CHAPTER 4
CONTRIBUTIONS OF THE PSYCHOLOGICAL SCIENCES

4.1
PERCEPTION, COGNITION, AND INFORMATION PROCESSING

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INTRODUCTION

Psychology, as the scientific investigation of behavior, has a long history of over 100 years of experimental studies of both normal and abnormal behavior. Much of this research consists of studies of sensation, perception, and cognition. By sensation is meant simple (unembellished), immediate, conscious awareness by a person of both external and internal stimulation. It consists of a response to an amorphous energy stimulus with minimal signal and symbol information. Perception refers to the use of the senses to obtain information about the environment, its objects, events, and conditions. It consists of a response to a stimulus with signal or symbol informational value or both. Cognition refers to obtaining, organizing, and utilizing sensory and perceptual information from the environment, from past experience, and from such mental activities as plans and strategies. Examples of cognitive activities would be memory, problem solving, thinking, and language. Although these distinctions among types of behavior have some didactic value, they sometimes are difficult to make in actual practice.

Sensation, perception, and cognition have long been regarded as important factors in psychopathology because much of the phenomenology of psychopathology can be related to deviations in these areas. These three domains have been treated in textbooks of psychiatry in two ways: first, by phenomenological description and, second, by reports of experimental evidence of disturbances in these domains. The phenomenology of psychopathology is replete with descriptions of deviations in sensory and perceptual behavior (hallucinations) and in cognitive behavior (delusions), and such deviations have often served as starting points for experimental investigations of psychopathology. Until recently, however, the experimental work has lacked a systematic coherence. Most of the experimental findings in the psychopathology of sensation, perception, and cognition may be laid at the door of serendipity, arising unexpectedly in the course of investigations aimed at other goals.

In this section, the authors propose to survey the relation of sensation, perception, and cognition to psychopathology in a systematic way by providing a uniform framework for studying deviant behavior. This framework is the recently developed human information-processing approach, which enables a more systematic and direct search for the sources of psychopathological deviations in behavior. The goal of information-processing investigations is to elucidate how incoming external stimuli or internally engendered stimuli enter the central nervous system (CNS) and eventuate in some kind of final response. That is, information processing investigates how incoming stimuli are transduced, selected, coded, stored, and transmitted through the CNS. Information processing can be regarded as an organizing principle, a way of conceptualizing some of the dynamic complexities that are known to characterize human behavior. To carry out the purpose of this section, some portion of the experimental literature in the field of psychopathology must be omitted because it lies outside the realm designated as information processing. Examples of the data that conform to the information-processing framework are included, however, and indicate how the remaining data may eventually be incorporated.

INFORMATION PROCESSING

What exactly is meant by human information processing? Perhaps the best way to answer that question is to consider an example of a simple behavioral act, such as obtaining and retaining a telephone number from the information operator. By describing and analyzing this event, one can define the terms and clarify the nature of the human information-processing approach.

Individuals contact the operator and give the name and address of the person they wish to call. The operator gives them the requested telephone number. They may respond: "Operator, you did say that the number is 734-2959? One moment. Let me find my pen to write it down. Oh, here it is, 734, 29, 29. Oh, no ink!!! 734, 29, or was it 59? Let's see, 2959, Operator, you said, 734-2959, didn't you? Thank you."

What does this example illustrate about information processing? What terms or definitions are used to describe this entire transaction? First, the operator speaks the seven numbers to the callers, so primarily this example is of auditory processing. The numbers are the auditory stimuli. The operator, in speaking to the callers, is beginning a chain of events and processes between the presentation of the auditory stimuli and the callers' response to them, which in this case is to write the numbers down on a piece of paper. This apparently simple act entails a large number of stages and controlling or modifying processes between the stimulus and the response.

What stages and processes are involved in this example of remembering seven numbers? The first stage has to do with sensation. This initial processing stage is called sensory registration; specifically, in the auditory case, it is called echoic memory. The physical energy of the telephone operator's utterances coming over the telephone lines is translated (transduced) into electrical impulses in the nervous system of the listener (caller). Specifically, the auditory vibrations from the telephone receiver stimulate the listener's ear and thus generate electrical impulses in the acoustic nerve. These sensory impulses are transmitted to the cortical level, where they are perceived as a simple sensory message; namely, as a phonetic
sound. At this sensory state, however, the sound is not necessarily categorized as a number; it simply remains a sound without any informational signal or symbol value.

If no further processing is to be done to the sound stimulus, such as ascribing meaning to it by labeling it as a letter or a number—a process called pattern recognition—then the sensory memory for the sound decays and the sound is not remembered. A large amount of auditory sensations to which people are subjected are not processed beyond the stage of sensory registration. Everyone is constantly bombarded by many more stimuli than they can or do respond to. These stimuli are ordinarily regarded as "noise."

If the sounds heard on the telephone were not the numbers that callers were expecting to hear from the operator but, instead, were a surge of static sputterings in the lines, the callers would not hear them, or at least would not pay much attention to them. Obviously, the expectancy to hear numbers is controlling, in part, what is heard. This fact illustrates the importance of attentional factors in information processing. Attention is a major influence on what is or is not processed, as well as how it is processed.

In this instance, because the callers are expecting to hear numbers from the operator, they presumably would process the sensory memory (the phonetic message) until they recognized the phonetic sounds as numbers spoken in English. This next stage of processing is perceptual and is called pattern recognition. When the phonetic sounds are given a meaning by the listeners, auditory pattern recognition has occurred. In this stage, the stimuli are first identified as numbers and next are recognized and remembered as particular numbers. Pattern recognition is accomplished by a comparator-type process in which the stimulus patterns to be identified are compared with patterns previously stored by the listeners as part of their long-term and short-term memories.

The next stage of processing is short-term memory, which is a cognitive process that follows pattern recognition. This memory has to last long enough for the numbers to be written down. Therefore, to help the callers remember, they repeat the numbers, or some of them, to themselves several times. This rehearsal is one of several ways in which they can facilitate memorization. Without rehearsal, their sensory memory of the phonetic sound following pattern recognition would decay rapidly.

The above example illustrates an information-processing analysis of a simple behavioral act and some of the terms used to describe it. A more general but important question is, what is the purpose of analyzing behavior using the information-processing approach? Of what value might it be, especially with regard to understanding psychopathology? One answer is that people do not remember phone numbers with equal facility. Some persons, such as the mentally retarded or the senile, may not be able to remember even one or two of the seven numbers. By analyzing the process of remembering the seven numbers into its component parts, one may better understand which stages or processes differ for the retarded or the senile as compared to most normal people. Does it occur at the sensory stage so that the incoming energy is not heard, or at the perceptual stage where pattern recognition takes place, or at the cognitive stage when it is stamped into memory? Or is the nature of the problem an attentional one involving an inability to focus or maintain attention during the behavioral act of remembering the numbers?

The authors' premise is that information processing in mental patients is different than in normal persons. The study of such differences requires investigations of where, when, and how the deviations in psychopathology occur in relation to the findings from controlled laboratory investigations of information processing in normal persons. Such knowledge could be invaluable to investigators in considering different aspects of the diagnosis and treatment of psychiatric patients, because it is possible that the various diagnostic entities show deviations that characterize different stages of information processing.

Some theorists have proposed that basic disturbances in information processing may constitute a fundamental component of vulnerability to psychopathology. Those disturbances in information processing may be permanent characteristics of the individual and may both antedate and postdate the onset of psychopathology. Such deviations may interfere with everyday normal activities and expectations and may help to explain why the experience of daily events assumes the bizarre and terrifying characteristics observed in psychosis.

Disturbances in sensation, perception, and cognition that have been observed in the laboratory have also been observed clinically. Kraepelin described schizophrenic patients as having difficulty in shifting attention, a kind of perseverative behavior influenced by the patient's rigid fixity of focus on some trivial portion of the environment. Some clinicians have described a pattern of overinclusion or difficulty in selective attention, a breakdown of the ability to filter relevant from irrelevant information. Others have suggested that, whereas acutely ill patients may be unable to filter out irrelevant thoughts and sensations, chronically ill patients may have learned the defense of selective inattention, narrowing their focus down to a reduced sphere.

Patients' subjective accounts provide a great wealth of detail about the way in which the experience of daily events are altered in psychopathology. Accounts of disturbed attention and perception are linked with various symptoms. It is easy to understand schizophrenic loosening of associations in relation to an inability to filter relevant from irrelevant perceptions and thoughts. Even the experience of auditory hallucinations may reflect an inability to discriminate external events in the environment from subjective thought processes.

The following description of a patient's subjective experience appears in Secheyeye's Autobiography of a Schizophrenic Girl:

One day we were jumping rope at recess. Two little girls were turning a long rope while two others jumped in from either side to meet and cross over. When it came my turn and I saw my partner jump toward me where we were to meet and cross over, I was seized with panic: I did not recognize her. Though I saw her as she was, still it was not she. Standing at the other end of the rope, she had seemed smaller, but the nearer we approached to reach each other, the taller she grew, the more she swelled in size. I cried out, 'Stop, Alice, you look like a lion; you frighten me.'

Although Secheyeye might have preferred a more psychoanalytic explanation, it is possible that the young girl's frightening experience might be simply explained as a perceptual distortion, a disturbance in her size constancy. Size constancy is a phenomenon that makes two objects that are equal in size and presented at different distances appear to have the same size, despite the differences in the size of the retinal image cast by the objects at the two distances. If failure of size constancy were the cause of her difficulty, one is still left with the need to explain why and how the disturbance in size constancy developed, but at least one would be dealing with a precise and testable explanation.

In spite of the obvious possible relationship between such clinical manifestations and deviations in attention and information processing, disturbances in processing as an explanation have not generally captured the interest of psychopathologists. Cromwell contends that the long-standing empha-
sis on clinical symptoms in psychopathology research is not because those symptoms are important etiologically, prognostically, or therapeutically, but because they are intolerable; they create problems for the patient and for the community. Although primary consideration has been given to such clinical symptoms for eight decades, little genuine understanding, prevention, or amelioration has resulted from this emphasis. Obviously, there is a great need for alternative approaches to understanding mental illness. The information-processing approach is one such alternative and it has been receiving considerable interest in recent years.

SURVEY Information-processing approach Haber has referred to the information-processing approach in psychology as a “revolution,” one that has caused a fundamental change in the way psychological research is carried out and the way ideas about behavior are formulated. That revolution has had major repercussions in the areas of perception, cognition, memory, learning, thinking, and problem solving. It offers a relief from the rigorous but static stimulus-response paradigm that characterized much of academic psychology during a period beginning with Watson’s behaviorism and continuing through World War II. It also promises to be a good contrast to the prevailing psychodynamic and other explanatory models in psychopathology.

Processing and information theory The term “information” in information processing can be traced to an early attempt to apply a theory of communication engineering to selected problems in psychology. Mathematical information theory attempted to define the transmission of informational bits in relation to the reduction of uncertainty in arriving stimuli. The formal definition of information was independent of both the stimulus and the response and was focused merely on transmission. This approach has not been particularly successful in the fields of biology and psychology, and interest in it in these fields has receded in recent years.

Processing and computers The emergence and use of electronic computers after World War II was another major influence in the development of information-processing research, especially for those aspects in the cognitive domain involving complex behaviors, such as problem solving and thinking. Today, computer technology is used to investigate such diverse topics as artificial intelligence, problem solving, rote verbal learning, and performance on different tasks, such as concept attainment and sequence extrapolation.

Processing as a sequence of events over time The processing of stimuli involves an ongoing series of events that occur over time. It is assumed that the time from the stimulus to the response can be divided into a sequence of discrete stages. During each stage, different operations are performed to transform and transmit energy and information. The objective of this type of research is to devise methods by which the flow of stimulus energy and information can be monitored and sampled at various time points to determine which operations occur sequentially (serially) and which occur simultaneously (in parallel), how and when and where in the CNS the energy and information are transformed or recorded, and where they are lost. This description of information processing is the one most closely related to the types of investigations to be considered throughout the remainder of this section.

ADVANTAGES AND DIFFICULTIES OF THE PROCESSING APPROACH Studying processes in terms of their temporal characteristics has several advantages. It makes time the common metric, allowing the comparison of a number of otherwise independent and dependent variables in terms of time, or the grouping of phenomena according to a common temporal metric. Because nontemporal measures in experimental investigations have been found to differentiate between normals and patients, or among types of patients, nontemporal measures remain of potential importance, even though they will not be discussed here. Perhaps such nontemporal experiments might prove even more powerful if they were investigated using temporal parameters.

The major advantage of applying a processing approach to psychopathology is that it becomes possible to precisely specify the impairments of different patient populations. Until now, most behavioral research on psychiatric patient groups has been devoted to demonstrating the existence of group deviations in such areas as perception, attention, motivation, and thinking. Such constructs as attentional dysfunction and thought disorder illustrate the global and nonspecific nature of the conclusions that can be drawn from such research. The explicitly detailed and quantitative models of information processing—tracking the different processes from stimulus to response—and the sophisticated research techniques for measuring various parameters of those models make it possible, however, to obtain fine-grained knowledge of areas of deviant as well as of intact processing in psychiatric patients.

Unfortunately, theories that have discussed information processing in relation to abnormal populations have generally attempted simply to demonstrate that a particular aspect of processing is disordered among a specific clinical subgroup. These theories usually rely on secondary analyses of data from studies with widely varying theoretical perspectives for which the information-processing paradigm was not intended. Indeed, it has been suggested that it is virtually impossible to apply post hoc interpretations based on information processing to data collected for other reasons or within the context of other points of view. With the advent of more information-processing research designed explicitly to study abnormal behavior, this disadvantage should become less of a problem.

One disadvantage of the information-processing approach is the difficulty in specifying what is meant by key concepts, such as information. Generally, the term is loosely used to refer to those aspects of the stimulus with which the experimenter is concerned. Further, many processing experiments, especially experiments concerned with sensory processing, primarily involve stimulus energy in which stimulus information is either absent or minimal. To use the term “information processing” to describe what is primarily “energy processing” would misrepresent what is actually being processed. Therefore, in those studies in which energy changes are predominant, the authors prefer to speak of energy processing, rather than information processing. Most traditional psycho-physical studies entail energy processing.

DESCRIPTION OF PROCESS AND PROCESSING In the field of perception, reference is made to perceptual processes—events occurring over time in relation to some triggering or evoking stimuli. A process is not observable by itself. In any processing experiment, the only elements that can be directly observed and measured are the initiating stimulus and the resulting end-response. The intervening processes are hypothetical constructs; they cannot be directly measured but must, instead, be inferred. The nature of the inference is heavily influenced by the stimuli administered, the tasks given, and the responses measured.

Processing can be analyzed in terms of several general questions. First, what is being processed? What is the nature of the stimulus material presented for processing, and how do
differences in stimuli influence the types of processing that occur? The “what” question refers to whether the primary influence of the stimulus is due to its physical energy or to its information; that is, energy processing or information processing?

Second, where is the processing occurring? The “where” question can be approached experimentally by determining the levels or loci of processing. Where within the CNS do particular processes occur or, at least, display a major focus of activity? With respect to levels, the question translates into, does the activity occur, relatively speaking, peripherally or centrally, at the input or output? With respect to loci, the question relates to the possibility of there being lateralized, functional hemispheric asymmetries for different measures and types of processing. By using selected behavioral techniques, researchers attempt to determine whether different types of processing are primarily associated with right or left cerebral hemispheric functioning.

Third, when does a particular process occur? At what time after the stimulus presentation does a given process occur? That question has to do with the sequence of processing events. If one knew when the different processes occurred between the stimulus and the response, it would be possible to reconstruct the temporal order of events between stimulus and response—the flow of processing.

