Mental Health Implications of Information Processing:

Studies of Perception and Attention

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Psychopathology, as the branch of psychology concerned with abnormalities in psychological functioning, consists of three main branches: _descriptive psychopathology_, which seeks to characterize the symptoms and syndromes of mental illness; _clinical psychopathology_, which attempts to devise effective techniques for diagnosis, treatment, and prevention; and _experimental psychopathology_, which is concerned with applying the methods and principles of psychological science to understanding the nature and origins of these syndromes. In large part, experimental psychopathology is identified with the search for _psychological deficits_ -- defects in the functioning of basic psychological processes that might account for the abnormal and maladaptive behaviors, experiences, thoughts, and actions that are characteristically observed in the victims of mental illness. Obviously the three enterprises are closely related: without good descriptions, experimentalists do not know what to investigate; and their research is predicated on the existence of an adequate diagnostic system, which in turn is based on systematic description. Basic research on the nature and origins of psychological deficits will inevitably contribute to a refined diagnostic system, as it uncovers differences among superficially similar syndromes, and features that unite categories that seem quite different on the surface. Ultimately, of course, the aim of experimental psychopathology is to lead to advances in treatment and prevention analogous to those achieved in this century by medicine.

Experimental psychopathology has a long tradition, beginning with the studies by Jung on word associations, Kraepelin on continuous performance, Shakow on attention, and Goldstein on concept-attainment. The classic review of studies of psychological deficit by Hunt and Cofer (1944) indicates that by midcentury a great variety of procedures familiar to academic experimental psychologists had been applied to clinical patients, covering such diverse topics as sensory thresholds, perceptual processes, reaction time, reflex functions, eye movements, motor performance, word associations, startle response, conditioning, memory, language, and thought. This tradition continued after the war, and the vast amount of research in this area was authoritatively summarized by Yates (1966, 1970). With the exception of a few systematic programs of inquiry (e.g., Eysenck, 1955; Lindsley & Skinner, 1955; Wishner, 1955), however, it is fair to say that experimental psychopathology was guided more by phenomena than by theory. Investigators were concerned with differences between patients and nonpatients in performance on psychological tasks, but these tasks were selected almost arbitrarily, with little effort expended in linking the positive findings in one domain with those in others. What was needed was an overarching theoretical conception of psychological functions that would link a variety of findings, and direct research toward fundamental rather than peripheral topics.

All of this changes with the emergence of the cognitive approach in psychology, which for the first time linked studies of attention, perception, learning, memory, language, thought, and problem-solving under the rubric of a general model based on the metaphor of the high-speed computer (e.g., Atkinson & Shiffrin, 1968; Newell & Simon, 1972). Within a few years this model became widely accepted within academic experimental psychology, and had begun to filter down to clinical psychology to guide the work of experimental psychopathologists. Symbolic of this transition is the review of psychological deficits in schizophrenia by Chapman and Chapman (1973), which devoted most of its pages to the classical approaches, but which included a chapter on information-processing. Six years later, a whole book appeared on this latter topic, and the earlier approaches received hardly a mention (Matthysse, Spring, & Sugarman, 1979). A similar shift is apparent in research on depression. Before 1967, depression was generally considered to be a purely emotional disorder, involving as it does dysphoria as its primary symptom, and studies of psychological deficit in this syndrome were largely nonexistent (Miller, 1976). However, the work of Beck (1967) and Seligman (1975) drew attention to the cognitive deficits characteristic of depressed patients, opening up a whole new line of inquiry on perception and cognition in the affective disorders.

Thus the year 1973 marked a major turning point in the field of experimental psychopathology. The purpose of this essay is to review progress within cognitive psychology over the past decade, with particular attention to studies of attention and memory, as it is relevant to issues in mental health. The importance of basic research on psychological functioning, particularly research on perception and attention, is nowhere better illustrated than by one of the most serious mental illnesses: schizophrenia. Schizophrenia affects approximately 1% of the population, and schizophrenics occupy approximately 50% of all the beds available for psychiatric patients. Total expenditures on schizophrenic patients represent about $14 billion, not to mention the emotional cost to the patient and his or her family, friends, and community. Schizophrenia is characterized by a wide variety of cognitive disorders, including a difficulty in focusing attention on task demands and excluding irrelevant stimuli, and perceptual disorders such as hallucinations. Despite its widespread impact, the nature of schizophrenia still remains largely a mystery. Similar disorders of attention, perception, and other aspects of cognitive functioning may be observed in depression, commonly referred to as the "common cold of psychopathology" because of its high incidence in the population; and in early infantile autism, a rarer but no less tragic and debilitating syndrome. Understanding the nature of the cognitive deficits in these mental illnesses, and others, is an important key to effective prevention and treatment. And central to understanding psychological deficit is an improved understanding of normal perception, memory, and cognition.

The Information-Processing Model in 1973

At the beginning of the period under review, research on attention, perception, and memory was largely guided by a multistore model of the memory system similar to that offered by Atkinson and Shiffrin (1968). This model consists of a number of different storage structures, and a set of control processes which transfer information from one storage structure to another; according to the model, information is transformed in various ways as it travels from peripheral sensory receptors to the permanent memory store, and as it is retrieved from permanent memory and placed in active use. According to the theory, a pattern of physical energy radiating from a distal stimulus falls on the sensory surfaces, where it is transduced into a neural impulse which is carried along a tract of sensory nerves toward a particular projection area in the brain. This incoming sensory information first makes contact with the higher mental processes involved in attention, perception, thought, and memory when it is encoded into memory structures known as the sensory registers. These registers contain a complete, veridical representation of the physical characteristics of the stimulus -- i.e., it has not yet been analyzed for meaning. In principle there are different sensory registers for each of the sensory modalities. Information held in these registers is subject to extremely rapid decay and it is effectively erased by newly arriving stimulation. Until it decays or is displaced, information held in the sensory registers is subject to analysis by a variety of feature-detection and pattern-recognition processes which begin to endow the physical stimulus with some semblance of meaning. Of course, no meaning analysis can be performed once the contents of the sensory registers have decayed or been displaced.

Once there has been some preliminary analysis of the meaning of the pattern held in iconic memory, another control process, attention, selects some of the material for further processing. By virtue of attention, information is transferred to the next storage structure, variously known as primary or short-term memory. Primary memory is the staging area of the cognitive system, where input makes contact with pre-existing information held in storage to form a full perceptual representation of the object or event. Attention has a limited capacity, so that not all information which has passed through the feature-detection and pattern-recognition processes can be transferred to primary memory. Information in primary memory can be kept there indefinitely if it is subject to yet another control process, maintenance rehearsal. Unrehearsed material is lost either through decay or through displacement by material newly arriving from the sensory registers. Information held in primary memory may be copied into secondary memory if it is subject to elaborative, as opposed to maintenance, rehearsal. Elaborative rehearsal is the culmination of perceptual processing, in which the individual makes meaningful associations between information held in primary memory and preexisting knowledge. Once the information has been encoded into secondary memory, it is permanently stored and may be returned to primary memory by means of a final control process, retrieval.

