pigeonholing, the author's homely term for the biasing of the assignment of states of evidence about stimulus events to category states.

Since 1958 Broadbent has become a strong advocate of the application of statistical decision-theory measures to the analysis of human performance. They form one basis for distinguishing among filtering, categorization, and pigeonholing. In psychophysical experiments and in watchkeeping (vigilance) experiments they reveal genuine changes in detection sensitivity. Broadbent ascribes these changes to filtering. Shifts in the observer's criterion for saying yes or in his confidence in a given response are considered to be pigeonholing adjustments. In selective-attention experiments (to use Broadbent's illustration), the instruction "Listen to this voice and repeat whatever it says regardless of any other sound you

hear" calls forth the filtering process, and the instruction "Listen to this medley of voices and repeat any digits you hear" emphasizes the capacity for pigeonholing. Here again decision analysis is shown to be useful. In commenting on theories of the speed of decision or reaction time Broadbent argues that adjustment to produce more efficient reaction to more probable signals is predominantly one of pigeonholing or decision-criterion adjustment, but that some filtering may also be operative.

The contribution of these concepts and of the attempt to broaden applications of decision theory to human performance is not so much one of new explanatory power; many investigators have made the same or corresponding distinctions in their own specific domains of interest. Rather their importance lies in the introduction of the *same* concepts across the whole range of human performance from sensory detection and response choice to reactions to environmental stressors.

The author argues for the research strategy of defining large classes of theories and systematically eliminating alternative classes on the basis of experimental evidence. There is some of this in his book, but he is also willing to extrapolate his inferences into regions where the evidence is fragmentary. He is usually careful to label these forays into the unknown for what they are, and they frequently provide the most stimulating passages of the book. In spite of his predisposition toward systematic hypothesis elimination, one gets the feeling that he does not find that nearly so much fun as the complementary process of formulating his own explanations of puzzling data.

Broadbent does not shirk his responsibility to take a position on virtually all the standard issues concerning human information processing. On the paradox of selective attention—how is it possible to select for processing certain aspects of a stimulus event and reject others without having already analyzed the stimulus to identify the aspects to be selected?—he supports Anne Triesman's arguments that attenuation or filtering takes place and that the category states can be biased to be excited more easily for highly probable signals. Thus, in his terms, the paradox is explained by a combination of filtering and pigeonholing. The fact that in tachistoscopic experiments words occurring frequently in the language are more easily perceived than less common words he attributes entirely to response bias or pigeonholing; but concerning the reduced probability of seeing emotionally charged words—the phenomenon of perceptual defense—he remains equivocal, except to argue that it is different from the word-frequency effect. He tends to support a statistical decision model of evidence accumulation as an explanation of variations of speed of decision or reaction time, and adheres to the robust version of Alan Welford's limited-channel-capacity theory as an explanation of the psychological refractory period, the tendency for the response to the second of two closely spaced stimuli to be delayed.

In his discussion of the issues surrounding the distinction between long- and short-term memory he introduces the concept of an address register that provides storage of the access points for information in either the long- or the short-term stores much like indirect or associative addressing in a computer. This notion provides a mechanism for introducing some of the subtle ways of employing selective address-coding cues or tags to enhance or inhibit the recall of certain items or classes of items. It is responsive to the current interest in forgetting as a failure of retrieval and makes the concept of pigeonholing meaningful in the analysis of memory.

For a book by an information-processing specialist, particularly one with interests in practical applications, Broadbent's earlier book, *Perception and Communication*, was notably challenging to any reader's information-processing talents. In *Decision and Stress* he has provided a glossary, has worked hard to achieve clearer explanation of the fundamental ideas, and has been generous with homely analogies. Nevertheless, the material is densely packed, and concepts such as pigeonholing may remain elusive for all but the most dedicated reader who devotes all of his processing capacity to the task.

One might reflect on the question of whether it is ever wholly feasible to survey and structure an area of research that is as broad as the one Broadbent has tackled. That it is a difficult task is evidenced in the fact that, except for occasional footnoted references to later work, it is apparently material available to him in 1967 that formed the basis for this book. Some conspicuous gaps result; for example, the work on memory search by Saul Sternberg and by many subsequent investigators is not mentioned. For an author of Broadbent's capabilities one must conclude that it is the complexity and breadth of the material as well as the strong theoretical treatment that account for the long lag between collection of the data base and publication. Greater timeliness certainly would be desirable, but I found myself sufficiently challenged by the data and theory he reports to want to examine how he *would* assimilate the new facts, and repeatedly that sent me off on yet another of those entertaining chains of digression that characterize one's interaction with a stimulating book.

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The Unfolding Nervous System

Developmental Neurobiology. MARCUS JACOBSON. Holt, Rinehart and Winston, New York, 1971. xiv, 466 pp., illus. $12.95. Holt, Rinehart and Winston Developmental Biology Series.

Question: when is a brain not a brain? Answer: during development. Through an incredible orderly progression of morphogenetic steps, the primordial cells, which start out as a simple flat plate of neuroectoderm, evolve into a stupendously complicated system of interacting neurons. The search for the underlying cellular and molecular signals that control this biological spectacle has tantalized the best minds in the brain business for the last century. Yet, the mysteries of the developing nervous system remain largely unsolved and developmental neurobiology must still rank as an "endless horizon" open for exploration.

The apparent lack of progress does not stem from a lack of serious experimental effort, for some of the most ingenious and sophisticated of biologic manipulations have been brought to bear on this problem. To the technical and conceptual achievements of Ramón y Cajal, Harrison, Detwiler, Weiss, and Hamburger, the last generation has added thymidine autoradiography, cellular electrophysiology, and genetic pathology. In fact, through combinations of these latter approaches the processes by which the cerebellum, the olfactory bulb, and the hippocampus attain their adult forms have been very fully described.

With this book Jacobson has attempted to review selected portions of a great number of experiments on the