The last two basic questions concerning processing are related to each other and are discussed here in terms of the construct of attention. One question pertains to how much of the stimulus material presented to a person is actually being processed? That question relates both to the nature of the stimuli themselves and to the capacities and organismic state of the person to whom the stimuli are presented. The other question is how does processing occur? What are the mechanisms of processing? This question concerns the control strategies—the operations by which processing is modified or regulated, especially by complicated and diverse attentional mechanisms.

Processing can be divided into three domains: sensory, perceptual, and cognitive processing. Those domains are defined by what is being processed and by where and when processing occurs. Issues regarding how much is processed and how the processing operations are carried out apply across all three domains.

The key components of processing studies are a stimulus that changes in time or a response that is measured in time, or both. Stated differently, processing experiments have either or both independent or dependent variables specified in temporal units. The range of times manipulated or measured provides an indication of which type of processing—sensory, perceptual, or conceptual—is being studied. Such defining characteristics mean that not all research can be regarded as directly studying processing. For example, an auditory detection threshold study may or may not be a processing study. It will not be regarded as a processing experiment if the sound stimulus was fixed in duration or was presented continuously while the intensity of that stimulus was increased until the subjects reported that they heard it; in that case, time has not been varied or measured. It becomes a processing experiment, according to the authors’ framework, only when the duration of the stimulus is varied or when the response latency is measured.

Because it is postulated here that deviations or impairments in psychopathology are most clearly understood from the results of processing experiments, the distinction between experiments that do or do not measure processing becomes crucial. By manipulating the stimulus over time or measuring in time, each processing study provides a temporal referent that can contribute to a processing analysis of behavior. Such temporal referents also make possible the grouping and comparing of otherwise diverse experimental studies on the common variable of time. The basic questions about processing will now be considered one at a time.

What is being processed? Variations in the nature of the stimuli presented relate to the differences in what is being processed for the three domains of processing—sensory, perceptual, and cognitive. In general, both sensory and information domains are involved in the three domains, because energy is the carrier of information. Energy stimuli are those that can be defined completely with reference to their physical characteristics, e.g., wave frequency and amplitude for sound or wave length and intensity for light. The description of informational stimuli is more complicated. "Information" is a term used loosely to mean stimulus complexity or the amount of stimulus patterning. Informational stimulus displays are complicated; they are configurational or have sign or symbolic significance. In addition, the quality of information depends not only on the stimulus but also on the person's prior experience. Despite the vagueness of the term "information," it is used here to indicate some undefined or unspecified component conveyed by the stimulus, the nature of which varies from experiment to experiment.

Across the three domains of processing, there are differences with respect to the relative importance given to energy and information. Sensory processing is concerned with measuring the effects of the response of precisely varied amounts of stimulus energy, as in the field of psychophysics. These energy stimuli still carry information, albeit of a primitive or limited nature, e.g., the stimulus is amorphous, or the stimulus is simply present or absent, as in absolute threshold research.

At the other extreme, in cognitive processing, the major emphasis is on the information content of the stimuli, which may be quite complex. In cognitive research, energy is held constant at some level, so that energy changes do not confound the major interest, the effects of information on the response measures.

Perceptual processing falls somewhere between sensory and cognitive processing, depending on the particular perceptual study. Some perceptual studies are concerned with variations in the energy aspect of a stimulus; other perceptual studies are notable in that they demonstrate perceptual differences with constant energy (illusions), or they display perceptual constancies in the face of changing stimulus energies (size and brightness constancies). Of course, even cognitive processing entails sensory processes, which are dependent on energy, and perceptual processes, which are guided by both energy and low levels of information. For example, the response to a visually presented word may be thought of as first entailing the sensory processing of contrast and color; next, the perceptual processing of lines, angles, and letter forms; and, finally, the cognitive processing of the meaning of the word.

Where does processing take place? Any systematic discussion of processing introduces questions about the underlying physiology or the physiological correlates of processing. Several processing models have been proposed to describe CNS functioning, but models that relate to both physiology and behavior are the less complex. Approached behaviorally, the question of physiological localization can be viewed in at least two ways. The first approach, the level on which processing takes place, considers whether the processes occur relatively more peripherally or centrally in the nervous system. Various experimental paradigms and testing procedures allow one to make rough inferences about the peripheral and central balance for given processes. The second approach, the specific locus of processing, considers in which hemisphere of the brain the process is located. By certain testing procedures—for example, dichotic listening and tachistoscopic hemifield presentations—it becomes possible to obtain estimates of the relative efficiency or speed of processing of the right and left cerebral hemispheres.

When does processing take place? Processing approaches assume that a sequence of stages takes place between the presentation of the stimulus and the subsequent response. Generally, the stages can be described as (1) the input stage, at which the energy and information components of the stimulus are incorporated; (2) the classification process in the brain; (3) the organization of the classified components; (4) the interpretation of what has been processed; and (5) the output stage, which culminates in the response. That description assumes a simple linear direction in time, but the process is actually much more complex. The number and the types of stages involved may differ for different types of stimuli, for different tasks, and for the person at different phases of practice or experience, as well as for different organismic states.
The three processing domains: The three general domains of processing—sensory, perceptual, and cognitive—can be characterized in general ways. First, they approximate a traditional division among psychological concepts. Second, each domain relates to a different time period after the presentation of the stimulus. Thus, sensory processing refers to the immediate poststimulus periods of time, usually for periods of up to a maximum of 1 second. Perceptual processing refers to slightly longer periods of time after the stimulus presentation, periods of up to about 5 seconds. Cognitive processing refers to still longer periods of time after the stimulus presentation, and the exact type of cognitive processing depends, in part, on the duration of the phenomenon under consideration. Such specific temporal distinctions are, of course, only approximate and are subject to modification. Further research should help to clarify whether processes should be grouped together or what time periods are believed to represent similar phenomena.

Third, the three processing domains can be distinguished according to the nature of the stimulus material. The applied stimulus can be either the actual stimulus—by which the organism is exposed—or an artifact that is derived from the stimuli. The intensity of the artifact depends on the physical characteristics of the stimulus, such as its intensity—or of the signal type, in which case the response depends more on the accurate meaning or significance of the stimulus. Studies of sensory processing usually entail the simplest stimuli, such as flashes of light and noise bursts. Experiments on cognitive processing usually employ the complex stimulus displays, involving words or sentences with signatures of time pressure. The nature of the stimuli associated with perceptual-processing experiments generally lie between the simple sensory stimuli and the more complicated cognitive stimuli. For example, shapes, dot-configurations, or patterns of notes (music) are used in perceptual-processing experiments. The above description of the three domains of processing—sensory, perceptual, and cognitive—were characterized along various structural dimensions, such as exactly what is processed and where within the organism the processing occurs. Finally, the combination of the “where” and “what” processing assumed that the structures responsible for processing in each domain could be localized, at least relatively, as to whether they were more central or peripheral in the nervous system; moreover, a more precise localization of the relevant physiological substrates or how each domain may eventually become possible. The discussion of the “when” of processing assumed that the processing activity in the key loci is greatest at certain specifiable time points after the application of the stimulus. Thus, we can hypothesize one of the underlying assumptions of each domain are wired in structures that are invariant from one organism to the next within a given species and from one situation to the next. Such structures may be analogous to the hardware of a computer that performs the input-process operations.

How processing takes place and how much is processed In addition to the structural dimension, processing activity may also be described in terms of certain control mechanisms, such as attention. Control procedures describe what is done to the incoming information, how operations are ordered, or how processing is carried out. Some examples of control procedures are searching, filtering, pigeonholing, categorizing, and rehearsing. Control procedures are analogous to computer programs or software that govern what is done and how specific tasks are performed on the computer or on processing information. These procedures are more transitory than processing structures; they vary from one person to the next, from one situation to the next, and from one moment to the next. Some control procedures can affect how much others in terms of the demands they place on processing structures. One may think of control procedures as varying in their requirements for capacity of computer memory. The concept of processing capacity refers to the question of how much of the incredible number of energy and information changes to which the organism is continuously subjected, how many can be processed? Some limitations on processing are imposed by limits on the capacity of information-processing structures. Just as there is no computer with hardware adequate to handle all the simultaneous jobs that could be entered in it, no organism is structurally equipped to process all the information-processing tasks that life imposes. Thus, limitations in processing capacity reflect the constraints of structure, as well as the constraints imposed by the functioning of ongoing control procedures.

Many theorists have proposed that, in some psychopathological disorders, patients may experience information overload because processing demands exceed available capacity. Overload may result for four reasons: too much information input, deficiencies in information-processing structures, interference of certain control mechanisms or procedures, or inefficient allocation of processing activities among simultaneous control procedures. These formulations of information overload come from a wide variety of research approaches representative of the sensory, perceptual, and cognitive processing domains.

Two modes of processing To further understand the relation- ships among sensory, perceptual, and cognitive processing, one may find it useful to adopt the distinction made between two modes of processing: data-driven and conceptually driven processing. Data-driven processes are most closely related to the energy and information components of the stimulus. These data are thrown into action by the arrival of an input of energy and information from the stimulus. The processing of the stimulus then progresses through an increasingly complex sequence of analyses until the stimulus is recognized or responded to and results in a measurable response. Data-driven processing is also described as bottom-up processing, because activity in the system begins with the arrival of the input, progresses directly to the early and relatively simple sensory processing of the stimulus, and proceeds through the later and more complex cognitive interpretation of its meaning.

In contrast, conceptually driven or top-down processing begins with the person's expectation or interpretation of what stimulus is to be encountered. The expectations provide a hypothesis to the system to test whether the interpretation of the stimulus is correct. Whereas data-driven processing begins with the stimulus and ends with the interpretation of the stimulus and the resulting response, conceptually driven processing begins with expectations and interpretations that go in the opposite direction to influence sensory and perceptual responses.

One may also use the phrase “externally driven” processing to refer to data-driven processing. Externally driven processing implies that the processing is initiated and controlled by external stimulus components. Similarly, conceptually driven processing may be described as internally driven. That term emphasizes initiation and control from within the organism based on the organism's expectations and interpretations.

In most processing of everyday stimuli, it is clear that the data-driven and the conceptually driven systems operate simultaneously. The extent to which the data-driven system is allowed to succeed, however, can be varied quite widely. The relationship here to sensory and perceptual processes relates to the data-driven system, and most of what is emphasized in cognitive processing relates to the conceptually driven system. The concept of attention represents a bridge between these two types of processing and helps to describe how the two systems operate in unison.

The distinction between those two modes of processing can be clarified and a description of how they might actually be measured or given by introducing the theory of signal detection, a theory that is beginning to be used in the area of experimental psychopathology. Signal detection theory provides two theoretically orthogonal response measures—a measure of sensitivity called the d" and a measure of response bias called beta, which reflects the readiness of the subject to make a given response. It is possible to conceptualize these two measures of signal-detection theory—d" and beta—as measures of the data-driven processing system and the conceptually driven processing system, respectively. Because the d" measure of sensitivity is affected by manipulations of the stimulus characteristics, it seems appropriate to relate that measure to the data-driven system. In contrast, beta is not influenced by alterations of the stimulus, but is varied by manipulating the subject's attitudes toward responding, by instructions, motivating payoffs, and expectancies about how often the stimulus is presented. These factors are all conceptually driven.

Attention and processing Despite William James's 19th-century claim that “everyone knows what attention is,” the subsequent years have not brought a consensus on the meaning of the term. Dozens of different uses of the term and many theoretical models have been developed to explain the phenomenon of attention. Nonetheless, in the past two decades the concept of attentional dysfunction has come into widespread use to describe and explain various aspects of psychopathology.

Empirical research has investigated whether attention is impaired in certain patient populations. The tools used to answer that question are techniques borrowed from experimental psychology. The intercorrelations among the various commonly accepted measures of attention are minimal, and this fact suggests that the concept of a unitary attention deficit is untenable. This lack of intercorrelation indicates that the different tests are not measures of the same kind of attention. The only common thread among the separate measures is that all attempt to appraise two key elements of attention. The first element is limitation on incoming stimuli; because not all simultaneously incoming stimuli can be processed, how much can be processed, and what governs those constraints on processing? The second element is selection; of all
PROCESSING CAPACITY AND LIMITATION. The phenomenon of attention is intimately bound up with the concept of processing capacity. With a multiplicity of stimuliimpinging on the organism at any time, it is not possible to process and respond to all of the inputs. Therefore, the organism’s behavior cannot be predicted directly from the stimuli, and attention describes the phenomenon by which some stimuli and not others command processing and behavioral attentiveness. How many inputs can be processed any one time seems to depend on the control strategies that are used to select among the stimuli and the demands place on the total processing capacity.

VOLUNTARY AND INVOLUNTARY ATTENTION. In a variety of different ways, most contemporary models of attention make a distinction between voluntary and involuntary attention. William James offered a subjective description of the difference by describing involuntary attention as passive or effortless processing in which attention is gripped, captured, or arrested by some object or event despite the intentions of the subject. Voluntary attention, by contrast, is brought to bear to the ability to direct the focus of attention in accordance with current expectations, plans, or goals. There are parallels between involuntary attention and data-driven processing and between voluntary attention and conceptually driven processing.

Involuntary attention is automatically initiated by stimuli that have some significance in terms of the organism’s enduring dispositions. In this way, stimuli can have involuntary attention. Research on the orienting response has demonstrated that a system is biased to preferentially respond to novel stimuli. Stimuli that are relevant to an aroused motivational or drive state will also automatically initiate attention. When a person is hungry, attention is automatically grabbed by the smell of dinner cooking. These examples thus far have described stimuli that are significantly large in terms of wired-in neuronal properties. There are other stimuli that involuntary attention give to because, over a long period of time, one has learned that they are important and require a response. One’s own name is an example of a learned stimulus that automatically commands attention. So is a red light when driving. Schneider and Shiffrin demonstrated that if a learned event and respond automatically and involuntarily to multiple categories of stimuli, some of them quite complex, if one is consistently trained to respond to them.

The process by which a learned to attend and respond automatically to certain stimuli has been described as the development of automaticity. After much practice, certain stimuli command attention and lead directly to interpretation and response, without requiring any conscious awareness, independently of the subject’s control. Such processing is described as voluntary because it is dependent on continuous or frequent attention.

The sequence of processing steps is well learned, it is possible to automatically process and respond to a range of events simultaneously without the effort of volitional control. Thus, automatically processes one’s limited processing capacity to deal with other events in the environment that require conscious effort and voluntary attention.

VOLUNTARY attention is a form of conceptually driven processing that describes the allocation of attention to stimuli that are relevant to current plans, expectations, and intentions. Voluntary attention is a type of controlled processing. In that form of top-down processing, persons control the types of stimuli for which they are searching on or on which they are focusing their attention. This type of attention is used to select some stimuli for processing and responding and to ignore others. That type of attentional activity proceeds slowly, requires effort, and is demanding of processing capacity.

To understand how automatic processing may develop from controlled processing, one may think of persons learning to ski. New skiers have to devote controlled processing to many aspects of the task at hand. They must exert concerted effort to pay attention to keeping the knees slightly bent and the hands slightly forward and to negotiating the sequence of shifts in weight that are necessary to carry out a turn. While addressing these needs, new skiers are likely to be distracted and the automatic responses that are difficult to suppress, e.g., the precipitous drop in your self-confidence—a sign of the learning of the falling. Skiing novices very likely feel somewhat overwhelmed by the number of events that must be non-conscious impossible to carry out all those processing tasks at once. After long practice, however, all those component events are processed smoothly and without awareness. It is even possible to add other processing tasks to the array, such as watching for other skiers and carrying on conversations. Indeed, attention to all the relevant elements has become so fully automated that it is nearly impossible for the skilled skier to describe what stimuli are monitored.