This broad conceptualization of the human information-processing system initiated two streams of further development. First, it provided a framework for investigating the properties of the various individual elements of the system, both structural and procedural. In due course, these various lines of research, carried out largely independent of each other, led to a wholesale revision of the basic model of the system itself. Particularly, the research underscored the involvement of secondary memory, as well as higher mental processes such as judgment and inference, in even "elementary" processes such as perception and attention. On the one hand, the new consensual model postulates a single memory structure uniting features of primary and secondary memory. On the other, it has stimulated an entirely new line of inquiry into categorization, judgment, inference, and problem-solving.

Research within the Framework of the Multistore Model

The Sensory Registers

The first step in the perceptual process lies at the sensory registers. By 1973, the register for the visual modality, dubbed the icon by Neisser (1967), had been well described; registers for auditory stimulation (Neisser's echo) and tactile stimulation (so far unnamed) had also been documented (for a detailed review, see Crowder, 1976). In the laboratory the nature of iconic memory is studied by means of a procedure devised by Sperling (1960): an array of letters is flashed briefly (typically for 50 milliseconds) on the screen of a tachistoscope, and the subject is asked to identify the letters which were displayed. Suppose that the array consists of nine letters arranged in a 3 x 3 square. Subjects who are asked to recall all the letters typically can report only four or five; on the other hand, if they are asked to report only the contents of a particular row (as designated by a high, medium, or low tone played after the display has been turned off), they can do this almost perfectly. Thus it seems that the icon contains the whole array, since the subject can read a randomly designated part of it, but fades before the subject can read the whole thing. The exact time course of the decay may be estimated by varying the interval between the time the display is turned off and the time that the person is asked to report a particular element. If the delay is more than 200-300 milliseconds, reporting reverts to chance levels. In another version of the experiment, Averbach and Coriell (1961) showed that information in the icon can be erased, as it were, by a new stimulus occurring at the same point in visual space -- this is known as backward masking (Kahnemann, 1968). If the masking stimulus occurs more than 200-300 milliseconds after the original stimulus, however, there is no masking effect -- presumably because the icon has already decayed on its own. During the time when the icon is active, information can be extracted from it at high speed -- about 100 characters per second. Since 1973, a great amount of progress has been made in locating the physiological locus of the echo in the visual system (Banks & Barber, 1977; Sakitt, 1976), though the details are still controversial.

The icon and its companion sensory registers are the first point at which the stimulus information makes contact with the cognitive processes involved in perception. The icon gives us time to turn our attention to, and extract information from, events that lie in our visual field but outside the focus of attention. The echo permits proper speech recognition, by holding individual phonemes so that they can be combined with later ones to form morphemes, and individual words so that they can be combined with later ones to form phrases. Thus, any defect in the functioning of these registers would have major deleterious effects on perceptual processing and adaptive behavior. Consider, for example, the consequences of having sensory registers subject to rapid decay; or, alternatively, the situation in which the procedures for feature-extraction and pattern-recognition are slowed. In either case, the person's information about the world would be very fragmentary indeed -- a perceptual world composed of fleeting unintegrated glimpses. In the case of vision, the individual might learn to compensate by constantly shifting attention from one portion of the perceptual field to another. A rapid decay of the echo, or slowed feature extraction from it, would have an especially deleterious effect on understanding verbal communication from other persons. In light of their difficulties in paying attention and communicating with others, it would seem that the sensory registers of schizophrenics would be prime targets for experimental investigation.

<u>Feature Detection and Pattern Recognition</u>

The classical multistore model implies that raw sensory input is transformed into perceptual representations by passing through a series of processing stages. In the case of visual stimulation, for example, one set of processes would detect simply physical features such as lines, slits, edges, and the like; information about the presence of these features would be passed through another set of processes, where angles, curves, shapes, colors, and movement are detected. Particular constellations of these features are then compared with patterns already stored in memory as a result of previous perceptual experience. If there is a match, then the information, now transformed and recoded several times over, is passed through the attentional mechanism to primary memory for further processing. Something like this does seem to occur, as shown by the Nobel-Prize winning research on feature detectors by Hubel and Wiesel (1965), and by the extraordinarily large body of research on pattern recognition processes in reading and listening.

Our knowledge of the most elementary, peripheral feature-detection processes comes from work on vision in nonhuman animals, such as the limulus crab, frog, and cat. Some qualities of visual stimulation, such as hue, are processed at the level of the receptor organ: the rods are sensitive to monochromatic light, and there appear to be separate cone systems responsive to wavelengths corresponding to red-green and yellow-blue color pairs. The operation of these cone systems has been described in the opponent-process theory of color vision (Hurvich & Jameson, 1974). Other visual qualities appear to be processed in the optic nerve, lateral geniculate nucleus, and occipital cortex. The emerging picture is one of a hierarchy of cells, each responding to a specific simple pattern of stimulation, or combinations of simple patterns. For example, some neurons seem to respond only to the presence of an edge, line, or slit in the visual field; these are called simple cells. Other simple cells detect movement of these contours. Whereas the simple cells respond only to a particular pattern of stimulation occurring at a specific point in the visual field, other neurons -- complex cells -- respond to these patterns wherever they are located. Other neurons, known as hypercomplex cells, process features such as size and direction of movement. An analogous set of feature detectors has been documented in the auditory system (Whitfield, 1967). Thus, each neuron in the auditory nerve is maximally responsive to a particular frequency. In the auditory cortex, there are some cells that respond to pure tones, others to complex ones, some to clicks, some to noise, some to increases and some to decreases in pitch, some to onset and some to offset. However, the precise workings of the auditory feature-detector system are not yet well known.

At the next level of the hierarchy are processes for recognizing particular patterns of features. While the feature-detectors themselves seem to be part of our genetic endowment, the pattern-recognition procedures must be acquired based on the visual and auditory environment of the organism. In the case of vision, individuals will learn to recognize, among other things, patterns corresponding to the letters of their written language; in the case of audition, individuals will learn to recognize the sounds that compose the phonemes of their native tongue. For example, the letter A contains one horizontal line, two oblique lines, and three acute angles; the letter B contains one vertical line, three horizontal lines, four right angles, and two discontinuous curves. Similarly, the phoneme /i/, as in heat, is vocalic, sonorant, high, and tense; the phoneme /I/, as in hit, is vocalic, sonorant, high, and lax. Work on visual pattern recognition originated in a computer simulation of letter-recognition developed by Selfridge and Neisser (1960), which assumed that patterns were recognized from the presence of particular features. However, more recent research, involving both linguistic and nonlinguistic stimuli, suggests that feature-detection is not a necessary prelude for pattern recognition -- that is, that some patterns can be recognized directly, without being decomposed into constituent features (for a review see Smith & Spoehr, 1974). Thus, letters are more easily recognized if they are presented as part of legitimate words, or pseudowords that follow the rules of English morphology, and if they are presented as part of nonword letter strings. Work on auditory pattern recognition was initiated by Liberman and his colleagues (e.g., Liberman, Cooper, Shankweiler, & Studdert-Kennedy, 1967). Their work also shows that pattern-recognition is not necessarily preceded by feature-detection. Following the original model of letter-recognition, it might seem likely that patterns, frequencies, durations, rises, and falls would be perceived as individual phonemes, which are then combined into syllables. However, Liberman et al. showed that syllables were the basic units of speech perception, and are not decomposable into their individual phonemic constituents. For example, when the syllables "di" and "du" are foreshortened to eliminate the sounds associated with their respective vowells the portion corresponding to the initial consonant was perceived as a chirp rather than a /d/; to complicate things further, the chirps are different depending on which vowell follows the consonant. A great deal of effort is now being expended in determining the invariants that permit individual phonemes to be perceived, regardless of the context in which they occur.

