Human Information Processing Achieves Handbook Status

W. K. Estes (Ed.)

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IT seems particularly appropriate that information processing should achieve handbook status at about the time that it is being most heavily bombarded by both disenchanted disciples and vigilant skeptics. This handbook helps fortify the information-processing framework and makes transparent the highly important contributions of the productive union of formal theory and empirical research in the study of cognition. Although the chapters are independent contributions, the common information-processing framework allows a highly pedagogical presentation of how psychological processes are studied.

Estes places the information-processing approach within the domain of the study of cognitive processing and sets the stage for at least four of the seven following chapters. Some of the topics in the introductory chapter recur in the following four chapters. One important distinction is between structure and process. The structural concepts provide characterizations of the information

preserved at a particular time of cognitive processing. Processes in information-processing models are operations that change the structure. Chase focuses on the measurement of the time for these processes. Donders's subtractive technique and the additive factors method are used to study mental operations that manipulate information held in various memory structures. Turvey continues the distinction between structure and process in the study of visual processing by analyzing the properties of iconic storage and the operations that transform and manipulate this information. The nature of iconic storage is shown to differ from more elaborate visible representations and relatively abstract nonvisible representations. Posner and Rogers maintain the distinction by being primarily concerned with the structural codes in information-processing tasks and the implications that these codes have on processing. Shepard and Podgorny continue the distinction with their interest in the nature of perceptual representation and the mental transformations of these representations. Although structure means something different to Greeno in his analysis of problem solving, he values the information-processing approach because it allows specific assumptions and tests about the cognitive processes involved in performance. To Simon, structure of the task environment and problem space are components in problem solving.

Chase provides the reader with a lovely pedagogical treatment of measuring the time for mental events. The chapter is beautifully organized and begins with a historical treatment of Donders's subtractive method. A quick review of Broadbent's filter theory and information theory sets the stage for

viewing humans as information processors. After presenting Sternberg's revision of the subtractive technique, Chase provides a detailed discussion of three experimental domains. The first is a verification task in which people decide whether a verbal description matches some visual display, the second involves semantic memory search, and the third involves quantification judgments, such as subitizing, counting, and estimation. In all of these areas, Chase instructs us on how the information-processing approach allows the quantitative measure of the time for a mental process. The time for mental processes in these various tasks illuminates the nature of processing. For example, when subjects are asked to name how many objects are present in the visual field, reaction time increases with increases in the number of objects. However, the rate of increase is much less for increases up to three or four objects relative to the increases in excess of three or four objects. The time differences are taken to reflect the limitation in short-term memory capacity.

TURVEY updates his influential *Psychological Review* article of five years earlier by reviewing the literature since that time and introducing the concept of field theory. After setting the stage with the prototypical information-processing model, he feels it is necessary to examine the well-known example from artificial intelligence research on how a machine identifies three-dimensional objects in a two-dimensional display. The point to be learned from this research is that a unidirectional mapping of lower to higher representations is not sufficiently powerful to capture visual information processing. In the research that follows, however, this issue does not appear to be addressed. Turvey explores the properties of the icon by first considering studies of information persistence and studies of phenomenal persistence. This distinction is important since it makes apparent the fact that informational persistence does not necessarily imply phenomenal persistence.

Turvey then goes on to develop the idea of visible and nonvisible visual representations. The visible representation is maskable, of indefinitely large

capacity, and very brief whereas the nonvisible visual representation is non-maskable, of limited capacity, and temporally substantial. This distinction is an important one and is reminiscent of Gibson's distinction between the visual field and the visual world, and corresponds to my distinction between preperceptual visual storage and synthesized visual memory. The structure process difference recurs when Turvey makes the distinction between the informational capacity of the icon and its persistence relative to the process responsible for transforming iconic storage to short-term memory. However, what is not made explicit is that a formal model is necessary to separate these two components. Turvey also explores the concepts of integration and interruption in masking. The most innovative contribution in Turvey's chapter is the introduction of two-field theory taken from an analysis of temporal relations in movement by Golani (1977). Using this framework, the standard forward-masking and backward-masking paradigms are placed in the framework of a large number of possible relationships between two signals. This classification is helpful and might also set the stage for a better integration of information-processing research and visual psychophysics.