SELECTIVE ATTENTION AND FILTERING. Contemporary research on attention emphasizes the problem of selective attention. Given one’s limited processing capacity, how does one allocate processing to relevant stimuli and avoid becoming overloaded by irrelevant stimuli? Many theories have postulated the existence of a filter, a gate of selection and response that may operate at some point in the information-processing sequence. However, models of attention imply that a large number of stimuli can be processed simultaneously or in parallel up to the point of the bottleneck. Therefore, stimuli must be processed serially, one at a time, so that some selection is necessary. Controversy has ranged over the location of the bottleneck stage and the characteristics of the filtering mechanism.

In recent years, theoretical models of selective attention have shifted from static structural conceptualizations of filter to active processing models that describe selection and filtering as control processes or operations. Although the original hypothesis about the filter as a structure that proved to be inadequate, the descriptions of the separate operations thought to be performed by the different filters have been retained.

One can describe filtering, also called “stimulus set” by Broadbent, as the capacity for driving attention by which some stimuli are selected to receive further processing because they display certain physical properties. A different kind of control process known as piquehoning is a conceptually driven process which selects inputs that correspond to expectations and thus qualify as targets warranting a response. Because piquehoning involves a situation that has a signal being particular to a specific response, it also has been called “response set.” The piquehoning control process, based on the conceptual analysis of performance by Broadbent and Gregory, is carried out by a late-stage filter. Interestingly, it has been suggested that the d* index for signal detection theory could serve to measure stimulus set and response set, respectively.

The following example may clarify the distinction between filtering and piquehoning. Two messages are presented, and someone is asked to listen to the message spoken by the female voice and to ignore the message spoken by the male voice. In that case, selection can be accomplished by filtering out the messages that has the inappropriate physical characteristics associated with the sound of a male voice. However, the person is asked to detect the names of animals spoken in the male voice, there is no audible difference between relevant and irrelevant target stimuli, so stimulus set is not necessary, and selective attention should operate efficiently. In contrast, when irrelevant, distracting events elicit automatic processing that the person must attempt to suppress by voluntary attention, the processing may lose its efficiency.

DIVIDED AND FOCUSED ATTENTION. In the discussion of attentional control processes, a distinction is made between two modes of attention that may be required of a person. In some tasks people are asked to divide attention among two or more inputs. For example, studies concerned with determining how much can be processed (the limitational aspects of attention) generally require divided attention. The effective of such investigations may be to determine how many simultaneous inputs can be processed accurately and to determine the extent to which the addition of further relevant inputs impair the speed or the accuracy of processing. Other tasks require the person to attend to a particular input while ignoring competing inputs; that is, to focus attention. Those tasks are used by investigators to study the selective aspect of attention. For example, they may inquire how efficiently stimuli sharing a common physical attribute must be attended to in order to select one competing stimulus. Or they may pose the problem of how easily stimuli belonging to a common conceptual category may be piquehoned out from all incoming information.

Arousal and attention. A tendency toward hypoarousal or hyperarousal has frequently been invoked to explain attentional anomalies in psychiatric patients, particularly schizoid schizophrenic patients. Arousal is a psychophysiological concept pertaining to the activation of the nervous system. The relationship between arousal and attention
is most easily understood in the case of voluntary or conceptually driven processing. Kahneman, in 1973, proposed that the degree of effort devoted to attentional processing is reflected in measures of arousal. Most patient studies, however, begin with the hypothesis that patients have an altered basal level of arousal, for whatever reason, and attempt to determine the consequences of that state for attentional control of processing. With a condition of low arousal, the case is clear enough. The patients are drowsy, rather than alert; there is no doubt.

In contrast, or for example, when a subject performs a cognitive operation, such as doing mental arithmetic, all of the various physiological measures of arousal show increased activity, e.g. heart rate increases, apparently because of the effort the subject exerts in problem solving or in preparing to make a response. In the other state of moderate arousal, most physiological measures, such as skin conductance and pupil diameter, also show increased arousal, but heart rate decreases. The subject in this state seems to be in a pattern of augmented awareness or appears to be waiting for something to happen. Motor responses are inhibited, and conditions are ideal for data-driven processing because the subject is receptive to being guided by external stimuli. Therefore, the interplay of arousal, task difficulty, and performance has been described in a classic law put forward early in the 20th century by Yerkes and Dodson, who observed that, for any task, the relationship between arousal and performance may be described by a function shaped like a bell curve. In other words, performance is best at a moderate level of arousal and deteriorates when arousal levels are either too low or too high. In addition, the optimum level of arousal depends on the difficulty of the task. A fairly high absolute level of arousal promotes enhanced performance on a simple task, whereas a lower level of arousal yields the best performance on a more complex task. Stated differently, the apex of the inverted U occurs at a higher arousal level for an easy task than for a more difficult task. The authors believe that the reason why performance deteriorates under high arousal on a difficult task is that the subject may tend to narrow attention to the dominant task stimuli. When the most important stimuli are few, they are the focus of simple task, the narrowing or focusing of attention may enhance performance. When, however, there are many complex features of the task, narrowing of attention may impair the subject's ability to discriminate relevant from irrelevant aspects of the complicated situation as a whole.

PROCESSING AND PSYCHOPATHOLOGY Although processing research is still too new to delineate exactly what happens to processing in instances of psychopathology, there is no shortage of theories or models. The different models can be thought of in relation to the earlier distinction between data-driven processing and conceptually driven processing. The models take different forms, varying primarily in their complexity. Some forms are simple models that posit a unitary deficit; others are more complicated, involving explanations about the balance or imbalance between the two modes of processing.

In unitary models, different types of patients are characterized as displaying impairments or disruptions of one of the two major modes of processing. Some patients may show deviations primarily on tasks in which data-driven processing is paramount; other patients may show deviations primarily in conceptually driven tasks. A few models focus primarily on the functioning of the data-driven mode of processing.

Johnson proposed a theory of depression based on information processing. At its core, the theory states that depression is a defense reaction mounted to cope with anxiety arising from a defect in the patient's information-processing mechanisms. Because of mounting anxiety, the patient stops analyzing incoming sensory information and becomes lethargic or, for example, overgeneralizes information. In mania, data-driven processing is accentuated, and information is said to be overprocessed, which, in turn, leads to depression. In depression, data-driven processing is suppressed, and information is underprocessed. Although it was suggested that the locus of the dysfunction in depression is at the sensory input stage, it was also acknowledged that research has not ruled out the possibility that affective disorders may also be characterized by changes at the output stage; that is, changes in the motor mechanisms.

At moderate levels of arousal, it becomes important to distinguish between different states of arousal, because that notion is not a unitary construct. Lacey has described two important states of moderate arousal. In one state, for example, when a subject performs a cognitive operation, such as doing mental arithmetic, all of the various physiological measures of arousal show increased activity, e.g. heart rate increases, apparently because of the effort the subject exerts in problem solving or in preparing to make a response. In the other state of moderate arousal, most physiological measures, such as skin conductance and pupil diameter, also show increased arousal, but heart rate decreases. The subject in this state seems to be in a pattern of augmented awareness or appears to be waiting for something to happen. Motor responses are inhibited, and conditions are ideal for data-driven processing because the subject is receptive to being guided by external stimuli.

At a high level of arousal, the interplay of arousal, task difficulty, and performance has been described in a classic law put forward early in the 20th century by Yerkes and Dodson, who observed that, for any task, the relationship between arousal and performance may be described by a function shaped like a bell curve. In other words, performance is best at a moderate level of arousal and deteriorates when arousal levels are either too low or too high. In addition, the optimum level of arousal depends on the difficulty of the task. A fairly high absolute level of arousal promotes enhanced performance on a simple task, whereas a lower level of arousal yields the best performance on a more complex task. Stated differently, the apex of the inverted U occurs at a higher arousal level for an easy task than for a more difficult task. The authors believe that the reason why performance deteriorates under high arousal on a difficult task is that the subject may tend to narrow attention to the dominant task stimuli. When the most important stimuli are few, they are the focus of simple task, the narrowing or focusing of attention may enhance performance. When, however, there are many complex features of the task, narrowing of attention may impair the subject's ability to discriminate relevant from irrelevant aspects of the complicated situation as a whole.

It has been proposed by Broen and Storms that chronic schizophrenic patients show disorganized responding because they behave like normal subjects performing a difficult task under conditions of high arousal. Attentional narrowing may be narrowed to a few features of the situation in such way that important information is overlooked and trivial information is overemphasized.

As described above, deviations in processing can occur within a single mode of processing, e.g. as an anomaly in the data-driven processing system. Other models describe deviations not in a single mode, but as an imbalance or breakdown in the integration between the two processing modes. Those models suggest that in psychopathology the normal interrelationship between the two modes of processing is altered or modified, so that one mode of processing becomes more frequent or dominant, with a corresponding reduction in the other mode.

A clinically derived hypothesis that has persisted for some time suggests that many persons with psychiatric disorders display disruptions of the balance between data-driven processing and conceptually driven processing in such a way that conceptually driven processing predominates. Freud, for example, suggested that the interest or (cathexis) of schizophrenic patients is withdrawn from the external world and refocused on internal preoccupations. To some degree, that observation may merely indicate that patients are not motivated to participate in most of the tasks the therapist gives them. It was suggested in the discussion of arousal that, at low levels of motivation, people do not have much processing capacity to invest and tend to allocate their available capacity to the least demanding activities, such as daydreaming. Alternatively, patients may simply be more interested in other events, rather than external events, and may voluntarily direct attention toward their own mental processes. In any event, the hypothesized reorientation of attention inward implies that conceptually driven or internally directed processing tends to prevail over data-driven, externally directed processing.

The best examples of an imbalance in which conceptually driven processing overrides data-driven processing come from clinical observations and patients' subjective descriptions. Here is one such patient account as described by McGhie:

I'm not sure of my own movements any more. It's very hard to describe this but at times I'm not sure about even simple actions like washing. It's not so much thinking out what to do it's the doing of it that sticks me. I found recently that I was thinking of myself doing things before I would do them. If I'm going to sit down for
example, I've got to think of myself and almost see myself sitting down before I do it. It's the same with other things like washing, eating or even dressing—things that I have done at one time without even bothered or thinking at all. I just have more time to do things because I am always conscious of what I am doing. If I could just stop noticing what I am doing, I would get things done a lot faster. I have to do everything step by step now, nothing is automatic. Everything has to be considered.

In the example above, highly overlearned processing sequences have become deautomatized. It now appears necessary for the patient's attention to be voluntarily directed to the relevant stimuli; processing proceeds from top-down, effortlessly, directed by the conceptual image of what is to be achieved. Processing should be slowed accordingly, because conceptually driven sequences take longer to execute. If that hypothesis is correct, one may predict that schizophrenic patients display particular difficulty in acquiring automatized, data-driven sequences or that automatic processing, once acquired, tends to break down and be rapidly replaced by controlled, serially, conceptually driven processing strategies.

Cancro conducted a study in which frequency of eye blinks was used as a criterion for differentiating between internal (conceptually driven) and external (data-driven) attention deployment. Earlier research had demonstrated that both psychiatric patients and normal controls showed a reduction in blinking during visual tasks and an increase during mental tasks. It was hypothesized that the proportion of time spent blinking versus fixating could serve as an index for internal and external attention, respectively. The results showed that schizophrenic patients spent more time blinking and less time fixating than did normal controls. Those data have been interpreted to indicate that schizophrenic subjects tend to pay attention to internal conceptual events in preference to external stimuli. These findings suggest that the patients may assimilate less information about the environment than do normal persons.

It is possible that Cancro's findings could be explained by the schizophrenic patients' poor level of motivation to attend to external events. Another possible interpretation of the data is afforded by the information-processing model outlined here. In many situations in which processing by normals is directed by the efficient operations of data-driven or even automatic processing, processing by patients may make use of the more demanding system of conceptually driven, controlled processing. Some investigators have even suggested that many of the symptoms seen in psychopathology can be attributed to a breakdown in the automatic processing that characterizes most normal behavior.

Although the theories reviewed thus far suggest that conceptually driven processing is predominant over data-driven processing in psychopathology, there are at least two theories that propose that the imbalance goes in the opposite direction; namely, to favor data-driven processing.

Salzinger's immediacy hypothesis of schizophrenic behavior postulates that schizophrenic patients are more controlled than are normals by stimuli that are immediately present in their temporal and spatial environment, even when these stimuli are irrelevant to the behavioral context. The key concept in this hypothesis is the compelling control of the immediate stimuli over behavior for the schizophrenic subjects. Presented with stimuli separated in time, the schizophrenic subject is more influenced by the proximal (immediately present) stimulus than is a control subject. To the extent that the proximal stimuli represent data that are externally engendered, whereas past stimuli are internally or conceptually represented, the immediacy hypothesis suggests that processing in schizophrenia is disproportionately data driven.

Rimland suggested that an imbalance favoring data-driven processing is also characteristic of some forms of childhood psychopathology. Based on the clinical observations of autistic and idiot savant children, Rimland proposed that processing in those children is locked into the exact physical dimensions or qualities of the stimulus. Rimland hypothesized that autistic children have great difficulty with conceptually driven processing in which attention is directed to the meaning of incoming stimuli, rather than to their physical properties.

In another model explaining processing in schizophrenia, Magaro and colleagues related different types of psychopathology to both the domains of processing (sensory/perceptual or conceptually) and to whether or not the processing is automatic or controlled. They concluded that the direction of the imbalance—toward data-driven or conceptually driven processing—depends on the diagnostic subtype of the schizophrenic patient. Paranoid patients show a greater than normal tendency to primarily display controlled, cognitive processing; nonparanoid schizophrenic patients are more likely to use automatic, perceptual processing. To the extent that perceptual processing is more data driven than is cognitive processing, it may be concluded that nonparanoid schizophrenic patients rely primarily on data-driven processing, whereas paranoid schizophrenic patients rely on conceptually driven processing.

**GENERALIZED PATIENT DEFICITS** Patients almost invariably perform more poorly—more slowly, less accurately—than do normal persons in experimental studies. These differences may be due to several general factors, such as patients' lower motivation or cooperativeness or inability to understand instructions, rather than to a postulated specific deficit. This presents a methodological problem known as the generalized deficit problem, and several proposals have been made to deal with it.

Perhaps the best approach to the problem is to devise experiments in which at least some of the patients do better than the normal controls. In that way, the obtained patient-normal differences cannot be described as due to a generalized deficit. Another approach is to design experiments in which several stimulus values are tested in order to generate a function or curve. Such a strategy allows a comparison of the functional curves for each group, and this comparison provides maximum interpretive information about the performance of the subjects; that is, their cooperation, motivation, and their ability and willingness to participate.

Underwood and Saughnessy discussed the generalized deficit problem in the context of how to avoid confounding by subject variables, such as age, intelligence, and gender, when comparing individuals with respect to other subject variables. The approach is to compare groups with respect to the data that have well-established reliability and empirical characteristics, to postulate a possible theoretical explanation for the expected differences between the groups to be studied, and to design a series of experiments involving several variables to test the validity of the postulated explanation. The outcome of that testing takes the form of searching for and hopefully obtaining significant interactions that are consistent with the postulated explanatory process. Obtaining the predicted interactions validates the postulated processes and indicates that the investigator has experimental control over the important variables.

One hypothesis might be that patients tend to use filtering operations when nonpatients use pigeonholing operations and that this difference explains the patients' deficit on the task under investigation. Then one might design a task in which the postulated preference of patients for filtering strategies yields a pattern of patient performance that is superior to the normal performance. Or one might induce normal subjects to use filtering operations even though pigeonholing is a more optimal strategy. In this case, one would test the prediction that normals perform like patients, because filtering is what
patients usually do without the added inducement of the experimental manipulation. By suggesting and successfully testing an explanatory process to clarify the basis for patient-normal differences, one obtains results that argue against a generalized deficit interpretation and, more importantly, one tests the effects of postulated mechanisms or processes. Such testing over several experiments constitutes the use of the powerful procedure known as “converging operations” to investigate processes and their interrelationships.