The research on pattern recognition without feature detection suggests that the basic information-processing model of perception is wrong. That model postulates the unidirectional flow of information from the peripheral sensory surfaces to the mind, with ever larger perceptual units being formed out of clusters of smaller ones. In the case of the phenomena just described, however, the larger units appear to affect the perception of the smaller ones. Thus, in addition to "bottom-up" processing, there seems to be a large element of "top-down" processing as well, in which higher cognitive units such as memories and expectations influence the processing of smaller units such as elementary percepts. Such a model was dubbed analysis-by-synthesis by Neisser (1967), who suggested that fragmentary stimulus information was supplemented by information retrieved from memory to generate a hypothesis about what the object or event must be. Neisser (1976) himself has retreated from a strong advocacy of analysis-by-synthesis on the grounds that the cognitive system would quickly become overloaded by a large number of specific perceptual hypotheses. Nonetheless, some form of analysis by synthesis or top-down processing seems to be demanded for an adequate theory of perceptual processing. Thus, investigations of perceptual processing in schizophrenia and other categories of psychopathology should not concentrate simply on feature-detection and pattern-recognition as independent, early control processes. Rather, they should also include the memory system and its associated procedures for retrieval, categorization, and inference, which supplies the internal portion of the perceptual cycle.

While the classic model implied a strict hierarchy, in which the operations of an earlier stage had to be completed before those of a later one could begin, new findings suggest that this might not be the case (McClelland, 1979; Posner, 1978; Taylor, 1976). This new theoretical perspective has important implications for investigators who would use traditional "additive factors" designs to uncover the stage at which the psychological deficit in, way, schizophrenia exists. Consider, for example, an abstract model of feature-detection and pattern-recognition that involved a series of four stages. In principle, we could present a subject with a task that required processing at only the first of these stages (e.g., detecting a slit versus a line), or the first two, the first three, or all four, and compare the reaction times associated with accurate performance. By subtracting the latencies associated with a two-stage task from those associated with a three-stage task, we could in principle calculate the time it takes to perform the elementary mental operations of the third stage; etc. Suppose we were to find that schizophrenics, for example, showed abnormally slow processing at this stage, compared to normals: we would then have compelling evidence for the location of their psychological deficit. However, there is some reason to think that these various stages of information-processing transpire in cascade -- i.e., with later ones starting before earlier ones have completely finished their jobs -- if not in parallel. If this is the case, then the results of additive-factors experiments may be misleading, and the chronometric method will be unable to specify the locus of the psychological deficit. Inasmuch as contemporary experimental psychopathologists are beginning to adopt the method in their investigations, basic research on the time relations of elementary mental processes is of central importance.

Attention

The modern study of attentional processes is about three decades old. In classic work, Cherry (1953) developed the dichotic-listening paradigm for the study of attention, in which subjects must shadow one competing stream of auditory information and ignore another, competing stream. His subjects could do this successfully, and analyses of their subsequent memory showed that they had been aware of only the raw, physical qualities of the unattended stimulus. At approximately the same time, Broadbent (1954) modified the dichotic-listening paradigm so that subjects were required to respond to two streams of material, each presented to a different ear simultaneously over a short period of time. These findings led Broadbent (1958) to propose that attention serves as a filter blocking out unattended information. Broadbent's theory, which lies at the base of the classic multistore model of the mind later proposed by Atkinson and Shiffrin (1968), had four implications: (a) the decision to let material pass through the attentional filter is determined by whether it possesses certain physical attributes; (b) information which has been physically analyzed by the feature-detection and pattern-recognition processes is analyzed for meaning only after it has passed through the attentional filter to primary memory; (c) attention is a limited-capacity channel, permitting only one stream of information to enter primary memory at a time; (d) accordingly, we cannot do two things at once, and the appearance of simultaneous processing is really accomplished by rapid switching of the attentional filter back and forth between two (or more) separate channels. Since 1958 research on attention has thrown each of these implications into serious doubt, so that our concept of attentional mechanisms has been thoroughly revised.

For example, experiments by Moray (1959) and Triesman (1960) showed that semantic as well as physical analyses were performed preattentively, at least under certain conditions. In Triesman's research, for example, subjects shadowing a story inadvertently followed it as it was switched between the ears, indicating that the unattended message had been analyzed for meaning to at least some degree. Triesman (1964, 1969) modified Broadbent's theory by proposing that the attentional filter could be tuned to various characteristics of the input -- physical, semantic, etc. -- as determined by the perceiver's intentions and the overall context in which the stimulus occurred. Moreover, she proposed that attention be construed less as a filter than as an attenuator, permitting unattended inputs to leak through and receive some degree of perceptual analysis. Broadbent (1971) later concurred with these revisions. An alternative theory was proposed by Deutsch and Deutsch (1963) and Norman (1968; Norman & Bobrow, 1975), to the effect that all stimulus inputs are analyzed to some degree along all dimensions, regardless of task demands, before attention is directed to them. This process is performed automatically, as the information enters the cognitive system, and -- since it is done preattentively -- outside of consciousness. The Broadbent-Triesman and Deutsch-Norman models differ, among other respects, in where attention lies in the information-processing system. For Broadbent and Triesman, it is a channel located between the sensory registers and primary memory, so that only a subset of available stimuli make contact with knowledge held in secondary memory; for the Deutsches and Norman, by contrast, information flows directly from the sensory registers, and from there via attention to primary memory. A number of experiments have been performed to determine which approach is more correct (e.g., Corteen & Wood, 1972; Triesman & Geffen, 1967; Triesman, Squire, & Green, 1974), but the issue is still undecided. The issue is central to understanding the basic function of the information-processing system, both normal and pathological.