Posner and his coauthor Rogers discuss his highly productive research on utilizing mental chronometry in the study of the time course of information flow in the nervous system. Posner is highly tied to structural concepts in his research and this is partly due to the fact that he views the early stages of information processing as a relatively passive process independent of the generation of hypotheses, expectancies, or other active control strategies. His value of codes is made transparent by beginning with the presentation of the La-Berge and Samuels bottom-up multicode model. Then they discuss many of his well-known experiments carried out on analyzing physical and phonetic codes. However, it is not clear why the first code is called *physical* when in fact *visual* or *perceptual* would be more appropriate terms. *Phonetic* seems to be an equally bad choice for the second type of code since there is no evidence that the code is phonetically based.

Posner and Rogers present a plethora of evidence for the distinction between these two kinds of codes. Most of this work has come from Posner's laboratory and other derivative research. They briefly mention work in auditory information processing in this area but fail to mention much of the relevant work carried out in the last three or four years. Then they turn to the study of psychological pathways and the activation of pathways producing facilitation and inhibition or benefits and costs in information-processing tasks. They end the chapter by adumbrating how mental chronometry can be used to study conscious experience by briefly discussing some work on attention bias and visual capture.

SHEPARD and his coauthor Podgorny continue their highly productive study of the perceptual dimension of cognitive processing or a psychophysics of mental representation. They begin with a distinction between symbolic stimuli and nonsymbolic stimuli. They explain that it is possible to shift a color (e.g., blue) gradually into another color (e.g., green) but it is not possible to transform continuously the word *blue* into another word, *green*, without passing through intermediate configurations. This example is arbitrary, however. It is also easy to change the printed word *cast* gradually into the word *east* without going through any intermediate words and difficult to go from the color green to the color purple without going through intermediate colors. Their example seems to fall short of trying to make a primitive distinction between symbolic and nonsymbolic stimuli.

Traditionally, psychophysics has been carried out when stimuli are actually present. Shepard's innovation is that he is doing the psychophysics of stimuli that are no longer present and, in fact, are presented to the subject symbolically. However, only a direct realist would believe that there was a basic difference between the study of psychophysics in these two situations. Research showing that similar results are found when stimuli are no longer present and when stimuli are actually present is not surprising to this reviewer. Any com-

parison between two stimuli involves comparisons of perceptual experiences and memory of the stimuli whether or not they are physically present at the time of comparison.

Shepard and Podgorny's chapter is a model of how theory and research function in information processing. There is no paucity of data in this chapter and the reader who desires a tutorial in this area can do no better than to study this chapter. My only complaint is that —in apparent contradiction of the authors' commitment to perceptual processing—the chapter is completely devoid of any visible representations.

GREENO states that the main new content of his contribution is a typology of problems based on hypotheses about the general kinds of psychological skill and knowledge needed to solve the problems. He specifies three kinds of problems: problems of inducing structure, of transformation, and of arrangement. The first involves identifying a pattern of relations among the elements as, for example, in an analogy. The second requires a transformation going from the initial situation to a goal and the third requires the arrangement of elements in a way that satisfies some criterion as, for example, in solving an anagram. Greeno argues that the major advances in the psychology of problem solving during the next several years will involve relationships between problem solving and learning. He proposes studying processes of learning that result in new procedures for problem solving or to study learning that results from successful problem solving.