Related to the generalized deficit problem is Chapman and Chapman’s contention that many of the reported differences between patients and normal subjects are not substantive differences due to psychopathology, but are simply “psychometric artifacts” caused by the use of experimental tasks or conditions that are not properly calibrated. All tasks or conditions must be similar with regard to reliability, discriminating power between persons, difficulty, and in the distribution of scores or measures. The calibration must be based on the normal group only in such a way that the group members do not give results that differ across tasks or conditions. Then, if the patients produce different results for the tasks or conditions, such differences can be related to their specific psychopathology and not to a generalized deficit. That conclusion holds even if the patients’ general level of performance is not as good as that of the normals.

SENSORY AND PERCEPTUAL DOMAINS

Three separate domains of processing—sensory, perceptual, and cognitive—were described earlier and were given operational definitions. Although, ideally, it should be possible to categorize processing research into the three domains, for the purpose of this section and for the description of the existing processing data, the sensory and the perceptual processing domains are presented together because they are traditionally considered together. For example, in the autobiographical reports of patient disturbances, both sensory and perceptual disturbances are reported interchangeably. Also, both domains share many methodological problems, such as the need for precise methods to assess the expected small effects and the possible contamination of data by patients’ medications.

Processing research in the sensory and perceptual domains usually involves relatively simple stimuli that are varied primarily along energy dimensions. The purpose of sensory and perceptual research is to assess a person’s ability to discriminate sensory stimulation. More specifically, research in these domains has several possible objectives: (1) to determine the conditions under which a stimulus is reported as present or absent (the detection threshold); (2) to establish which stimulus is different from several similar stimuli (the discrimination of differences, as in a forced-choice procedure); (3) to determine whether two stimuli seem to be the same or different (a matching procedure); (4) to measure a response that is based on instructions requiring the subject to respond to a designated target stimulus while ignoring others (a recognition procedure); and (5) to require a response about some specified quality of the stimulus, such as: Is the stimulus flickering or fused (an identification procedure)? Those basic psychophysical questions can be answered by examining verbal reports or by measuring psychomotor responses, e.g., reaction-time responses. The intention here is to emphasize sensory and perceptual studies that measure processing. Strictly speaking, detection thresholds that do not involve temporal measures are not measures of processing, but as they are basic to all other phenomena, they are included here.

PSYCHIATRIC PATIENTS AND SENSORY AND PERCEPTUAL DEVIATIONS

In previous editions of this textbook, the question of whether there are genuine sensory and perceptual differences between psychiatric patients and nonpatients was discussed, and it was concluded that, although autobiographical reports by former patients strongly suggest that sensory and perceptual differences exist, their clear experimental demonstration is difficult. Such differences, if present, are probably quite small. Consequently, to reliably demonstrate these differences would require precision equipment, well-designed experiments in which the generalized deficit problem is adequately considered, and patients (and normals) who are able and willing to participate in what are often boring or uninteresting tasks, sometimes over extended periods of time. With so many stringent requirements, it is not surprising that the available evidence is ambiguous.

One potential source of confounding in sensory and perceptual studies, that of patient medication, can be reduced by comparing different types of patients taking similar drugs, if one assumes that there is no interaction between the drug and the type of patient. A statistical approach to the problem is to correlate drug dosages, or their chlorpromazine equivalent, to the dependent variable(s). The testing of some patients on and off medications can help determine the effect of medication on behavior. Some investigations have shown that psychotropic drugs taken in therapeutic dosages do not seem to modify certain sensory response measures, such as reaction time. Other studies even suggest that medication “normalizes” patients’ performance; therefore, if medicated patients still differ from controls, then unmedicated patients might be expected to display even larger differences. Still other studies suggest that psychotropic drugs do modify sensory and perceptual performance, sometimes in a complex interaction with patient diagnoses. Therefore, none of the drug “control” procedures completely disposes of the possibility of confounding.

Clinical psychophysics

Clinical psychophysics refers to the application of highly developed techniques of psychophysics to clinical problems; in this case, to the field of psychopathology. It is possible that patients do not really differ from normals in sensory or perceptual capabilities, but actually differ only in their willingness to accept the task and to respond as required; that is, they differ only in response bias. Clinical psychophysics provides the techniques of signal detection theory, which hold promise for measuring not only a person’s perceptual sensitivity but also a person’s response bias. The beta index of signal detection measures a person’s willingness to make the positive response under investigation. Because patients may differ systematically from normals in such biases, the measurement of beta should be systematically investigated.

An investigator of response bias using signal detection theory is faced with several problems. Studies of response bias have used a variety of bias measures, and there has been little attempt to standardize them. In most individual studies, only a single response-bias value is obtained for each group. Because several measures are available and they do not necessarily measure the same things, one problem is determining which measure of response bias to use. In addition, future studies should report response biases at several values of the parameter under study. Another strategy might be to manipulate bias for different clinical groups by increasing or decreasing it with special incentives. This approach may enable investigators to determine why and how psychiatric patients differ with respect to response bias. The empirical interrelationships between the numerous different measures of response bias are largely unknown, which means that this is an area of research in psychopathology that remains to be systematically explored.
In two auditory threshold studies, Rappaport and his colleagues reported that paranoid schizophrenic patients displayed a stricter or more conservative response criterion than did nonparanoid schizophrenic patients and normal persons. In comparison, in a visual two-flash study reported by Gruzelier and Venables, paranoid schizophrenic patients had more lenient criteria than did nonparanoid schizophrenic patients and normal persons. Those results seemed opposite to Rappaport's conclusions. How are those discrepancies to be explained? Are they due to the interaction of tasks (detection threshold versus two-flash threshold) or to the use of different measures of response bias or criterion? The two studies by Rappaport used the conventional signal-detection model and formulae to obtain the measure of beta; the other study by Gruzelier and Venables used derived signal-detection measures based on the method of constant stimuli. Because the empirical relationship between these diverse measures is unknown, it is likely that the discrepancy between the results are due to the different measures.

The measurement of response bias is simply part of a larger problem concerned with the influence of different response factors in behavioral measurement. There seems to be increasing evidence that response factors can be of crucial importance in psychiatric research. Clearly, several factors can influence responding, and attempts must be made to distinguish between these factors and to develop separate research strategies for measuring them.

Sensory studies. Sensory processing includes (1) the detection threshold, (2) temporal resolution, and (3) temporal integration.

Detection threshold. Several auditory and visual threshold reports suggest that some psychiatric patients show less sensitivity to stimuli than nonpatients in a variety of threshold-type tasks, even though early studies that looked at behavioral threshold estimates for groups generally failed to report significant differences. The earlier studies were based on unreliable, global clinical judgments and used more classical psychophysical methods, and these methods did not control for response bias. In comparison, more recent threshold investigations have emphasized refined classification procedures for homogeneous grouping of patients by using semistructured psychiatric interviews, which give more reliable diagnoses and provide detailed analyses of patients' clinical symptoms and syndromes. The recent studies have also employed forced-choice or signal-detection procedures as a way of eliminating or measuring response bias. Several investigators have suggested that not all psychiatric patients should be expected to show sensory differences from normals. Some patients display thresholds in the same range of performance as normals, whereas other patients have markedly higher thresholds than normal subjects. It would be interesting to group patients according to their sensory performance to see whether the patients showing particular patterns of sensory deviation also show unique symptoms or syndromes. For example, how might a subgroup of schizophrenic patients who displayed elevated visual detection thresholds differ clinically from other schizophrenic patients?

Bruder, who used a forced-choice technique to measure auditory threshold in two of his studies, reported higher thresholds for patients with affective disorders than for schizophrenic patients and normal controls. The latter two groups did not differ. In both studies, significant correlations were reported between the clinical symptom of speech retardation and the auditory threshold ($r = 0.56$, $r = 0.41$), respectively. The left-ear threshold was the discriminating measure; the left-ear threshold, measured only in the discriminating measure, was not significantly different across the groups of subjects. Speech retardation is a symptom frequently associated with the diagnosis of psychotic or endogenous depression.

An auditory-threshold study by Babkoff and his colleagues used noise-burst stimuli of three different durations. The analysis indicated that psychiatric patients had a 5-decibel higher threshold for all stimulus durations than did the normal controls. A subsequent analysis compared the normal controls with subgroups of patients formed from symptom profiles based on clinical information obtained from a semistructured interview. Interview data were scored to obtain the symptom profiles that had been derived from a factor analysis. From the data, two groups of patients were identified—a depressed group and a schizophrenic group. Patients with the highest factor loadings of depression showed the highest thresholds. Patients with schizophrenia-like profiles of symptoms also had thresholds that were higher than those of the normal controls. Schizophrenia patients showed different thresholds only at some specific stimulus durations. By dividing the patients into more homogeneous groups on the basis of similarities in clinical symptoms, the researchers were able to strengthen their conclusions about the threshold data.

TEMPORAL INTEGRATION. The concept of temporal integration refers to the way in which stimulus energy is processed in the period immediately after the presentation of the stimulus. Complete temporal integration is said to occur when the stimulus is very brief, because then all of the presented stimulus energy is used in determining the response—its magnitude, latency, or accuracy—regardless of how that energy is distributed in time. For example, two equal-energy stimuli, a brief and intense stimulus as compared to an equivalently longer but reciprocally less intense stimulus, should produce the same response because they have the same total energy. For stimuli of longer duration, not all the stimulus energy presented is processed by the organism, because the longer duration prevents complete integration; that is, utilization of all the energy. Several characteristics of temporal integration have been measured for a variety of behavioral and physiological responses by using numerous techniques and procedures. The brevity of the time constants of integration places the measure primarily in the sensory-processing domain, although, under some conditions, temporal integration has been demonstrated for periods lasting several seconds.

There have been only a few temporal-integration studies of psychiatric patients. Because disorders of the CNS may be expected to reflect changes in the characteristics of temporal integration, neurological or psychiatric patients may differ in integration from normal subjects. Wilson reported that subjects with postgeniculate brain lesions displayed changes in temporal integration (longer critical durations), but subjects with pregeniculate lesions did not differ in temporal integration from intact controls. Eriksen also reported that older people had longer critical durations.

Two studies with psychiatric patients, one in audition and one in vision, reported consistent results, even though they differed in modality, in the energy levels of the stimuli tested, and in the way it was measured. The auditory-threshold study by Babkoff, mentioned previously, used a verbal report to measure the detection threshold. Grouped into factorially based diagnostic categories of schizophrenic and affective disorders, the patients displayed two distinct auditory temporal integration functions. The integration function for the normal controls was the typical function for normals, showing a linear reciprocal relationship between changes in stimulus intensity and duration for a constant threshold response. Patients with affective disorders also displayed linear integration functions, but with greatly reduced slopes, suggesting that those patients processed energy differently than the normal subjects. The schizophrenic patients' integration function was distinctly different: for the two briefest stimuli, there was a steep integration function, steeper even than for normals; but for the longest duration stimulus, the function for the schizophrenic subjects became flat, indicating that for this stimulus duration they had reached critical duration sooner than the normals and were no longer completely integrating the energy of the stimulus. The functions for the normals and the patients with affective disorders at the longest duration continued to decrease, indicating that complete integration was still occurring for them, even for the longest stimulus. Thus, in that auditory study, schizophrenic patients seemed to have the shortest critical duration.

The visual temporal-integration study by Collins also reported that schizophrenic patients—especially those who clinically displayed "speech disorganization," a dimension related to thought disorder—showed shorter critical durations than did other psychiatric patients and normal controls. In that study, stimuli were of a fixed temporal threshold level, and subjects lifted their fingers in a simple reaction-time response as quickly as possible when they saw a flash of light. Here again, as in the audition study, some schizophrenic patients
showed shorter periods of complete integration. Attempts to replicate this visual integration result, however, have not been successful.

It is important to note that temporal integration is not simply a peripheral or receptor phenomenon; it is most correctly interpreted as reflecting CNS processing. Also, there may be an empirical relationship between temporal integration and temporal resolution, with increased resolution being associated with shorter periods of integration.

**TEMPORAL RESOLUTION** Temporal resolution refers to the ability of the organism to process successively presented stimulus inputs as discrete events. At slow input rates, the subject is able to process the inputs as discrete and successive. As the interval between successively presented inputs, such as flashes of light, decreases, resolution is no longer possible, and the successively presented inputs merge. The light no longer seems to flicker, but is seen as continuous; that is, temporal resolution is absent. Temporal resolution is possible for all types of inputs, and there are numerous ways of measuring resolution, such as the critical-flicker-frequency threshold, the two-flash threshold, and the temporal-order threshold. Those different measures of temporal resolution may, however, be independent of each other.

In the domain of sensory-processing research with psychiatric patients, studies of temporal resolution, such as critical-flicker fusion, have been quite prevalent. The critical-flicker-frequency technique, for example, has been used extensively to measure the effects of stress, anxiety, and other arousing and activating stimuli. Bibliographies of the general critical-flicker-frequency literature list more than 2,000 references, many of which have clinical, organismic, and psychopharmacological significance; however, measurement of the critical-flicker-frequency threshold has methodological difficulties. Clark reported that previous deviations in critical-flicker-frequency thresholds displayed by schizophrenic subjects may have actually been response-bias differences and not sensory differences. When Clark and his colleagues measured the critical-flicker-frequency threshold by using a forced-choice technique (a procedure that eliminates opportunities for response-bias contamination), the previously reported higher thresholds for patients (less temporal-resolving capacity) as compared with normals was eliminated. It was concluded that the previous critical-flicker-frequency studies were actually measuring only response-criterion differences (willingness to report flicker) and not differences in temporal resolution. A recent signal-detection investigation of depressed outpatients by Herskovic arrived at a similar conclusion: there were no flicker-sensitivity threshold differences between depressed patients and normal subjects, but patients with major depressive disorders displayed stricter measures of response bias (were more conservative).

The two-flash threshold, which is a type of flicker, is another sensory measure of temporal resolution. It has been used extensively to study clinical populations.

Venables used the two-flash threshold as a measure of cortical activation, a hypothetical concept related to CNS functioning. He reported that the two-flash threshold correlated with an electrodermal (skin potential) response, which served as his measure of arousal of the autonomic nervous system. Furthermore, the direction of the correlation differed for different groups of subjects. Generally, normals and paranoid schizophrenics showed a positive correlation between the two measures; the relationship was negative for nonparanoid schizophrenics. Venables postulated that the chronic, nonparanoid schizophrenic patients display a breakdown in the mechanisms regulating the basal and autonomic arousal threshold for normal and paranoid schizophrenic patients showed higher two-flash thresholds and lower skin-conductance levels. Other researchers have also investigated the effects of experimentally increased arousal on the two-flash threshold for normals and schizophrenics. The normal subjects showed increased resolution (lower two-flash thresholds) with increasing arousal, but for the schizophrenic patients resolution decreased. Those data suggest that the patients may have been at a higher initial level of arousal than the normals and that additional arousal led to a reduced level of performance, an explanation that could be predicted from the Yerkes-Dodson Law.

For methodological reasons, two-flash threshold results to date must be considered tentative. First, the results were based on correlations between the two-flash thresholds and other physiological measures, a result that limits conclusions to correlational statements, rather than to causal ones. The groups of subjects themselves did not differ significantly in the threshold measures. Second, other investigators have failed to replicate the results, and methodological studies of the two-flash threshold procedure have found it to be sensitive to numerous variables—such as age, sex, and method of measurement—and those factors were not adequately controlled in the earlier patient studies. A potential problem with much of that early research is the inadequacy of the psychophysical methods used. Generally, the two-flash thresholds were obtained by using an abbreviated method of limits based on relatively few trials. This method does not separate the temporal-resolution sensitivity of the subjects from their response bias, and that failure, as in the critical-flicker-frequency research, may have contributed to undermining this entire area of research.