All theorists now agree that incoming stimulus information can be processed for meaning before attention has been directed to it, at least to some degree and under some circumstances. This change in position has direct relevance to one of the most controversial topics in mental health research -- subliminal perception or preconscious processing (Dixon, 1971, 1981; Erdelyi, 1974; Silverman, 1982). The claim is that subjects can avoid processing threatening or otherwise anxiety-evoking stimuli -- a claim that raises the paradox that one must analyze the material for meaning before one can disattend from it. Early demonstrations of the effect, as represented by the classic work on perceptual defense, vigilance, and "The New Look", were faulted partly on the grounds that the kinds of semantic analyses required by the theory could not be performed outside of conscious attention. Admittedly, these early demonstrations were often methodologically flawed as well. At this point, however, it seems that the possibility of such influences on perception no longer should be rejected out of hand. This shift in stance would not necessarily imply acceptance of psychoanalytic theory, with its emphasis on sexual and aggressive motives. However, many clinicians with a more eclectic orientation are convinced that many of their patients are engaging in defensive cognitive maneuvers in order to restrict their awareness of objects and events that would arouse unpleasant emotions. Further exploration of preattentive semantic analyses should indicate the mechanisms for this effect, and determine whether it is substantial enough to be clinically significant.

Another approach to selective attention has investigated the limited-capacity feature of the process. In the same manner that research has increased the number of attributes that can receive preattentive processing, so has it expanded to capacity of attention and the manner in which it can be allocated. The initial impetus for this line of research came from an early study by Neisser (1964), who asked his subjects to search through a large array of letters to find one or more targets. If attention has only a limited capacity, and can be directed toward only one task at a time, it should take longer to search for two or three targets than for only one: each stimulus item must be compared to each of the targets in turn before attention can be directed to the next item. However, Neisser found that practiced subjects could search for as many as 10 items simultaneously, with little or no increase in reaction time. These findings have been confirmed and elaborated in a number of ways, most recently in important research by Schneider and Shiffrin (1977; Shiffrin & Schneider, 1977). They showed that practice increased the number of stimulus items that can be held in attention and processed simultaneously. Schneider and Shiffrin argue cogently for a distinction between automatic processing, in which the procedures are involuntary and consume no attentional capacity, and controlled processing, in which the procedures are voluntarily initiated and terminated, and consume varying amounts of attentional capacity depending on the difficulty of the task. The point is that automatic vs. controlled processing is not an intrinsic feature of any particular cognitive task, but rather is determined by the amount of experience that the individual has had with it -- and, perhaps, by individual differences in cognitive flexibility. Perhaps most compelling in this regard is a set of demonstrations by Spelke, Hirst, and Neisser (1976; Hirst et al., 1978), who trained people to read and take dictation at the same time. These two tasks, each of which alone ordinarily would consume all of our available attention, came to be performed simultaneously with a high degree of accuracy; however, not all subjects were able to show the effect, even after a great deal of practice.

The notion that certain cognitive operations, once deliberate and capacity-consuming, can become automatic and effortless through routinization, is now widely accepted. The conclusion that attentive processes can run in parallel, however, has met with more resistance. Accordingly, there has been a large increase in research on "doing two things at once" (e.g., Posner & Boies, 1971). The general conclusion is that it is possible to do two things at once provided that the attentional demands of the two tasks do not exceed the amount of attentional capacity available; when this happens, the two tasks must be performed in series rather than in parallel, with attention alternating rather than divided between them. Kahneman (1973) has offered a new theory in which attention is considered to be a limited resource that either can be deployed on a single task, or divided among many tasks, at a time. The precise way in which attention is allocated is determined by the individual's enduring cognitive dispositions, momentary intentions, and the difficulty of the task(s) at hand. Difficulty is determined both by the intrinsic requirements of the task (e.g., it is impossible to sing and speak at the same time, though it is possible to attend to visual, auditory, and tactile stimuli simultaneously), and by the amount of experience with the task. Theoretically, with the right choice of tasks and enough practice, attentional capacity would seem to be unlimited.

All of this research has implications for the experimental study of psychopathology, especially our understanding of psychological deficit in schizophrenia. Many investigators have suggested that schizophrenics suffer from deficits in attentional processing (for reviews see Chapman & Chapman, 1973; Oltmanns & Neale, 1976). Unfortunately, most of these theories, and the experiments generated by them, appear to have been based on some version of Broadbent's original filter theory. Few experiments, if any, have attempted to incorporate the major advances in our understanding of selective attention made by Norman (1968) and Kahneman (1973). For example, we do not know whether schizophrenics and normals differ in the extent of preattentive processing of physical and semantic attributes; in the amount of attentional capacity which each has available; in the ability to translate momentary task-oriented intentions into an effective allocation policy; and in the ability to profit from extended practice with tasks which initially make large demands on attention. This last is of particular interest in light of the common claim that acute schizophrenics are aware of an overwhelming flood of stimulation, whereas chronics are unresponsive to even major changes in their environment. The research on routinization suggests a mechanism by which schizophrenics could learn, over time, to allocate their attention in such a manner to process most of this information automatically and effortlessly, outside of focal attention -- or to ignore it altogether. However, before such questions can be answered -- indeed before they can even be raised sensibly -- what seems to be required is a wholesale theoretical reorientation so that research on the pathology of attention better articulates with research on normal attentional processes.

The implications of research on attentional processes goes beyond schizophrenia, however, to depressions and the kinds of maladjustments observed in everyday problems in living. Clinicians who work with depressives typically comment on their patients' extreme readiness to perceive the unpleasant aspects of a situation, coupled with their studied ignorance of the positive aspects; the same could be said for phobics and for those with chronic anxiety disorders. The patients themselves often remark on the "irrationality" of these cognitive biases, but this recognition does not help to overcome them; in fact, therapy for depressives and agoraphobics is extremely arduous and unrewarding. One reason for this state of affairs may be found in the routinization of attention, by which certain stimuli or features of stimuli may be encoded, or ignored, automatically without the person having any control over them. If these pathological allocation policies have been acquired and isolated from conscious control over a long period of time, it may require an equally long period of time to supplant them with new, more adaptive ones.

Primary Memory

By virtue of paying attention, some information passed through the feature-detection and pattern-recognition process is further passed into the next storage structure, primary memory. The classical multistore model of information processing identifies primary memory with consciousness, so it is here that our survey of attention and perception should end. Primary memory is the stage at which information from the distant past, retrieved from secondary memory, makes contact with that from the immediate perceptual field, yielding a perceptual representation that has been endowed with some meaning. Primary memory may be identified as the major workspace of the memory system: it is here that information is maintained in an active state while the person carries out further perceptual-cognitive operations on it, or employs it in some other cognitive activity.

The operation of primary memory may be demonstrated in a number of ways. Consider first the familiar serial-position effect in recall: if a subject hears a long list of words and then is asked to remember what they have heard, they will typically recall the early and late portions of the list better than the middle; however, if the subjects are required to engage in some distracting activity such as mental arithmetic for 10-30 seconds after presentation and before the test, recall of the items presented most recently drops dramatically -- and the longer the interval, the greater the drop. A similar point is made in a procedure devised independently by Brown (1958) and Peterson and Peterson (1959). A subject hears three words and then is required to count backwards by threes from a given number. A short time later they are asked to recall the words. The results are dramatic: after less than 18 seconds of mental arithmetic recall of the three words falls to very low levels. Finally, Waugh and Norman (1965) invented a very different kind of task: subjects hear a list of 16 digits, some of which are (of necessity) repeated; the very last digit is used as a "probe" to memory, and they are required to recall which digit followed the probe's first appearance. Accuracy drops off markedly as the number of digits between the first and final appearances of the probe digit increases. All three paradigms suggest that recently acquired (or retrieved) information is held for a brief period of time in a state in which it is readily accessible.