The relation of problem solving to other areas of study in cognitive psychology, such as perception in short-term memory, seems more tenuous to Greeno, and he argues that it does not seem optimal to engage in detailed study of the mechanisms that are used to retrieve and store information during problem solving until we have a better knowledge of what that information is. This seems to contradict his statement that one should study processes of learning because it has been demonstrated that coding and storing information are critical components involved in learn-

ing, and that the nature of learning is best illuminated by dissecting the learning process to allow an evaluation of each of the stages of information processing involved in the learning situation. Furthermore, Greeno argues that understanding problem solving will probably be more dependent upon areas of language understanding and question answering that are also concerned with issues of representing knowledge rather than with theories about basic processes of perception and memory. This contrasts sharply with Shepard's conclusion that the more we learn about perceptual processing the more we are likely to learn about cognitive function. In fact, one can conceptualize many of the experiments in Shepard and Podgorny's review as miniature problem-solving situations in which the perceptual component plays an important role. Perceptual and memory components have also been shown to be critical in language understanding.

nents: a condition component, which consists of a set of tests to apply, and an action component, which executes the action of the production. In one simulation program, the model views problem solving as a subject employing two complex processes: an understanding process, which generates a problem space from the text, and a solving process, which explores the problem space to try to solve the problem.

In the final chapter of the book, Chant and Atkinson apply learning models and optimization theory to the problems of instruction. They review the development and application of mathematical models that help the pedagogical decision maker with maximizing learning in the applied situation. When a student is asked to learn a list of paired-associate items (e.g., in learning a second-language vocabulary), it is possible to derive optimal presentation strategies from different learning models. One strategy would emphasize those items

that are not yet learned. Another strategy would give each item equal weight regardless of the apparent learning of the items. These models are valuable and allow direct tests in both experimental and applied situations. The only relationship of this chapter to the information-processing framework that I can determine is that of using formal models.

THE first three volumes in this series presented overviews of conditioning, discrimination, learning, motivation, verbal learning, and memory. The last three volumes can be characterized by a wide coverage of active research programs in perceptual and cognitive processes. As handbooks go, this series ranks at the top and this volume certainly provides the core cluster of theoretical ideas, concepts, and methods of contemporary research in cognition that the editor hoped to communicate.

SIMON, who recently won a Nobel Prize in economics, discusses human problem solving in the framework of an information-processing theory. The research has relied on the methods of computer simulation and the analyses of thinking-aloud protocols. Problem-solving behavior is viewed as an interaction between an information-processing system, the problem solver, and the task environment (i.e., the task described by the experimenter). In contrast to Greeno's metatheory, Simon relies heavily on developing a picture of the human information-processing system from experiments in perception and memory, and allows an important role for perceptual processes, especially recognition processes. He cites some of Greeno's work that supports the contribution of perception and recognition in solving geometry problems. Recognition processes, according to Simon, play a crucial role in determining when enough information is available to establish the value of a variable in cryptarithmetic and when enough values have been established to reach the problem goal. Simon also relies on the idea of production, which is a process of two compo-

A Critical—But Sympathetic— View of Issues In Psychiatric Diagnosis

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Critical Issues in Psychiatric Diagnosis. New York: Raven Press, 1978. Pp. xi + 343. $25.00.

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THIS is the second volume of proceedings from an annual meeting of the American Psychopathological Association that I have reviewed for this journal (see *CP*, 1977, *22*, 5–6). I have also read other volumes from the same series. As before, I am struck by the high quality of the papers presented, the scope of the issues considered, and the coherence and critical acumen of the editors' synthesis. While psychologists will take serious issue with some of these papers—I did with a couple of them— no one can dismiss the work as unimportant or uninformed. As a cogent "state-of-the-art" of thinking on diagnosis by authorities in diverse fields, the book is a nonpareil.

The volume—and the 1976 meeting at which these papers were presented— is divided into four sections. The first —an effort to define mental illness in a way that will lead to consensus across both professions and disorders—includes separate definitional attempts by the book's coeditors as well as by psychologist Kurt Salzinger (whose approach is behavioral rather than, like theirs, symptom centered), along with a fascinating exercise in cross-cultural relativism by anthropologist Jane Murphy. The second section, of primary interest to many of the readers of this review, attempts to assess the role of psychological testing in psychiatric diagnosis. It includes papers on projective testing and diagnosis by Margaret Singer, on projective tests for psychodiagnosis of children by Rachel Gittelman-Klein, and on "illusory correlation" by Loren and Jean Chapman.