It is possible that response-bias differences are not the only factor accounting for patient-normal differences in critical-flicker-frequency and two-flash threshold studies. Numerous investigations using diverse measures of the temporal resolution—critical-flicker-frequency, two-flash threshold, and temporal-order judgments—have concluded that there are large differences in temporal resolution for brain-damaged subjects and for normal subjects taking various psychotropic drugs. To the extent that psychiatric illness is conceptualized in terms of either CNS impairment or biochemical impairment, sensory-processing measures would be expected to reflect such dysfunctions. In summary, the possibility remains that psychiatric patients display both genuine, temporal-resolution differences and response-bias differences.

**Perceptual studies** Most of the perceptual studies with psychiatric patients have either not been replicated successfully or are not studies distinctively concerned with measuring processing. Some perceptual studies, such as those of spiral-figural aftereffects and kinesthetic aftereffects, illusions and constancies, have major methodological difficulties. Research investigations of the relationship between perceptual performance, cognitive styles, and psychopathology have declined in recent years. Studies of subliminal perception and perceptual defense also have been severely challenged on methodological grounds. Erdelyi, however, defended this research in perception on the grounds that the empirical evidence in the area is too incomplete to reach a final judgment about its validity. Instead, he argued that there is a need to approach conditions in an information-processing framework in order to do justice to the complex factors that may influence performance at all stages between the stimulus input and the response output.

Two perceptual research techniques that have been extensively used to test psychiatric patients are reaction time and visual masking. Those topics illustrate the type of perceptual-processing research prevalent in the field today.
REACTION TIME  The time between the presentation of a stimulus and the subject's response to that stimulus is called reaction time. Simple reaction time is measured when there is only one stimulus and one response, the same response being produced to the same stimulus on each and every trial. When there are several stimulus and response options, such as multiple stimuli with multiple responses or multiple stimuli with one response, the technique is called choice-reaction time. These different procedures are interpreted as measuring either different mechanisms of processing or different stages of processing. Considerable knowledge exists about the reaction-time measure, both empirically and theoretically, and several sophisticated, quantified models of reaction-time behavior exist.

Reaction-time studies of abnormal subjects assume that all subjects, both normal and abnormal, are about equal in performing the motor act itself. Of interest are the changes in speed and accuracy of the response as indicators of CNS functioning. Reaction-time studies of patient populations generally report that patients' responses are slower than those of normals, leading to the belief that the speed of patients' processing is slowed. Because reaction times are known to change as a result of numerous factors, there are several possible reasons for the difference in the speed of reaction times of patients and normals.

One particular area of reaction-time work with patients is the cross-modality reaction time; this technique can be treated as a perceptual phenomenon because it involves simple stimuli and simple reaction-time responses. A typical paradigm for the cross-modality reaction time is that the subject is told to respond on each and every trial to either of two stimuli, e.g. a flash of light or a brief tone. The general finding of several cross-modal reaction-time studies with patients conducted in the past two decades is that schizophrenics show a significantly greater lengthening of simple reaction time than do controls when the stimulus in the preceding trial was in the different modality. That effect has been referred to as the cross-modal retardation or modality-shift effect and is most pronounced when the sequence of stimuli is not known ahead of time and some degree of stimulus uncertainty on the part of the subject is produced.

Cross-modal retardation has been found in both acute and chronic schizophrenic patients and in process and reactive schizophrenic patients. The modality-shift effect persists even when patients and controls are informed what the forthcoming stimulus on each trial will be; thus, it seems unlikely that an expectancy hypothesis can explain the cross-modality effect. The modality-shift effect also is obtained when patients and nonpatients are statistically equated on reaction-time speed by using an adaptation of the analysis of covariance method. It is also manifested when normals whose reaction times are equal to that of the schizophrenics are used as the comparison group. In addition, in three independent studies of drug-free schizophrenic subjects, cross-modal-retardation effects were obtained, indicating that the effect is not due to the influence of drugs. The results from a study using a non-schizophrenic psychiatric control group suggested, however, that the modality-shift effect is not unique to schizophrenic patients, because patients with major affective disorders also displayed cross-modal retardation.

In order to ascertain if the cross-modality effect reflects a genuine specific deficit, rather than the generalized deficit that characterizes schizophrenic patients in general, Mannuzza recently conducted a relevant cross-modality reaction-time experiment. He designed his study to directly fulfill the Chapman's requirement that tasks be matched for reliability and variability on normal subjects in order to prevent obtaining results that could be due to a psychometric artifact. Under the appropriate matching, Mannuzza's schizophrenic patient group showed extraordinarily large modality shift effects, lending credence to the argument that the cross-modality reaction-time procedure is a robust, well-established indicator of psychopathology.

VISUAL MASKING  Visual masking is a complex perceptual phenomenon that takes several forms and has been interpreted in various ways. One paradigm to study masking is to present two brief stimuli separated by a short interval of darkness. One stimulus, the masking stimulus, may be a visual "noise" pattern; the other stimulus, the test stimulus, can be an identifiable word, letter, or a geometric form. In one form of masking, both stimuli are presented successively to the same retinal region; that is, they overlap in retinal location but are separated in time. If the two stimuli are presented—say, 20 milliseconds apart—the masking stimulus interferes with the perception of the test stimulus, and the subject cannot report its contents. As the interval between the light pulses is increased, the test stimulus gradually becomes visible and is reported with greater frequency or accuracy. Longer interpulse intervals produce less and less masking until masking is said to have disappeared and the test stimulus is reported with 100 percent accuracy.

Visual masking of this type has been investigated with schizophrenic patients.

Saccuzzo reported that under masking conditions, normals and non-schizophrenic psychiatric patients did not differ in performance, but both of those groups showed less masking than did two schizophrenic groups, one group with delusional symptoms and one group without delusional symptoms.

In a follow-up study, Saccuzzo and Miller measured the critical interstimulus interval, the minimum temporal interval between the presentation of a test stimulus and a masking stimulus at which the masking stimulus no longer interferes with the processing of the test stimulus. The results indicated that a longer critical interstimulus interval was needed for the schizophrenic subjects than for the other subjects. Also, all subjects showed less masking with practice, but there were no differential practice effects between patients and normal controls.

Since those initial studies, done some 10 years ago, Saccuzzo and Braff have conducted close to a dozen, similar visual-masking studies of a variety of subjects: delusional schizophrenics, remitted schizophrenics, schizotypal personalities, manic patients, depressed patients, mentally retarded subjects, and elderly subjects. Saccuzzo interpreted the differences obtained in masking between schizophrenics, normals, and the other groups of patients as being due to a slowness in processing (encoding) the information from the iconic storage stage, which is a visual short-term memory stage following the offset of the stimulus. That slowness was assumed to affect both the quality and the quantity of the information reaching the higher brain centers.

Conclusions from much of the masking research with patients are limited by the previously mentioned generalized-deficit effect because the patients, usually the chronic schizophrenic patients, who perform worse than the normals and the other patients, are the ones who differ significantly in the measures tested. One way to begin to overcome this problem would be to use signal-detection or forced-choice techniques, which Saccuzzo and Braff have begun to do in their most recent investigations. They also are using a converging operations approach within a theoretical information-processing framework.

STRATEGIES FOR MEASURING WHERE PROCESSING OCCURS  Visual masking and reaction time can be examined in relation to two questions posed earlier about the "where" of processing. First, at what level of processing do the masking and reaction-time responses occur? Second, what are the loci of those behavioral responses; that is, is there any evidence for hemispheric asymmetries in function? In both
cases—the level of processing and the locus of processing—
the fundamental interest is whether psychiatric patients of
various diagnoses typically differ from one another and from
 normals.

Although the levels and loci questions can be explored
physiologically, in this section the authors have emphasized
primarily behavioral measures. Fortunately, it is possible, by
using selected behavioral techniques and strategies, to obtain
preliminary and approximate answers to the question of
where in the pathway between the stimulus and the response
the crucial processing occurs.

**Levels of processing**  An important processing question to
investigate is the level at which the phenomenon under con-
sideration occurs. A lower level of processing refers to a
peripheral stage; a higher level of processing is one that occurs
more centrally in the nervous system. At least two general
strategies can be used to ascertain the different levels of
processing: (1) procedural or methodological strategy and (2)
theoretical strategy; the theoretical approach is always evalu-
ated with regard to empirical data. Those strategies are illus-
trated with reference to visual masking and reaction time.

**Visual masking**  Estimates of the level of processing for
masking can be obtained by the use of selected stimulating
conditions that are known to be dependent on particular
anatomical connections. For example, in vision, the use of
dichoptic stimulation provides a behavioral way of estimating
the level of processing. *Dichoptic stimulation* refers to the
 technique in which corresponding points of the retinas of
both eyes are stimulated independently; that is, each eye only
receives input from the stimulus presented to that eye and
not to the stimulus presented to the other eye. Such indepen-
dence can be obtained by separating the two stimulus fields
with a partition. In dichoptic visual masking, the test stimulus
is presented to one eye, and the masking stimulus is presented
to the other eye. The stimulation of the corresponding points
is achieved by the use of prisms to fuse the fixation point of
each independent, visual-stimulus field. The subject sees the
two visual fields as a single, fused field.

The dichoptic strategy is to compare the results obtained
by dichoptic stimulation with the results obtained by monocular
(or binocular) stimulation. If masking is the same for
both the dichoptic and the monocular conditions, the inter-
pretation is that the obtained effects are not peripheral, be-
cause the anatomy of the visual system with respect to di-
choptic stimulation is such that interactions between the two
eyes may occur beyond the optic chiasma, for there are no
known anatomical connections directly across the retinas of
the two eyes. Differences between the experimental outcome
of the two stimulating conditions allow one to evaluate the
relative contributions of the peripheral and central systems to
the phenomena under investigation. For example, if the di-
choptic condition shows little or no visual masking but the
monocular condition shows a full masking effect, then masking
would seem to be largely a peripheral phenomenon. Thus,
the use of selected stimulating conditions enables one to make
inferences about the level of processing. To date, most visual-
masking studies with patients have been conducted binocu-
larly, and that condition does not allow conclusions about
the level of processing.

A theoretical approach to study the level of processing was
provided by Turvey, who postulated that there would be
different quantitative outcomes (functions) for visual masking,
depending on whether the masking was primarily central
or peripheral. In this view, two distinct quantitative state-
ments can be tested by the obtained data; one is additive, the
other is multiplicative. The additive relationship supports a
central interpretation, whereas the multiplicative relationship
supports a peripheral one. Walsh applied Turvey's experi-
mental paradigm to investigate the effect of age of subjects on
visual masking. Walsh's data supported the interpretation that
older subjects are slower in processing than younger ones, and
the data displayed an additive quantitative relationship, which
supports the hypothesis of central masking. This study nicely
illustrates the use of Turvey's theory in relation to obtained
data in order to distinguish between peripheral and central
effects.

**Reaction time**  A theoretical approach for investigating the
question of the level of processing in reaction time was offered
by Sternberg for normal subjects and has been tested by
Wishner for psychiatric patients. Sternberg's additive method
assumed that the interval between the stimulus and the re-
response can be depicted as a sequence of independent stages
or events, such as encoding, serial comparison and scanning,
binary decision, and response organization. Each stage re-
ceives an input from a previous stage, transforms that input,
and passes it to the next stage. The total reaction time is
simply a sum of the times accumulated in those individual
stages. As the reaction time is changed by experimental ma-
ipulation, the duration of one or more of the stages also
changes. If two separate variables affect different stages, they
should produce cumulative (both positive and negative) ef-
effects on the final reaction time. If interactions are present, the
same stages are influenced by both variables. If interactions
are absent, different stages are influenced by each variable
separately. The exact variables or procedures used can indicate
whether the stages under consideration are more or less per-
ipheral. For example, stimulus variables are considered more
peripheral than are response variables.

Wishner and colleagues applied the Sternberg paradigm to test
schizophrenic patients. It was reasoned that if these patients show
an impairment in one or more processing stages, they should respond
differently from normals to the manipulations affecting a particular
stage. The subject was asked to remember a set of digits that served
as target stimuli, and the subject's reaction times to the targets were
measured. The parameters of the task were varied to place more or
fewer demands on each processing stage. Wishner reported that there
was no specific schizophrenic deficit at any processing stage. The
reaction times of the schizophrenic patients were lengthened to the
same degree as were those of the normal subjects by manipulations
increasing the processing demands at each stage. In all cases, the
reaction times of schizophrenics were simply slower than were those
of normals. The data suggested that schizophrenics perform the
operations at each stage in the same manner as do normals, but they
require a longer time to complete each phase of processing.

In reaction-time research, it is also possible to introduce
methodological strategies for evaluating the level of process-
ing. For example, Weiss made a distinction between premotor
and motor time by measuring both the reaction time and the
latency of the electromyographic (EMG) response to the same
stimulus. The time between the onset of the stimulus and the
first noticeable change in the electromyographic record is the
premotor time; latency was interpreted as reflecting the central
component of the over-all reaction time. The total reaction
time minus the premotor time is the measure of the motor
time, which was interpreted as the peripheral, output com-
ponent of the total reaction time and seemed to show minimal
individual differences. The results from these reaction-time
studies strongly supported the notion that changes in total
reaction time are primarily associated with changes in the
premotor (central) component and that the motor component
is not an important factor in evaluating reaction-time results.

**Locality of processing**  In recent years there has been a renewed
that can be drawn? Dysfunction in the realm of attention and the control of processing has been proposed as a possible underlying problem that might account for the plethora of differences between patients and normals.

Although many tasks are described as measures of attention or attention dysfunction, the intercorrelations among them are minimal. Therefore, it is incorrect to describe attention as a single phenomenon. Rather, the term "attention" is used to refer to various operations that limit and modulate the amount of information intake and the types of information selected across the processing domains.

Attentional studies in psychopathology have been chiefly concerned with two questions. First, are there differences between patients and controls in how much can be processed and how fast it is processed? Second, do patients and controls differ in their abilities to exclude certain stimuli from awareness? In other words, do they differ in the capacity to focus attention selectively? Further, do patients differ in what is and is not selected for processing from among the stimuli bidding for attention, as well as in how such selectivity is achieved?

As a consequence of these different objectives, studies assessing how much can be processed usually require divided or extended attention among many inputs. In contrast, studies of the selective aspect of attention require focused attention to one input out of an array of competing inputs.

CONTROL PROCESSES AFFECTING ATTENTIONAL LIMITATIONS The studies described in this section are of greatest relevance to the sensory-perceptual domain. They aim to investigate limitations at the input or sensory-perceptual end of processing. These studies attempt to determine the amount of input that can be processed simultaneously by the sensory and perceptual systems. They use brief stimuli and examine control processes occurring with rapid latency after an input is received. Generally, such studies concern data-driven processing; that is, they examine processing initiated by the arrival of a stimulus and minimally guided by conceptual expectations. In the one case in which a concept does guide the search for a target, the concept is an elementary one. Subjects are asked to search for either of two letters, and their search entails primarily physical discriminations between distinctive perceptual features of these letters, as opposed to other letters. If the search were guided by a more elaborate conceptual category—for example, animal names or prepositions—such studies would be of greater relevance to the cognitive-processing domain.

Span of apprehension The span test determines how many stimuli can be perceived simultaneously in one glance. The test attempts to measure the basic capacity limits on data-driven processing. Processing capacity is measured over brief durations of time corresponding to those usually associated with sensory-processing experiments. A tachistoscope is used to visually present varying numbers of stimuli for some duration of time, usually less than 100 msec. Eye movements cannot occur with such rapid latency; therefore, the reception of stimuli must literally be accomplished within a single glance. The information present in the stimulus display persists, however, in a sensory (iconic) store for at least several hundred milliseconds after the display terminates. The quality of information in that brief sensory store is degraded over time.