Some research has shown that forgetting may occur from primary memory merely due to decay over time (Reitman, 1974), but the most important factor appears to be interference from other information passing through primary memory. For example, the forgetting which occurs in the Brown-Peterson task increases over the course of a few trials, a process referred to as the buildup of proactive inhibition (Keppel & Underwood, 1962); it also depends on the degree of similarity between the material to be remembered and the interpolated task, a process suggesting retroactive inhibition (Wickelgren, 1965). In the absence of an opportunity for decay or interference, however, material in primary memory is so readily accessible that subjects hardly ever make mistakes in retrieving information from it.

William James, who gave primary memory its name, thought for this reason that material in primary memory itself did not have to be remembered, for the simple reason that it had never left consciousness. However, Sternberg (1960, 1969) clearly demonstrated that it makes sense to think of retrieving information from primary memory. He employed a procedure in which subjects are given a small number of digits to hold in awareness; then they see a probe digit, and must determine if the probe is contained in the memorized list. Subjects make few mistakes on this kind of task, but the time it takes to make their responses depends on a number of factors -- for example, the size of the memory set. Apparently, then, even in primary memory it takes time to scan the stored material to determine if it contains a match for the probe. It is not clear yet whether this search is serial (one item at a time) or parallel (many items at once), or whether it is self-terminating (stopping once the target is located) or exhaustive (working through the entire set regardless of the outcome of any individual decision). The dominant view is that primary memory search is serial and exhaustive (Sternberg, 1965), though Townsend (1972) has argued that the issue is fundamentally undecidable.

Secondary Memory

Ordinarily, any review of research on attention and perception from the information-processing point of view would stop with primary memory -- because it is in primary memory that a full perceptual representation of an object or event is constructed. However, perhaps the greatest development in cognitive psychology since 1973 has been the increasing appreciation of the role played by secondary memory in perception. Evidence for this impact comes from a variety of sources. First, it appears that information held in the sensory registers routinely makes contact with information in permanent memory during the processes of feature detection and pattern recognition -- including the activation of underlying semantic representations. Second, the distinction between primary and secondary memory has been blurred almost to the point of nonrecognition by the studies conducted within the "levels of processing" framework in verbal learning and memory. Third, it is clear that the process of perception -- extracting features, recognizing patterns, filling in missing data, making various types of judgments, and assigning objects and events to categories -- makes use of information of all sorts that is stored in the individual's permanent memory. Accordingly, understanding the structure of permanent memory becomes directly relevant -- even essential -- to understanding attention and perception.

Contemporary researchers and theorists find it convenient to maintain two somewhat independent distinctions within the permanent memory system: between declarative and procedural knowledge (Winograd, 1975), and between episodic and semantic memory (Tulving, 1972). Declarative knowledge is factual knowledge concerning the nature of the physical and social world: what words, numbers, and other symbols mean; what attributes objects possess; to which conceptual categories they belong; where and when certain events happened; and the like. Procedural knowledge is knowledge of how to manipulate and transform declarative knowledge: mathematical operations; rules of syntax, inference, and judgment; strategies for acquiring, storing, and retrieving memories; motor and cognitive skills; and the like. Episodic memory is memory for personal experiences: such representations include features describing the spatial and temporal context in which certain events occurred, and are embedded in the individual's personal autobiographical record. Semantic memory, by contrast, may be thought of as the person's "mental lexicon", consisting of categorical information which has been stored without reference to the context in which it has been acquired and used. Semantic memory contains world knowledge in addition to lexical knowledge, which is why some theorists (e.g., Hastie & Carlston, 1980) prefer the term generic to semantic memory. Hermann (1982) has provided a concise historical summary of the development of the episodic-semantic distinction in memory, and argues for a third form of permanent memory, skill memory, which is roughly analogous to procedural knowledge. This taxonomic structure is complicated somewhat by the additional concept of metamemory (Flavell & Wellman, 1976), or knowledge about memory: one's awareness of what facts are available in storage (even if they are not immediately accessible) and what procedures are available for encoding new information, retrieving old knowledge, and performing other cognitive tasks.

Theoretically, a declarative memory may be characterized as a bundle of features describing an object or event and, in the case of declarative memories of the episodic type, additional features describing the context in which it was perceived (Bower, 1967; Tulving & Watkins, 1975). Precisely which features are encoded depends on a number of factors, including the amount of attentional effort devoted to the stimulus, the degree to which the object or event has been elaborated and recoded during preattentive, perceptual, and postperceptual processing, and the like. Such a memory is commonly represented graphically as a set of nodes representing concepts interconnected by directed pathways representing predicate relationships between them. Both episodic and semantic memories can be represented in this format. Procedural memories can be represented in much the same way as declarative memories: a set of nodes representing goals, conditions, and actions which can be taken to achieve the goals if the conditions have been met; these nodes are interconnected by pathways to form production systems (Anderson, 1976). Recently, Anderson (1982) has proposed a three-stage model for the acquisition of procedural knowledge. According to this point of view, a procedural memory is first encoded as a declarative memory, or factual information about the skill; then, through a process of knowledge compilation requiring many hundreds of hours of use, the declarative memory is converted into procedural form. Whereas the declarative version is open to introspection, procedural memories are held to be largely unconscious; knowledge compilation also increases the speed with which a particular procedure can be applied.

Perhaps the most striking development in memory research has been the development of these network models of memory, and their implimentation as operating computer programs within artificial intelligence systems. A variety of such models are available, of which the most prominent are those of Quillian (1969; Collins & Quillian, 1972; Collins & Loftus, 1975), Kintsch (1974), Norman and Rummelhart (1975), and especially Anderson (1976, 1982; Anderson & Bower, 1973). These computer models are being refined continuously on the basis of actual experimental data, and some of the available computer programs do quite a good job of simulating human performance in certain language and memory tasks. Anderson's ACT model, unlike the others, incorporates both procedural and declarative memories, and thus comes closer to being a comprehensive computer simulation of memory. While these simulations have focussed on the performance of normals, obviously there is no reason why theories of psychological deficit should not also be implimented and tested in this way. Computer simulation -- whether of perception or memory -- forces the theorist to be rigorous in defining fundamental structures and processes. For this reason, we may expect to see an increasing adoption of the simulation method and other aspects of artificial intelligence among experimental psychopathologists -- attempts, that is, to build machines that "break down" in a manner analogous to that observed in cases of mental illness.