The book's third section surveys the place of genetic studies as validators of diagnosis. Included are papers by Crowe on genetic studies of antisocial personalities, by Tsuang on family studies of schizophrenia and affective disorder, by Kety, Rosenthal, and Wender on genetic studies of schizophrenia subtypes, by Donald Goodwin on the genetics of alcoholism, and by Gottesman and Golden on technical problems associated with research of this kind. The volume concludes with a section on laboratory validation methods, including the EEG (by Fink), amine neurotransmitter studies (by Cowdry & Frederick Goodwin), evoked potentials (by Sutton & Tueting), and neurotransmitter-related enzymes (by Murphy & Buchsbaum).

To BEGIN what will almost certainly be one of the most hotly debated of the volume's papers, psychiatrist Robert L. Spitzer and psychologist Jean Endicott relate that "we eventually came to believe that mental disorder should be defined as merely a subset of medical disorder" and that, accordingly, definitional efforts should be directed toward "defining the broad rubric of medical disorder." Since Spitzer (as Chair of the American Psychiatric Association's Task Force on Nomenclature and Statistics) is one of the principal architects of DSM–III, whose vastly expanded purview has generated a great deal of controversy, this statement has special significance. Even though Spitzer and Endicott continue their paper by acknowledging the problems such a definition of mental disorder might cause, the fact that they consider the position a viable one is nonetheless worthy of note. Also controversial to the psychologist is their view that the hallmarks of a medical disorder (negative consequences of the condition, an inferred or identified organismic dysfunction, and an implicit call for action) need not assume "that the organismic dysfunction or its negative consequences are of a physical nature." By broadening the concept of mental/medical disorder to include nonorganismic dysfunctions smacks of unempirical empire building, some would say. Yet much of the rest of what these authors have to say—and the facility and precision with which they say it— will appeal to the psychologist impatient with fuzzy diagnostic concepts and imprecise definitions.

Following this paper is one by Donald Klein, coeditor of the volume. Among the issues with which he deals in his effort to define mental illness better are the self-ascribed and assigned roles that effectively exempt some of us from responsibility for our own behavior, the role that suffering plays in defining illness, the similarities and differences in "functional" and organic illness, and the roles that unhappiness, social deviance, and ego dystonicity and syntonicity play in defining mental disorder. The reach is broad and sweeping and the concepts considered are intriguing. At the least, Klein accurately portrays the diagnostic enterprise as overwhelmingly complex, even chaotic; at the most, he offers a schema for definition that is thoughtful, considered, and realistic.

OF special interest to psychologist readers of this volume will doubtless be the extended section on the role of psychological testing in psychiatric diagnosis. While the projective test pioneers, including Rorschach and Murray, were emphatic in their belief that their creations ought to be used to explore personality rather than assign diagnostic labels, generations of psychodiagnosticians have chosen to ignore their advice. With what validity has this decision been made? According to Singer, progress can be measured in terms of increasing reliability of the criterion diagnosis against which the projective test diagnosis is to be compared, the increasing sophistication of efforts to elucidate the levels of personality and dimensions of behavior the projectives tap, and increasing efforts to develop more appropriate statistical procedures for analyzing resultant data. But can the Rorschach differentiate subtypes of schizophrenia and neurosis? Not yet, Singer believes, but it is on the way to identifying conceptual style differences that may have essentially the same result. Gittelman-Klein's overview of the diagnostic validity of projectives (*and* the WISC) with children is much less hopeful: "Anyone who still claims that the WISC subtest scatter is relevant to personality diagnosis or psychopathology has to catch up on some read-