Cash and colleagues administered displays of four or eight stimuli lasting 70 msec to schizophrenic and nonschizophrenic psychiatric patients. When asked to report all the stimuli in the display (full-report procedure), the schizophrenics performed as accurately as did the controls. The adequate performance of schizophrenics under full-report conditions permits two interpretations. The first interpretation

**ATTENTION AND THE CONTROL OF PROCESSING**

Given the variety of difficulties that characterize the schizophrenic’s handling of information, is there any unifying thread

interest in the possibility of an asymmetry of function (functional lateralization) for the two cerebral hemispheres. Currently, an extensive amount of this type of research is under way in the field of psychopathology, as well as with neurologically lesioned or commissurotomized (split-brain) patients. The evidence suggests that the left hemisphere is specialized for analytic, sequential, and verbal processing and that the right hemisphere is specialized for holistic, spatial, and nonverbal processing. For normal persons and patients without known neurological problems, such hemispheric specialization would be only relative, because, in those persons, excitations from stimuli travel to both hemispheres, and both hemispheres are involved in the processing.

The strategy for establishing the locus of function involves many complexities, because numerous organismic and experimental factors are known to modify the overly simplistic depiction of the asymmetry of functioning outlined above. The age, sex, and handedness of the subjects are a few of the important subject factors. Experimental factors of importance include the amount of practice and the implicit interpretations the subjects give to the instructions provided them about how the experimental task should be done.

In behavioral studies of the locus of processing, the most frequently used techniques are, for audition, the dichotic listening procedure, which involves presenting separate messages to each ear, and, for vision, the tachistoscopic and hemifield procedure, which involves the presentation of visual stimuli to the right or left of the fixation target. In dichotic listening, the stimuli are presented through earphones to separate ears, and the expected lateralized gain is due to the known anatomy of the auditory system; that is, 40 percent of the neural fibers are ipsilateralized (uncrossed), and 60 percent of them are contralateralized (crossed). Thus, more fibers cross to the other side than project to the same side of the nervous system, and this organization leads to the expectation that right ear stimulation would show a left hemisphere advantage, and vice versa.

In the case of visual stimulation, the visual equipment used to present the stimuli is called a tachistoscope, and the research strategy is based on the known anatomy of the visual system. Stimuli that are presented to the right of the fixation stimulus (the right visual field) project directly to the left hemisphere, and stimuli presented to the left of the fixation stimulus (the left visual field) project directly to the right hemisphere. Combined with reaction-time measurements, those hemifield presentations with the tachistoscope provide an excellent technique for the assessment of possible hemispheric differences with respect to several measures, such as response latency, percent report, and percent accuracy of discrimination.

Precise investigations of the relationship between functional brain asymmetries and psychopathology are comparatively recent, but several investigators have described theoretical possibilities supported by some clinical data. The most frequent hypothesis is that schizophrenics display left-hemispheric dysfunction; a less-mentioned hypothesis is that the affective disorders show a right-hemispheric dysfunction. Clinically, those postulations seem reasonable, given the language-related disturbances—presumably left hemisphere dysfunctions—seen in schizophrenia and the mood or affective disturbances characteristic of depressive disorder, because there is some evidence that the right hemisphere is specialized for the processing of emotional or affective material.
is that schizophrenics resemble normals in their perceptual-processing capacity and their memory capacity. In other words, schizophrenics are adequate in perceptually processing a normal amount of stimulus information in the display and in verbally encoding that information into short-term memory. An alternative interpretation is that schizophrenics may perceptually process fewer letters in the display than do controls, and, therefore, they do not, unlike the controls, overload short-term memory. Thus, whereas schizophrenics may recall nearly all the limited amount of information that they have apprehended, controls may apprehend more information but may be unable to demonstrate that fact because of memory limitations.

A study by Knight and colleagues illustrated a processing approach to the study of capacity limitations. Knight reasoned that a partial report should yield a performance superior to a full report when tests are conducted immediately after the display presentation, when the icon is still intact. They found that nonpsychotic patients and overinclusive schizophrenic patients showed an expected superiority of partial-report performance over full-report performance. In contrast, minimally and moderately overinclusive schizophrenics showed no superiority of partial-report performance over full-report. Therefore, attentional capacity in overinclusive schizophrenic and nonpsychotic patients seems to be assisted by a normal icon, whereas capacity in minimally and moderately overinclusive schizophrenics is not.

Asarnow has adopted a modified version of the visual span of apprehension procedure in which the subject is asked to judge which of two targets—for example, T or F—is present in the display. That slight variation changes the task in two ways. First, selective processing is now required. Only target stimuli are relevant; nontarget stimuli are irrelevant distractors. Second, the search-processing task requires conceptually driven processing, as well as data-driven processing. Because subjects know which stimuli are relevant before the display comes on, their expectations guide the allocation of processing efforts. Because the display is presented only very briefly and can include many elements, this version of the task also investigates limitations on how many inputs can be processed at once.

Asarnow and MacCrimmon found that schizophrenic patients performed as accurately as did normal subjects when identifying a single presented tachistoscopically in an array. When the display contained a variety of distracting letters in addition to the target, the performance of the schizophrenics deteriorated relative to that of the normals. Thus, for example, MacCrimmon found that remitted schizophrenics and children of schizophrenics were as impaired as ill schizophrenics in failing to detect the targets in arrays that included distracting elements, suggesting the possibility that this measure is a vulnerability marker.

Filtering impairment One possible explanation for schizophrenic patients’ impairment in search tasks is that schizophrenics are impaired in their ability to filter or exclude nontargeted stimuli with inappropriate physical characteristics from further processing. Such a problem would reflect an anomaly of data-driven selection or filtering. In 1974, Davidson and Neale tested that possibility. They hypothesized that, if schizophrenics cannot filter out irrelevant stimuli on the basis of physical characteristics, their search performance should be unaffected by increasing or decreasing the physical similarities between target and distractor stimuli. Although schizophrenics performed less accurately than did controls at all levels of target-distractor similarity, Davidson and Neale found that the performance of these patients did improve as distractors became increasingly different from targets. Thus, a complete absence of filtering ability cannot explain the schizophrenic patients’ search deficit.

Slowness of processing Another possible factor in schizophrenic patients’ search deficiencies is over-all slowness in processing. Schizophrenics may perform the scanning and filtering of the display normally, but they may carry out those functions more slowly than do normals. Thus, they may perform processing operations on the icon for a longer than normal period of time and not have completed encoding all the stimulus information before the icon fades. If the icon is processed at a snail’s pace, then only a limited amount of stimulus information can be processed before the stimuli are no longer available. There is considerable evidence to support the hypothesis of slow processing speed in schizophrenia. Russell and Page found that the time needed to detect a target amid distractors increased disproportionately for schizophrenics relative to normal controls as the number of distracting elements was increased. In that reaction-time study, schizophrenics were able to identify the correct target as accurately as did normals, but they required considerably more time to do so, especially when many stimuli had to be searched.

Pigeonholing impairment Another processing deficit that may be involved in the schizophrenic impairment involves an anomaly in pigeonholing. The subjects must judge, often in the absence of a clear sensory impression, which stimulus was present and which response is warranted. If the patients are biased toward giving a particular response, for example A, in the absence of absolute certainty about what the stimulus was, their performance will differ from that of persons who alternate between T or K when uncertain. Moreover, patients who broaden the allowable categories of response by occasionally reporting G or W will also demonstrate a pigeonholing abnormality and be impaired on the span test. Several theorists have suggested that schizophrenic persons experience particular difficulty in performing pigeonholing operations.

CONTROL PROCESSES AFFECTING MAINTENANCE OF ATTENTIONAL SELECTION Whereas the studies discussed above were most concerned with the capacity limitation aspect of attention, those described below are concerned with the selective aspects of attention. These studies consider focused attention in the presence of distractors. This research is most relevant to the cognitive processing domain because processing takes place over an extended time span, and conceptually driven control processes are brought into play to maintain processing activities.

Divided attention versus focused attention All span of apprehension studies of attentional limitations required divided attention. Attention was divided among all the stimuli presented tachistoscopically or between the two target stimuli, T or F. The requirement for divided attention was consistent with the objectives of those studies; they aimed to determine how much can be processed.

In contrast, studies of attentional selectivity examine how well subjects can focus attention and exclude distracting stimuli from awareness or from response. Selective attention studies require focused attention to target stimuli. The target may be brief and infrequent, as it is in vigilance tasks in which the focus is maintained by suppressing responses to intermittent extraneous environmental or mental events. Alternatively, targets may be continuous, and distractors may also be continuous, as they are in dichotic listening or competing voices tasks.

Maintenance of alertness In addition to requiring focused attention, vigilance and dichotic listening tasks require another element not found in divided-attention tasks. They require that processing efforts be maintained at a high level over relatively prolonged periods of time. The demands on maintaining alertness are particularly pronounced when initially slow or poor performance can interfere with the efficient processing of stimuli later in a sequence. Alertness can also be required when subjects are given a warning signal to be followed by a stimulus on a forthcoming reaction-time trial. In that case, alertness must be maintained for a relatively brief period throughout the duration of the preparatory interval.

The concept of arousal is particularly germane to the problem of how subjects maintain alertness. Broadbent speculated that it is necessary to postulate two arousal systems, a lower one concerned with executing well-established decision proc-
es and an upper one that modulates the lower system to maintain a constant degree of alertness. That distinction is similar, although not identical, to the one proposed by Claridge between subcortical and cortical arousal. One might describe the maintenance of alertness as a process by which arousal is modulated or held at a constant level by conceptually driven operations.

**Vigilance** Deficits in schizophrenic patients’ information processing have been very clearly demonstrated on tasks requiring vigilance. The most widely used measure of vigilance for psychiatric populations is the Continuous Performance Test (CPT), which was originally proposed as a measure of brain damage. In that task, a sequence of single letters or digits is continuously flashed on a screen, and subjects are required to depress a lever whenever a particular target stimulus or sequence of stimuli occurs. Performance is scored for reaction time to target stimuli or for errors of omission (failing to detect a target) and errors of commission (responding to a nontarget stimulus). Chronic schizophrenics, particularly those with a family history of mental illness; remitted schizophrenics; and children of schizophrenic parents display more errors than normal controls.

The other major paradigm that has been used to study sustained attention in psychiatric patients is the set reaction-time procedure originally proposed by Shakow. In that technique, reaction time to simple energy stimuli is measured as a function of the duration and regularity of the preparatory interval between a warning signal and the stimulus to respond. The set technique has generated an enormous amount of research in schizophrenia, most of it consistent with the hypothesis that diverse groups of psychiatric patients display deficits in vigilance in that they cannot maintain a preparatory set.

Many of the tasks used to measure vigilance and sustained attention require conceptually driven, pigeonholing operations. These procedures are likely to reflect a wide range of generalized deficits in the patient population without necessarily being particularly revealing of the specific nature of the deficit. Problems in maintaining motivation loom large as potential explanations of the poorer patient performance on the CPT. Since tests of sustained attention are particularly difficult, it is necessary to compare performance on them to a control task matched on discriminating power to be certain that impaired performance does not simply reflect the generalized patient deficit. A related problem involves the need to determine that subjects are sufficiently motivated to voluntarily attend to the procedure and perform the task requested of them.

If these nuisance factors can be ruled out, there are at least two possible explanations for obtained deficits in sustained-attention performance. The first suggests that deficits in sustained attention arise from slowness in processing each individual stimulus event in the processing sequence. The second hypothesis suggests that deficits are caused by involuntary shifts in the focus of attention away from the major task and toward distracting events. Rappaport and Hopkins proposed that some schizophrenic patients undergo periodic defocusing of attention, during which they simply tune out and undergo an elevation of thresholds to external stimulation. This position bears some resemblance to Canco’s proposal that schizophrenic attention may be devoted preferentially to internal mental events, rather than to external events; however, Rappaport and Hopkins predicted that the turning inward would be periodic, rather than continuous. Shakow suggested that schizophrenic attention is drawn away from the task at hand and toward the adoption of minor sets to distracting mental or environmental events. Cromwell and Dokecki suggested that, once distracted, schizophrenic patients have difficulty in disengaging from or disattending to irrelevant events. The hypothesis that sustained-attention deficits in psychiatric patients are caused by distracting external events is inferred indirectly from vigilance tasks. That hypothesis is tested directly by dichotic-listening experiments.

**Dichotic shadowing** In dichotic-listening tasks, subjects are asked to shadow or repeat a single message or channel, word by word, while ignoring a simultaneous distracting message. Deviations in the ability to maintain focused or selective attention are inferred from errors in shadowing performance and from enhanced memory for stimuli presented on the distracting channel.

In a study comparing schizophrenic patients with alcoholic controls, Wishner and Wahl administered a task that varied the rate of stimulus presentation and the instructional set to maintain either focused or divided attention. For the slow-presentation condition, two-syllable words were presented at the rate of 25 words a minute; for the fast-presentation condition, one-syllable words were presented at 50 words a minute; the number of syllables a minute was actually the same at both presentation rates. Without distraction, schizophrenic patients were not impaired; they repeated the words as well as did alcoholic controls. Under the fast-presentation condition when distraction was present, schizophrenics made significantly more shadowing errors than did alcoholics. At the slow-presentation rate, the schizophrenic patients’ deficits were largely overcome. Schizophrenics did not make more errors than controls, except when they were instructed to divide attention and to remember distracting words. In terms of memory for distractors, whether tested by recall or tested by recognition, alcoholics remembered more distractor words than did schizophrenics. On the basis of these findings, Wishner and Wahl concluded that schizophrenic patients’ dichotic-listening difficulties arise both from their slowness and from inefficiencies in filtering irrelevant stimuli.

In two recent studies, Straube and Germer, as well as Pogue-Geile and Oltmanns, failed to find evidence that shadowing errors increased for schizophrenics to a greater than normal extent when distraction was introduced. Pogue-Geile and Oltmanns had subjects shadow prose passages, whereas Straube and Germer used strings of words.

Using a sensitive new scoring system for errors, Spring and her associates found that schizophrenic patients made more errors than normal controls when shadowing with distraction. These findings occurred in one study that asked subjects to repeat proverbs and unpredictable sentences presented with distraction at fast (105 syllables per minute) and slow (55 syllables per minute) presentation speeds. Findings were also replicated in a second study that compared shadowing of word strings with and without distraction, where distractor and no distractor tests were matched on discriminating power. Unlike Wishner and Wahl, Spring found schizophrenic shadowing errors to be greater than normal at both fast and slow presentation speeds. This may not be a genuine discrepancy, however, because Spring’s slow speed was similar to the Wishner and Wahl fast speed, at which schizophrenics were impaired in comparison to normals.

In both of Spring’s studies, schizophrenic patients and their first-degree relatives exceeded normal controls lacking familial psychopathology in the extent to which they shadowed words from the distractor ear after being instructed to ignore those words. That finding may mean that schizophrenics and their relatives processed distractors excessively in comparison with normal controls, suggesting a problem in filtering or stimulus set. Alternatively, schizophrenics and their relatives may not differ from controls in the degree of processing of distractors, but patients and their relatives may be more inclined to verbalize about distracting stimuli. The latter would suggest difficulties in pigeonholing or response
selection. Consistent with a possible problem in pigeonholing, schizophrenics exceeded other psychiatric patients, as well as normals, in a confabulatory shadowing error that bore no phonetic relationship to sounds on the main channel or distractor channel. Relatives of schizophrenics did not differ from normal controls on confabulation errors.