Since 1973 the distinction between primary and secondary memory has almost completely disappeared. Some authors have felt the need to postulate yet a third type of memory structure, a working memory which holds representations of the immediate environment, as well as procedural memories which have been retrieved in accordance with intentions and environmental demands (Baddeley & Hitch, 1977; Bower, 1978). An alternative conception, offered by Tulving (1968), Craik and Lockhart (1972), and Wickelgren (1973), among others, is of a single, unitary memory store. From this point of view, the distinction between primary and secondary memory is not a matter of different storage structures but rather a matter of whether an item in memory has been activated or not. And the persistence and retrievability of a memory is not a matter of where the information has been stored, but rather a matter of the amount and type of perceptual processing received by the stimulus, and the degree to which a pre-existing memory representation has been activated during perceptual processing. Crowder's (1976) notion of process dualism is one attempt to reconcile these competing points of view, but at this juncture the unitary memory theory is clearly on the ascendance. Following the change in the theory of attentional processes, the shift from two memories to one completes the destruction of the classic multistore model of memory; and a major task for the future is to build a new model around a single memory system that will accommodate all the data developed in the study of primary and secondary memory structures.

Cognitive Psychophysiology

Perhaps the most dramatic development in the last decade has been the introduction of a whole new repertoire of electrophysiological techniques to supplement the usual paradigms of choice, reaction time, detection, and recognition that have formed the basis for most of the research conducted within the information-processing paradigm. The trend is obviously related to the successful use of single-unit recordings from sensory ganglia to document feature detectors in the visual and auditory systems, as noted earlier. The difference is that the new techniques are noninvasive, making use of electrodes applied to the surface of the skin rather than embedded subcutaneously, permitting the electrophysiological exploration of cognitive functions in normal humans. An anticipation of this trend is the work by the Laceys (e.g., Lacey & Lacey, 1974), on the cardiac correlates of directed attention. Of course, the EEG provides a more direct index of cortical activity, but it was not until high-speed computing technology became widely available in the laboratory that investigators were able to relate electrical and mental events to each other in specific ways through the analysis of evoked potentials (Donchin, 1979, 1982; Hillyard, 1981; Kutas & Hillyard, 1982; Naatenen, 1975, 1982).

Four components of the evoked potential have been studied in detail. The early components, occurring within 80 milliseconds of event onset, are known to be responsive to characteristics of the physical stimulus but not to changes in the cognitive processing by the organism. The "Nd" wave, a negative potential occurring after about 100 milliseconds, appears to be enhanced when a signal occurs for which the observer has already been prepared, while the P300 wave, a positive potential occurring about 300 milliseconds after onset, appears to reflect the amount of attentional processing being devoted to the stimulus, whether the observer was previously prepared for it or not; P300 is lengthened when the stimulus is especially complex or the processing task is especially difficult. Finally, the amplitude of the N400 wave appears to be enhanced when a new stimulus is anomalous, incongruous, or in some other way violates established semantic expectations.

From the point of view of basic research, the development of evoked-potential methodologies appears to be a major advance in the study of the neural substrates of cognitive processing. Moreover, it points the way to a new, more precise mental chronometry that may ultimately permit a clear choice between early and late theories of selective attention, as described earlier. Both concerns, of course, are highly relevant to research and theory within experimental psychopathology. It seems likely that the untoward genetic-biochemical events that eventuate in the symptoms of schizophrenia and early infantile autism, among other mental illnesses, leave their mark at the level of the neurons that generate evoked potentials. Thus, the development of this methodology may also yield both the neurological substrate of these and other syndromes, and a means for reliably diagnosing them and identifying individuals at high risk for developing them.

Topics in Cognitive Perception

Interactions of Perception and Memory

Recent trends in the study of memory appear to have revived Bartlett's (1932) notion that the memory trace is a byproduct of perceptual processing. Certainly the most prominent manifestation of this point of view is the "levels of processing" approach to human memory first announced by Craik and Lockhart (1972) and considerably revised and refined over the next decade (e.g., Craik & Tulving, 1975; Jacoby & Craik, 1979; Lockhart, Craik, & Jacoby, 1976). Their original finding was the items which were analyzed for meaning (i.e., at a "semantic" level) are more accessible in memory than those which were analyzed only in terms of their visual or acoustic properties (i.e., at the "orthographic" or "phonemic" levels). More recently, there has been a shift away from postulating discrete levels of processing, with the implication that an item has to be processed through superficial levels before it can be processed at the deeper ones. Rather, it is now held that the more attentive effort devoted to the stimulus during perception, the more features of the object or event encoded, and the more links formed between the mental representation of the stimulus and other information that is available in memory, the more accessible that event will be at some later attempt at retrieval (Anderson & Reder, 1979; Jacoby & Craik, 1979). Apparently, the memory effect is mediated by two somewhat different mechanisms: more thoroughly elaborated items become distinct from other, similar items that are also stored in memory; and increases in elaboration increase the likelihood that the item will be the recipient of activation spreading from other nodes in the memory network.

As a kind of corollary to the elaborative processing principle, the "encoding specificity principle" of Tulving and Thomson (1973) further cements the link between perception and memory. Perhaps the commonest finding in research on memory is the differential accessibility of items retrieved through free recall, cued recall, and recognition procedures. Typically, this effect has been explained in terms of qualitative differences in the amount of information supplied by the retrieval cue: memory is best when the cue is a copy of the item itself. However, these effects can be abolished or reversed if the information supplied by the cue, however rich in other respects, fails to match the information encoded with the item at the time of perception. Perception entails first distinguishing figure from ground, and then describing both the event and the context in which it occurs. A cue which specifies the right object, but the wrong context, will mislead the process of retrieving and reconstructing information from memory; so too, of course, will an inappropriate description of the retrieval at the time that _it_ is perceived. In its most general form, the encoding specificity principle states that the accessibility of a memory trace is dependent on the degree to which the features of the retrieval cue, as perceived, match the features of the event perceived at the time of the initial encoding. Tulving (1979) has noted the similarity between the encoding specificity principle and the emphasis in the elaborative processing principle on the distinctiveness of the encoded memory trace.

A third topic linking perception and memory has to do with the fate of stimulus information as it is related to the perceiver's expectations. In describing the perceptual cycle, Neisser (1976) argued that the perceiver's exploration of a stimulus was determined in part by the perceiver's expectations, as shaped by inference from those features already extracted from the stimulus and the local context in which it occurs, and as derived from the perceiver's memory for previous instances of that particular stimulus category. Such effects are quite familiar -- in the ordinary course of reading or listening, we often fail to detect misspellings or mispronunciations -- and they have been documented extensively in the perception laboratory, in part under the rubric of the context effects described earlier. Most of the available research has employed some measure of memory as the critical dependent variable, and some controversy has arisen over the processing of material that varies in congruity with respect to these expectations. Hastie (1980) has surveyed a wide variety of research on verbal learning, memory for text, concept attainment, perception of form, scenes, and sequences of events, stereotyping, impression-formation, and other information-processing tasks. His analysis suggests that there are three levels of congruity: new information can be wholly relevant to a pre-existing mental schema; or, if it is relevant, it can be either congruent or incongruent with expectations. The available literature yields a U-shaped function relating schema congruity to subsequent memory, with memory poorest for items that are schema-irrelevant; among schema-relevant items, memory is slightly superior for items that are <u>incongruent</u> with the schema. In a series of experiments, Hastie (1981) included all three conditions in a single experiment, a desideratum not often met in the previous research, and confirmed the effects. His explanation relies on two separate processes: memory for schema-congruent information is best because the schema supplies additional relevant cues at the point of retrieval. He argues that schema-incongruent information, by virtue of its surprise value, receives both extra attention and extra perceptual processing as the observer attempts to resolve the apparent discrepancy and make the new information "fit". The deep, elaborate encoding received by the stimulus in the course of this extra processing results in a more readily accessible memory trace.

To review the vast amount of literature supporting the elaborative processing, encoding specificity, and schema-congruity principles would take this review far beyond its intended scope. At a theoretical level, these principles are important for what they reveal about the manner in which perception and memory are linked: perception is based, in part, on information held in memory; and perceptual processes have consequences for the observer's later memory for the events in question. In this manner, they are good representatives of a truly unitary view of cognitive processing. The principles have already seen some application, at least implicitly, in research on psychological deficits in organic brain syndrome, schizophrenia, and depression. Further research on these and related principles of perceptual processing and selective attention will lay the conceptual and methodological foundation for further research along these lines.

Categorization

As Bruner has noted, every act of perception is an act of categorization. Whether the object of regard is an object, a person, an event, or a speech act, stimulus information is encoded in the memory system with respect to an organized system of concepts concerning the physical and social world. Before about 1973, our understanding of categorization was implicitly or explicitly guided by what has come to be known as the classical view of categories (e.g., Bruner, Goodnow, & Austin, 1956; Hull, 1920). This view, which dates back to Aristotle, holds that a concept is a summary description of an entire class of objects or events. A concept, as a mental representation of a category, consists of a set of defining features: attributes that are singly necessary (i.e., every instance possesses every defining feature) and jointly sufficient (i.e., every object or event possessing all the defining features is an instance of the concept). Concepts are located within a hierarchical system characterized by perfect nesting: within any particular branch of a hierarchy all the defining features of superordinate categories are also defining features of subordinate categories. This all-or-none arrangement means that categories are quite homogeneous, with sharp boundaries between them.

Over the past decade the classical view of categorization has been subject to increasing criticism on both conceptual and empirical grounds, and a new position, generically labeled the probabilistic view, has emerged (e.g., Rosch & Lloyd, 1978; Smith & Medin, 1982). Categories are still held to be summary descriptions in this view, but the features possessed by the summaries are now only correlated (i.e., probabilistically associated) with category membership. No feature is singly necessary, and no set of features jointly sufficient, to define a category. While categories are still organized hierarchically, the various levels are now characterized by imperfect nesting, such that within any particular branch the subsets do not necessarily possess all the features that are characteristic of supersets. With correlated rather than defining attributes, category members can be quite heterogeneous, though some members may be judged to be more "typical" category instances than others. In any event, the lack of defining features means that there will no longer be any sharp boundaries between categories.

According to the probabilistic view, categories are represented by a prototype instance, which may be concrete or abstract, which possesses many features associated with the target category but few features associated with membership in alternative or contrasting categories. The process of assigning an unfamiliar object or event to its proper category may be described as feature matching: the perceived (or inferred) features of the object are matched with the features of the prototype, and if enough features match the assignment is made. In determining feature overlap, particular attention is paid to central features (i.e., those which are highly correlated with membership in the category) rather than peripheral ones (i.e., those showing low correlations).

The probabilistic view may be fairly said to dominate contemporary work on categorization, as investigators study the nature of the features, the structures of the hierarchies, and the manner in which concepts are acquired by both adult and developing child. For example, there are reasons for thinking that children, in the course of acquiring a vocabulary, first learn concepts at a basic level; only later, apparently, do they integrate basic-level concepts to form superordinate categories, and differentiate within the basic level to form subordinate categories. Tracing the course of conceptual development is an extremely important aspect of the study of language development, and has implications for the study of mental retardation. For example, it may be that retarded children acquire concepts at the basic level as easily as normal children do, but are deficient in fleshing out a full, multi-level hierarchy of categories. If so, appropriate remediation efforts might be directed, in part, to structuring the child's learning environment to facilitate integration and differentiation.

The shift from the classical to a probabilistic view of categorization also has implications for two of the most important theories of the nature of organic brain syndrome and schizophrenia. One hypothesis, in its various forms, held that such patients were more concrete in their thinking than normal individuals, in that they were relatively incapable of forming abstract concepts. The alternative is of overinclusion, to the effect that schizophrenics are excessively broad in what they construe to be instances of a particular concept. Both hypotheses are plausible, given clinical observations of thought disorder in schizophrenic patients. However, almost a half-century of research on categorization in schizophrenics has failed to reveal any such deficits. Nevertheless, practicing clinicians continue to be impressed by the disordered patterns of conceptualization demonstrated by their patients -- so much so that defective concept-formation remains one of the cardinal symptoms of schizophrenia specified by the official diagnostic manual of the American Psychiatric Association. This apparent paradox may be due to the fact that the laboratory studies of both concreteness and overinclusion were all predicated on the classical view of categories, and employed highly artificial stimulus materials. With a new theory of the structure and organization of concepts in hand, and an increasing sensitivity among researchers to the importance of using stimulus materials that are more lifelike, a new attack on the phenomenon of categorization in schizophrenia may be in order.

The syndromes of psychopathology -- schizophrenia, affective disorder, phobia, psychopathy, etc. -- are first and foremost mental categories consisting of various attributes -- hallucinations, delusions, euphoria or dysphoria, irrational fear, antisocial behavior, etc. Patients are assigned to particular diagnostic categories depending on the pattern of symptoms which they present. For some time now, however, practitioners and researchers alike have been concerned about the unreliability of the diagnostic system: few patients, if any, fully match the features of "classic" cases described in the textbooks; and there is a great deal of heterogeneity within each of the major and minor categories of psychopathology, so that one schizophrenic does not necessarily resemble another very closely; and the boundaries between categories are often quite fuzzy, so that there is considerable uncertainty whether, for example, a patient is properly classified as a phobic or an obsessive-compulsive, a schizophrenic or depressive, neurotic or psychotic. One of the symptoms of this state of affairs is the disagreement among clinicians as to the proper classification of particular patients; another is the gradual evolution of "in-between" categories of psychopathology, such as schizoaffective disorder and borderline personality disturbance.