Findings suggest that under some circumstances schizophrenic patients and their relatives have difficulty excluding distractors when sustained, selective processing is required. It may be that focused-attention deficits become evident in schizophrenics when selection between inputs must be sustained over time. It is, however, far from certain that such difficulties arise from deficient stimulus set, defined as an inability to filter out irrelevant stimuli on the basis of a simple physical cue. It may be that schizophrenic patients simply allocate attention in an unusual way, bypassing the instructions and devoting a greater than normal amount of attention to the distracting message. It may also be that schizophrenics have disorganized response selection. This disorganization may be due to their failure to edit inappropriate responses or due to their misinterpreting extraneous stimuli as warranting a response.

COGNITIVE DOMAIN

In the sensory and perceptual studies described above, the response to an incoming stimulus occurs immediately after stimulus presentation. In the measures to be discussed next, a longer period of time elapses between the presentation of the stimulus and the response. Because more time is required for cognitive processing of the stimulus, one can infer that such processing progresses through a greater number of stages than does sensory and perceptual responses.

Unlike sensory and perceptual processing, which depend only minimally on the organism’s prior learning experience, cognitive processing is highly dependent on prior experience as it is encoded in stored memories. Cognitive processing can be described as involving a response to signal stimuli—stimuli to which prior learning has been attached—so that the response involves the retrieval of short-term and long-term memories.

One of the most important aspects of cognition is thinking and its deviations. Disorders of thinking have been described for centuries in relation to a number of forms of psychopathology; for some clinicians, thought disorder still serves as the hallmark of schizophrenia. Little persuasive experimental work has been undertaken on abnormal cognitive functioning, particularly in psychosis, because of the inaccessible nature of cognition, the difficulties of working with the mentally ill, and the enormous and unstable range of signs and symptoms evinced in the various conditions.

Cognitive behavior seems refractory to explanation, unless the entire history of the patient is taken into account. At the same time, different patients with the same disorder have different histories, and this variance may reflect different courses of illness. Those two considerations suggest that progress in the study of cognitive functioning in relation to psychopathology may depend largely on longitudinal and prospective studies.

This discussion of cognitive behavior deals with schizophrenia, and to a large extent, the discussion follows the organization of relevant material by Broen. Although cognitive performance is impaired in other disorders—such as anxiety, neurosis, and depression—that impairment seems to be less fundamental, less profound, and less enduring.

Classical descriptions of cognitive behavior in schizophrenia are approached from different theoretical points of view as described by Bleuler and Jaspers and in impressive detail in psychoanalytic case history by Sechehaye. Those descriptions and the clinical and quasieperimental studies show that the most attention has been paid to difficulties in the schizophrenic patient’s memory, categorizing behavior, simple word associations, and quality of speech in spontaneous connected discourse.

SHORT-TERM MEMORY

There are numerous measures of cognitive processing, some of them highly complex. All the sophisticated measures of cognition require short-term memory processing. Short-term memory is measured by processing tasks in which the response occurs in a matter of seconds or minutes after the stimulus is presented. The study of memory is one of the oldest areas of research in psychopathology. A variety of categories for classifying memory deficits have been proposed.

Short-term memory in normal persons

Previous models of human memory emphasized the existence of several storage systems: sensory memory, short-term memory, and long-term memory. Sensory memory has been described as a sensory-perceptual phenomenon that preserves an image of the stimulus for several hundred milliseconds after the disappearance of the stimulus—long enough to permit the encoding of its relevant components. The output of that encoding process is preserved in short-term memory. Verbal materials, regardless of whether they are presented visually or in spoken form, are encoded primarily in terms of their acoustical properties in short-term memory. A limited amount of semantic information from the stimulus also seems to be contained in short-term memory. A particular processing operation, rehearsal, is performed on material in short-term memory and can serve to modify the limited storage capacity of that system. Rehearsal is a kind of inner speech that occurs serially, one item at a time, and slowly, at a rate of three to six items a second. Rehearsal seems to serve two functions: (1) It maintains information in short-term memory storage by essentially representing it, because material that is not rehearsed simply decays from storage and is lost; and (2) it helps transfer information from short-term memory to long-term memory.

Many theories of schizophrenic deficit predict that a consequence of slowed processing of the patients is an overload of short-term memory because only a limited number of items can be rehearsed at one time.

Recent models of memory point out that the characteristics of memory for an item depend on the way it has been rehearsed, how it has been encoded, and how much processing it has received. This depth-of-processing aspect of memory storage has been articulated most clearly by Craik and Lockhart. As stimuli undergo a sequence of different stages of processing, they are encoded and represented in different ways. At early sensory stages, stimuli are encoded in terms of images of physical features, and they can be preserved only briefly. At intermediate stages, stimuli are represented through matching or pattern recognition with familiar templates, e.g., words are remembered as acoustic patterns. Such representations exemplify the degree and the duration of retention associated with short-term memory. At later stages of analysis, memory templates are modified, enriched, and reorganized on the basis of semantic associations and abstractions from past experience. Those traces persist longest and display properties associated with long-term memory.

Greater depth of processing by an individual implies that more semantic and cognitive analyses have been used by them to encode stimuli. Stimuli that have received the greatest depths of processing are encoded and organized most effi-
ciently and persist longest. Thus, stimuli that are structured and encoded in terms of deep, cognitively enriched traces are remembered longest. Craik and Lockhart postulated that there are two types of processing or rehearsal operations. Type I processing involves maintenance rehearsal, which recirculates stimuli at a given level of encoding without reorganizing them. Maintenance rehearsal simply maintains stimuli in conscious awareness and affords effective temporary storage, but does not lead to long-term storage of the input. Thus, rote rehearsal in the absence of deeper semantic processing and reorganization of the input does not facilitate long-term memory. Type II processing elaborates the input in terms of meaningful cognitive associations and facilitates long-term persistence of the memory trace.

In examining short-term memory, one is concerned with two different sets of operations. First, one is concerned with the encoding operations performed on the memory test stimuli, a process referred to as registration. If stimuli are not encoded or are not encoded deeply enough—that is, registered—their traces may decay before the memory test is administered. Second, one is concerned with retrieval operations governing the manner in which the memory trace is relocated and brought to consciousness.

Memory deviations in psychiatric patients With those distinctions regarding normal, short-term memory, one can pose several questions about the short-term memory of psychiatric populations: (1) Do patients have normal mnemonic structures to organize the encoding of stimuli? (2) Do patients generally use normal mnemonic organization when given a memory task? (3) Can patients be induced to use normal encoding strategies if they do not generally do so? (4) If normal encoding can be induced, does deeper encoding facilitate recall in the same manner for patients as for normals?

Before reviewing the relevant literature for schizophrenia, one must distinguish between recognition memory and recall memory. In recognition memory, a memory test item initiates the attempt to identify a matching template in memory. That process entails pigeonholing. It essentially involves pattern recognition and a decision about whether two patterns—one a stimulus, the other a memory trace—are identical. The matching process can be performed accurately when stimuli are encoded at a fairly shallow depth in terms of either physical features or acoustic properties. Recall memory, by contrast, requires conceptually driven processing to initiate a search for some class of templates in memory. An active search requiring conscious, strategic efforts must be initiated by the person. The search operates most efficiently if memory items have been encoded efficiently and deeply into meaningful cognitive categories.

Recall is more difficult than recognition. Recall makes more extensive demands on the voluntary execution of controlled processing activities and, accordingly, taxes the person’s motivation and processing capacities. Koh and Peterson reported that schizophrenics displayed recall but not recognition deficits relative to normal controls. Traupman found that process schizophrenic patients, but not reactive schizophrenic patients, displayed impairments in recognition. On the basis of those memory findings, it has been proposed that most schizophrenic subjects display deficits in search or retrieval operations, but not in pigeonholing or decision operations. Process schizophrenics are hypothesized to suffer an input dysfunction that impairs organized encoding and, consequently, hampers recognition. An alternative hypothesis is that process schizophrenics suffer generalized deficits reflected on any task. Nonprocess schizophrenics suffer less severe generalized deficits that are revealed primarily on more difficult or more discriminating tasks. Unfortunately, most memory studies comparing patients and normals on recognition and recall have not matched the two memory tasks in difficulty for normals, a match that is required to eliminate the previously discussed psychometric artifact problem, as described by the Chapmans.

Do patients have normal mnemonic structures? Weingartner and colleagues have investigated that question by asking patients to categorize stimuli in word lists to determine whether they could organize stimuli in a manner that would facilitate recall. For word lists devised to be easily sorted into categories, schizophrenics sorted stimuli into the same number and types of categories as did normals. Traupman found that only reactive schizophrenics, and not process schizophrenics, profited from the categorization in memory lists. For random, unrelated words, schizophrenics imposed less structure or organization on the list than did normals. Normals grouped the list into approximately three categories, whereas schizophrenics formed more than eight categories. Those data suggest that schizophrenics can perform the necessary deep, cognitive analyses that encode material for long persistence in memory; however, they tend to perform such organization not on their own initiative, but only when stimuli readily suggest the organization. Because tasks requiring subjects to actively impose an organization on memory stimuli generally facilitate deep processing, lack of initiative on the part of the patients may lead to an impairment in their long-term memory.

It is important to ask whether the structure inherent in the memory list is preserved in the subject’s own structuring of recall. Traupman found that the degree of intertrial repetition, an index of clustering or categorization of items in recall, was greatest for normals, less for reactive schizophrenics, and least for process schizophrenics. Weingartner found no difference in the degree to which schizophrenics and normals recalled items in sequential or clustered order; however, these data also suggested an important drawback for schizophrenics who attempt to reorganize recall by clustering. Schizophrenics displayed more than the normal number of intrusion errors, recalling nonlist words in the same superordinate categories as list words. That observation suggests that, even when schizophrenics impose sufficient organization to process the memory list deeply, the usual recall advantage observed with deep processing in normals may be lost for schizophrenics. That loss seems to be due to the phenomenon described as loosening of associations—the likelihood of response is increased by generalization to the entire class of semantic associates for the encoded stimulus, rather than limited to the target stimulus.

Can patients be induced to use normal encoding strategies, and does deeper encoding facilitate recall in the same manner for patients as for normals? Koh and Peterson reasoned that, if the difficulties schizophrenic patients have in recall reflect problems in encoding stimuli at sufficient depth to permit retrieval, recall difficulties may be overcome by inducing subjects to perform deeper semantic encoding of stimuli during input. Koh and Peterson induced subjects to process list words at different depths of encoding. Subjects were asked questions about words to induce graphic processing (questions about word letters), phonemic processing (questions about rhyme words), semantic-conceptual processing (questions about synonyms), or semantic-propositional processing (using the word in a sentence). A surprise memory test was then administered. Recognition memory was not impaired for schizophrenics in this study and was further improved by greater depth of processing in the same manner as in normals.
Schizophrenic recall memory was impaired; however, on closer inspection, the recall deficit was evident only for words that had been processed at the rhyme level, not for words processed at the semantic level. For schizophrenics, encoding for rhyme may be particularly likely to induce competition among clang associates during recall. It therefore appears that, if schizophrenics can be induced to use semantic processing, their recall deficit is overcome. Moreover, as processing becomes deeper, memory is enhanced at the same rate for schizophrenics as for normals. When, however, schizophrenics were asked to generate semantic processing themselves by proposing their own words for the memory test, this procedure did not overcome the schizophrenic recall deficit.

Schizophrenic short-term memory seems to be most impaired on tasks requiring self-generated processing efforts. Such effortful tasks are likely to be more difficult than control tasks, even for normals. Schizophrenics take longer to complete any processing operation than do normals, and if they are deprived of time, they may not be able to demonstrate their capacities, particularly on tasks that require the longest processing time, even in normals. Koh and Peterson found that the time taken to answer questions requiring greater depth of processing increased proportionately for schizophrenics and normals and did not differ significantly between the groups when the stimuli were presented words. For self-generated words, however, schizophrenics required significantly longer time than did normals to complete each level of processing operations. Because the recall task in that study was time limited, it is possible that schizophrenics did not actually differ in recall capacity, but were simply not given enough time to complete their retrieval operations.

RELATIONSHIP BETWEEN COGNITION AND LANGUAGE
Categorizing and conceptual behavior According to Whitehead, abstraction has two general meanings: (1) analysis of actual objects, events, and relations into attributes, like redness or sphericity, the so-called abstraction from actuality, and (2) abstraction from possibility, by which an abstractive hierarchy is erected from attributes by a consideration of possible relations among the attributes. Abstraction from possibility is the recognized method for extracting implications from assumptions, as in logic, law, philosophy, and mathematics.

Many schizophrenics evolve rather elaborate logical constructs (abstractions from possibility), but fail on conceptual tests because they are unpredictable in abstraction from actuality, often defining category boundaries in an unusual fashion or selecting an incidental attribute, rather than a commonly recognized property, as the basis for classification. In that respect, their behavior shows high eccentricity or lack of socialization, but not necessarily low abstract ability.

In an experiment by Chapman and Taylor, schizophrenics were given cards bearing the names of fruits, vegetables, and birds and were asked to identify the fruits. The patients sorted fruits into the experimentally designed category, but also included vegetables—although not birds—to a far greater extent than did normal subjects. Thus, the schizophrenics were overinclusive in their categorizing, in a manner that showed that, although they were able to categorize, they were also responding to commonalities across stimulus classes (fruits, vegetables) that are conceptually and culturally of high probability but are irrelevant to the task. In a second part of the experiment, schizophrenics were given the same cards and were asked to sort edible items together, that is, to include fruits and vegetables in the same category and to exclude birds. The schizophrenics performed about as well as did normal subjects.

The experiment showed several important aspects of schizophrenic conceptual behavior. First, it showed the patients' conceptual ability to be adequate under certain nontrivial conditions, and it showed their ability to think abstractly. Second, it showed the often-noted tendency of schizophrenics toward a loosening of conceptual boundaries and toward overinclusion.

Chapman and Chapman have theorized that schizophrenic errors are an exaggeration of normal association biases. Particularly, schizophrenic errors reflect responses to the dominant meanings of words or objects at the expense of subordinate but contextually more appropriate meanings. The associative hierarchies or lattices of normal’s and schizophrenics’ meaning responses are substantially the same; however, normal persons, unlike schizophrenics, take into account the total context. Thus, normal persons are able to bypass the dominant (most probable or most readily available) response and use the weaker but more appropriate one; they are able to assess the necessary level of generality or abstraction more appropriately than do schizophrenics, to separate personal or situation-bound meanings from those in the common cultural realm.

Chapman and Chapman’s theory can correctly predict both overinclusion—grouping things together inappropriately when the dominant meanings are the same—and overexclusion. Overinclusion occurs when there are overdetermined or formulaic responses (black: white; father: son: Holy Ghost), responses that are easily available but too loose or at too high a level of superordination for the situation (a bicycle is the same as an airplane because one can go places on both of them). For example, in the Chapman and Taylor study, the semantic compound “fruits and vegetables” predominated over the narrower category, “fruits,” and resulted in overinclusive responding. In the case of overexclusion, when the basis for inclusion is mediated by a relatively weak meaning response, it is not so classified. For example, in a study by Chapman and Chapman that required things with “heads” to be grouped together, schizophrenic patients apparently limited themselves to responses with animate meaning, and thus failed to give responses like pins, hammers, and so on.

Other modern theorists, such as Broen and Storms, have offered explanations of schizophrenics’ classificatory behavior that emphasized not the effect of dominant response tendencies, but its complement—the increase in probability of responding with interfering or incompatible responses. Both types of theory assumed an ordered response hierarchy that is essentially the same in both normal subjects and schizophrenics. Broen and Storms proposed a partial collapse of such hierarchies, thus raising the probability of alternative or competing responses, which, in normal people, would be improbable or would be elicited only after the more probable responses had been rejected. Also, there is evidence from learning theory experiments and comparable studies in psychopathology that, under conditions of high drive, such as anxiety, ordinarily low-probability responses are raised toward or above threshold.

Word association Idiosyncratic word associations are among the most striking and most noted aspects of schizophrenic behavior. Systematic studies over many years have demonstrated that, compared with responses in normal persons, schizophrenic patients’ responses in word association tests are unusual, but not meaningless, and are variable from test to test in the same subjects. Their clinical value aside, those phenomena by themselves are of little more than descriptive interest until they are related to a broader behavioral context. Such a context is provided by the connected speech of schizophrenics, in which it has long been noted that seemingly unnatural verbal associations and intrusions break into the progress of directed discourse.
Schizophrenic language Early work in language was directed at intrapsychic processes—thinking and association—and only recently has the focus shifted to its interpersonal, social, and communicative aspects.

Language has been defined by Carroll as

a structured system of arbitrary vocal sounds and sequences which is used or can be used, in interpersonal communication by an aggregation of human beings, and which rather exhaustively catalogs the things, events, and processes in the human environment.

Schizophrenic language seems to suffer in regard to two aspects of that definition: (1) arbitrary vocal sounds and (2) interpersonal communication. The arbitrariness of the relationship between sounds and their referents requires that those relationships be learned through social interaction with the things, events, and processes in the human environment, a requirement that the schizophrenic patient may not fulfill in the same way as the normal control. Furthermore, the very arbitrariness of the relationship often focuses too much attention on the sound itself in the schizophrenic, leading to echolalia, clang associations, and garbled speech. Also, the tendency for schizophrenics to have less interpersonal communication than do normals and, thus, less feedback also militates against the development and maintenance of communicative ability. Language has been used as a means of detecting schizophrenia, and it has become an important field of investigation.

Schizophrenic speech The disordered speech of schizophrenics is unmistakable yet elusive. Transcribed samples of such speech, and by no means the most bizarre examples, can be reliably identified as seriously abnormal by university students. Yet, schizophrenic speech is not frequent; many patients rarely or never show disordered speech, and those who do by no means do so in all their utterances, but only do so in connection with certain situations or topics, often those that are emotionally toned. The most dramatic and oft-recorded forms of schizophrenic speech—such as echolalia and word salad and, for that matter, muteness—are rare in modern times.

Salzinger and others have reviewed the objective characteristics of schizophrenic speech emitted in situations approximating sustained natural discourse, such as interviews, monologues, and unstructured interpersonal colloquy. Schizophrenic speech is repetitious, nonfluent, has occasional neologisms, is somewhat impoverished in breadth of vocabulary, and, in general, is less comprehensible than the speech of normal persons. Neologisms aside, those characteristics are not sufficient to define the peculiar quality of schizophrenic speech; much normal speech, if analyzed objectively, is nonfluent, repetitious, lexically constrained, and barely understandable. The basic discriminating aspect of speech that judges identify as that of psychotics is its incomunicability and culturally unusual referential range. What is odd about schizophrenic speech is not how it is produced, but what it is about.

Brown went so far as to suggest that there is nothing wrong with schizophrenic speech, only with schizophrenic thinking. He said that schizophrenic speech is recognizable as such because the speaker says things that others in the language community know cannot be true, even metaphorically or hypothetically, and that in such speech others recognize a profound failure of reality testing and knowledge of the world.

For further experimentation on cognitive processes in schizophrenia, speech is an important behavior to choose because it is an important class of human behavior, needs no special instructions to perform, is fairly easily recorded and analyzed, and can be elicited in a wide range of natural settings.

Deviations in the communicability of speech One of the most striking characteristics of schizophrenic behavior is the fact that conversation with schizophrenic patients is often very difficult. In extreme cases, the lack of clarity in schizophrenic speech is regarded as pathognomonic. Just what goes wrong in such conversations is often difficult to analyze, but it has become generally recognized that it is a disturbance not in language itself, but in its communicability to the listener. It is as if the schizophrenic did not take into consideration the immediate needs of the listener. That difficulty in communicability has a variety of sources, and one of them is that the listener often finds the referents in the schizophrenic's conversation elusive; that is, when the schizophrenic refers to an object or event, it is not always clear to the listener which event or object is being referred to.

Cohen suggested that there are two possible sources for the disorder in referent communication: (1) disorders in the speaker’s repertoire of associations to meanings or descriptions of a referent and (2) disorders in the selection mechanism through which the speaker edits out contextually inappropriate (cryptic, ambiguous, or misleading) responses before they intrude into overt speech. There is even a third possibility: The schizophrenic speaker fails to heed the listener's immediate needs insofar as the referents the patient utilizes remain obscure.

To test which of those possibilities explain the actual behavior of the schizophrenic, Cohen applied the following basic experimental paradigm: (1) An explicit set of stimulus objects—colored displays—was presented to a subject (the speaker), (2) The speaker was instructed to provide a verbal description of one of the colors (referent) in the display in such a manner that (3) the listener, given the verbal description, was expected to be able to pick the correct referent out of the display.

The first question that needed to be answered was whether the deviation in the communication act was the result of some disturbance in the schizophrenic's repertoire of words, concepts, and associations. To test that hypothesis, Cohen asked the schizophrenics to listen to a normal speaker's performance of the task. The schizophrenics were able to select the correct referent, indicating that they comprehended the speaker's communication and that they, therefore, possessed the required repertoire of words, concepts, and associations necessary to carry out the task. It was only when schizophrenics served as speakers that they failed to communicate the referent appropriately.

In an attempt to discover why the schizophrenic speakers were unable to communicate appropriately, Cohen hypothesized that there are two stages to the communicative process: (1) the sampling stage, in which the repertoire of possible communicative descriptions of the referents is sampled, and (2) the editing stage, in which the appropriateness of the selected sample is examined, the inappropriate response is rejected, and further sampling of other possible responses follows. Cohen's findings indicate that the schizophrenics' difficulties lie in the editing stage. Acute schizophrenics responded with a prolonged delay and at great length when the difficulty of the discrimination increased. In other words, they responded perseveringly. After the initial response, the referent for acute schizophrenics' was no longer the color referent but was the immediately preceding word in their utterance. Instead of responding to the stimulus situation, the schizophrenics began responding to the words in their own utterances. As Cromwell noted, once the schizophrenics discovered
that their dominant association did not meet the task demand, it was as if they pulled the windowshades down on the outside world and started associating to their own associations. Cohen dubbed that phenomenon "perseverative chaining." In comparison, schizophrenics apparently failed to edit and, instead, responded impulsively. They took no longer to respond when the discrimination between colors was very difficult than when it was easy.

Goldfarb and colleagues dealt with referent communication in schizophrenic children and their mothers, based on a number of experiments by Krauss and Glucksberg. The Goldfarb study was unidirectional—the mother being the speaker and the child being the listener, never the speaker. In an earlier experiment, Goldfarb had reported that the mothers of schizophrenic children were judged to be inferior to the mothers of normal public school children in speech and language, thus serving as poorer models for communication for their children. That was found to be true even though more of the schizophrenics' mothers were from upper-class families than were the control group mothers.

To determine just where and how in the referent communication process the mothers of schizophrenic children deviated from the mothers of normal children, Goldfarb and colleagues carried out a referent communication experiment. The mother's task was to describe a block in such a manner that her child could find it in his duplicate set. There were 14 dyads of normal public school children and their mothers; all the children were about 9 years old. The results indicated that the mothers of the schizophrenic children were inferior in at least three aspects: (1) mutuality (their responsiveness to the children's requests for help); (2) content (the level of information in the mothers' messages), and (3) style (evidence of cognitive fragmentation, tentativeness, and ambiguity).

The inferior quality of referent communication in the mothers of schizophrenics may be in response to the extreme behavioral deviations of the children. Nevertheless, the impact on language development in the children seems inevitable. If the children incorporate their mothers' referent communicative style as their model, they cannot help but become poor speakers in reference communication later in life.

According to Rochester and Martin, another source of schizophrenics' communicative difficulty in considering the listener's immediate needs is that they provide misleading or unclear cues about the location of referents. Normals gave only 2 percent of unclear referents in the noun phrases of their speech, thought-disordered schizophrenics gave 19 percent of such unclear referents, and the nonthought-disordered schizophrenics gave 12 percent.

The language system used to accommodate the listeners' immediate needs—the so-called informational system—demands unusually complex information processing from the speakers so that they can continually update and retrieve information from a short-term memory store. Because schizophrenics probably have difficulty in short-term encoding and retrieval operations, they experience difficulty in the rapid shifting of attention required between a prior clause and the clause being produced, and that characteristic is what produces the incomprehensibility noted in their referential utterances. That characteristic may be what makes their referents elusive. Rochester postulated a lack of capacity in the way schizophrenic speakers use their memory system, not in their short-term memory capacity as such.

**IMPLICATIONS OF DEVIATIONS IN INFORMATION PROCESSING**

This section of Chapter 4 has reviewed the application of information-processing procedures, one of the most striking recent developments in experimental psychology, to the study of psychopathology. Information processing deals with the problem of how the sensory systems take in external energy and information and transform them into behavior. Experimental psychologists are providing means for probing the normal development of the intactness of a behavioral response by monitoring the manner in which energy stimuli are transduced by the receptors and are processed successively through the iconic (visual) or echoic (auditory) sensory stages, to the immediate memory storage stage, and then to the cognitive processing stage, culminating in a long-term memory store. In addition to examining the structural domains described above, experimentalists are interested in examining any deviations in the action of mechanisms controlling processing, such as attention, arousal, and motivation. The impact of specific techniques for examining information processing, such as signal detection and forced choice, are exciting breakthroughs in understanding these processes. The basic knowledge gained on normal information processing helps determine how mental patients deviate from normal expectancy.

In addition, recent developments in experimental psychology concerning various behavioral techniques and strategies provide answers to questions about the loci of processing, such as the hemispheric asymmetry question, or the levels of processing, such as the peripheral versus central question. Those strategies, perhaps ultimately applied in conjunction with psychophysiological measures, offer the possibility for answering important questions about the relationship between CNS functioning or malfunctioning and psychopathology.

The following selection of tentative findings illustrates how the cutting edge of information-processing research may enhance the detection and understanding of psychopathology: In the sensory and perceptual domains, detection thresholds are generally higher (less sensitive) in mental patients than in normals; temporal resolution (critical-flicker-fusion and two-flash thresholds) seems to be less sensitive in some cases, although advanced methodologies indicate that a major difference in these measures may be one of response bias, rather than sensory sensitivity; critical duration for temporal integration differs from normals; visual masking of patients is greater; reaction time is generally slower; and special reaction-time indices, such as the cross-over index and cross-modality effects, are highly differential for psychopathology, with special reference for schizophrenia.

In the cognitive domain, short-term memory is not used effectively by schizophrenic patients, but it can improve under training; referent communication suffers when schizophrenics are the speakers, but schizophrenics do as well as normals do as listeners: and the cloze technique provides a measure of the communicability of schizophrenic speech.

In the attentional control of processing, the following techniques have been shown to differentiate patients from normals: (1) Iconic storage, measured by the span of apprehension task, seems to be deficient in minimally or moderately overinclusive schizophrenics. (2) In the target selection version of the span test, schizophrenics perform poorly because of slower than normal processing in the iconic stage, thereby losing items in the visual display that are not processed for lack of time; they also show impairment in pigeonholing. (3) In dichotic listening, schizophrenics perform poorly when shadowing with distraction possibly because of the schizophrenics' difficulty in filtering out distraction or suppressing responses to distractors.

The generalized-deficit problem is one stumbling block that impedes fruitful systematic research in this area. Because mental patients almost invariably do less well than normals
in any task, before an observed difference in performance can be attributed to a specific dysfunction it is necessary to rule out the general lethargy and the lack of motivation and interest that characterize most patients. Several techniques have been developed to deal with the generalized deficit of patients, including: (1) the signal-detection technique, (2) the forced-choice technique, (3) the selection of tasks in which patients unexpectedly perform better than do normals, and (4) the use of control tasks calibrated on normals for equivalence to the experimental task. The use of these sophisticated techniques, it is hoped, can help provide relatively reliable indicators of psychopathology.

One of the hopes for the information-processing approach to sensory, perceptual, and cognitive dysfunctions in psychopathology is that it may help to establish specific markers of vulnerability to mental disorders even in those persons who have never developed episodes but who, for either genetic or experiential reasons, have a high risk of doing so. Because the initial step is to determine the presence of these markers in individuals undergoing an episode, the question arises whether those dysfunctions are antecedent or consequent to the development of the episode; that is, are they trait (vulnerability) or state (episode) markers. Regardless of their position in the causal chain, how do those subtle, mild laboratory-discovered dysfunctions play a role—if they do—in the development of the gross dramatic behavioral dysfunctions or deficits noted in psychopathology?

If information-processing methods provide indicators that mark the development of episodes, they would be of extreme importance clinically, because objective markers of the beginnings and the ends of episodes and of anticipated exacerbations in the form of miniepisodes would be of great importance to the clinician in guiding the treatment of the patient.

The relation of vulnerability markers to grossly different behavior is a little more problematical. What possible connection can there be between, on the one hand, a higher visual threshold, a slower reaction time, a slower cross-modality shift in reaction time, or impaired shadowing with distraction and, on the other hand, hallucinatory or delusional behavior or autistic and communication disturbances? Perhaps the slow reaction time, the awkwardness in shifting attention from one sensory modality to another, the hypersensitivity to critical duration in integrating sensory inputs, and the hyperresponsiveness to distracting stimuli tend to gang up on the developing youngsters or on the adults and render them mavericks among their peers. Gradually, they begin to feel that there is something the matter with them, and their self-image, communication abilities, and general interaction with others begin to falter. In that way, the gross deviation in behavior may be an epiphenomenon built on the differences in information processing that can only be discovered in the laboratory. Such discoveries may offer an opportunity for intervention before the full-blown episode develops.

In this section, the authors have begun to provide, through the information-processing approach, the objective indicators that may eventually improve diagnosis. By interdigitating phenomenological symptomatology with the internal information-processing network, the relation of abnormal processing to symptomatology can become evident. The supplementary evidence from laboratory technique may lessen the dependence of diagnosis on clinical symptoms and signs alone and, thus, may increase the reliability and validity of present-day nosology. The nexus between symptomatology and information processing may also open up the possibility of therapeutic intervention. By determining the location and nature of the deviations from the normal route in information processing that take place in the schizophrenic patient, it may become possible to determine the contingencies that give rise to these deviations in a vulnerable individual. This determination may lead to the shortening of episodes of illness and even to the prevention of episodes. Thus, uncovering the underpinnings of psychopathology in terms of information processing may lead to salutary results.

SUGGESTED CROSS REFERENCES

The anatomy and physiology of the central nervous system is covered in Section 3.1. Motivation and affective arousal is discussed in Section 4.4. Sensory deprivation is described in Section 6.3. Clinical manifestations of psychiatric disorders are described in Chapter 13, and the examination of the psychiatric patient is discussed in Chapter 12. Schizophrenia is discussed in Chapter 15. General living systems theory is discussed in Section 1.2.

REFERENCES


4.2 JEAN PIAGET

HERBERT P. GINSBURG, Ph.D.

INTRODUCTION

This section presents a brief introduction to basic ideas stemming from Piaget's monumental work on the development of intellect. The task is not easy because Piaget's work is both copious and difficult to understand. Born in 1896, in Neuchatel, Switzerland, Piaget (Fig. 4.2-1) pursued an energetic career of research and writing. In 1918, having obtained his doctorate in zoology in the University of Neuchatel, Piaget decided to explore the field of psychology. He worked briefly at several psychological laboratories and also at Bleuler's psychiatric clinic. At this time, he became intrigued with the work of Freud, Jung, and Adler, read deeply in the psychoanalytic literature, and was even analyzed by one of Freud's disciples. The contact with psychoanalysis influenced both Piaget's theoretical framework and his early theory of egocen-