In the past, the diagnostic rules appeared to assume, implicitly or explicitly, that the various categories of mental illness were proper sets defined by necessary and sufficient features. Certainly many criticisms of the diagnostic system were based on this assumption. However, it seems probable that the categories of psychopathology are natural concepts, not proper sets, consisting of correlated rather than defining features. In fact, recent analyses of diagnostic decisions indicate that practicing clinicians use the diagnostic categories as if they were fuzzy sets represented by prototypes, and actually perform a feature-matching process such as that described earlier when assigning labels to real cases (Cantor, Smith, French, & Mezzich, 1980). The most recent revision of the official manual used for diagnosis of psychopathology implicitly recognizes this new view of diagnosis. A more rigorous application of the probabilistic view of categorization is likely to improve our understanding of the diagnostic system, and our ability to employ it effectively to suggest effective interventions for treatment and prevention.

Imagery

A major development in research on perception, with direct relevance to the nature of mental illness, pertains to the topic of mental imagery. The relevance is to hallucinations, which are common symptoms of various psychopathological syndromes, including schizophrenia and affective disorder (Siegel & West, 1976). Hallucinations are mental images, but with a difference: normal images are perceived as internal mental representations of stimuli, and as the products of memory-based constructive activity; by contrast, hallucinations are projected externally, their origins in memory and deliberate constructive activity are unacknowledged by the subject, and consequently they are confused with actual stimulus input. The process of understanding hallucinations begins with an understanding of the nature of mental imagery. During the early years of the cognitive revolution research on imagery remained largely unrecognized, but a virtual avalanche of research reports was released by Haber's (1969) documentation of eidetic images, Paivio's (1969) studies of the effects of mental imagery on memory, Shepard's work on mental rotation (Cooper & Shepard, 1973; Shepard & Metzler, 1971), and Segal's confirmation of the Perky phenomenon (Segal & Fusella, 1970). This long-neglected research was collected and summarized in a number of books (Paivio, 1971; Richardson, 1969; Segal, 1971; Sheehan, 1972), and served as the impetus for sustained inquiry into the 1980s (Kosslyn, 1980; Pinker, 1980; Shepard, 1978).

A great deal of evidence now supports the contention that mental images are products of the same kinds of processes that are involved in ordinary perception. For example, the time it takes to rotate an imagined object, or to shift attention from one point of an imagined scene to another, or to make perceptual comparisons among objects, is proportional to the time it would take to perform these same operations on actual perceptual input. In short, having an image before the mind's eye closely resembles seeing. The point remains controversial (Anderson, 1978; Pylyshyn, 1981), and further research is needed to clarify the situation.

At the same time, the manner in which images are transformed into hallucinations remains to be determined. Before this can happen, however, it will be necessary to develop experimental techniques for the study of hallucinations that are as rigorous as those used to study images. Individuals with diagnosed psychopathology are unlikely to be useful in this regard, both because their hallucinations are already established by the time they are diagnosed, and because of the possible confounding contributions of organic brain syndrome and social influence. However, there are conditions in which normal individuals experience hallucinations, and these may serve as laboratory models for the study of the pathological case: dreams, daydreams, hypnogogic imagery, and hypnosis. Hypnosis is especially promising, inasmuch as it appears to be the only state in which hallucinations can be induced in normals under tight experimental control. Recently, Hilgard (1977) has proposed a neodissociation theory of divided consciousness which suggests that the cognitive procedures involved in generating images can be divorced from the central executive control system. The theory provides a conceptual framework uniting hallucinations of all types, but the mechanisms underlying hypnotic and other dissociations remain to be discovered by future research.

Judgment and Inference in Perception

In addition to examining the structure of the memory system which provides the information used to generate expectations and inferences, a complete understanding of normal and pathological perception must also explore the judgmental, inferential, and problem-solving processes which result in the final perceptual construction. The study of problem-solving is now well advanced (e.g., Newell & Simon, 1973), but it has not yet been applied systematically to the topic of perception. More directly relevant are studies of judgment, and particularly normal biases and errors in the judgmental process. The earliest models of judgment were based on idealizations of formal, logical reasoning: the rules employed by logicians to draw conclusions from specified premises. Beginning in about 1971, a new set of models of judgment and decision-making began to emerge (e.g., Einhorn & Hogarth, 1975; Kahneman & Tversky, 1972, 1973; Slovic, Fischoff, & Lichtenstein, 1976; Wason & Johnson-Laird, 1972). Perhaps the most important finding of this research is that even normal people do not perform deductive and inductive reasoning tasks strictly according to the rules of logic and normative inference. Partly, this state of affairs simply reflects their inadequate knowledge of the rules of logical inference -- a problem that can be resolved by training. However, people often fail to apply rules that they know perfectly well. Instead, they resort to judgmental heuristics -- shortcuts which are likely to yield a correct answer, but which also increase the probability of error. For example, subjects may be led to accept a conclusion based on false premises if these premises are worded positively (all, some) and to reject a conclusion if the premises are worded negatively (no, not).

The use of judgmental heuristics is especially prominent in inductive reasoning, in which people form hypotheses based on available information. For example, judgments are likely to be biased by the relative salience of features and objects in the environment, memory, or imagination; by the ease with which they can think of examples; or by the degree to which one object resembles another. Perceptions of correlation between two features or events are strongly biased by the salience of these events, as well as by intuitive judgments of similarity. People seem disinclined to seek out all the relevant information, weight it appropriately, correct for potential unreliability and lack of validity, and the like when forming perceptual hypotheses. And when they test these hypotheses against the data provided by the real world, they appear to be biased in favor of confirmation -- seeking out, and paying particular attention to, information that is consistent rather than inconsistent with their hypothesis. In fact, these heuristics often -- even usually -- lead to correct judgments and inferences; and they certainly save time and cognitive effort. While not entirely irrational, however, they certainly represent departures from the normative rules of statistical inference associated with formal scientific procedures.

These studies of reasoning, problem-solving, judgment, and inference take on particular importance in light of the frequent observation that mental patients are prone to judgmental errors of various sorts. For example, schizophrenics are often held to differ from normals in that they reason illogically; now, we know that even normals are prone to logical lapses. Other theories acknowledge the existence of logical errors and judgmental biases in normals: one prominent theory holds that schizophrenics show an exaggeration of normal biases, while another holds that depressives lack precisely those biases which protect the self-concepts of normals; now we know better precisely what these sorts of cognitive-perceptual biases are. Research on depression is currently making extremely productive use of contemporary research on judgment and reasoning; this body of research and theory has yet to influence analyses of schizophrenia, however.

Social Perception

A major and largely unanticipated development within the study of perception and memory has dealt with the processing of information about social stimuli -- oneself, other persons, the interactions between them, and the situations in which these interactions take place. Asch's (1948) work on the unique perceptual qualities of particular combinations of features, is a good example of research on social perception influenced by Gestalt theory. Asch found that changing a single item on a list of traits ostensibly characterizing another person could dramatically alter the way that person was described by an observer; and that the first item of information presented about that person exerted a disproportionate influence on the final impression. A more recent link between social and nonsocial information processing has to do with the perception of faces. Beginning with the work of Reed (1972), investigators have employed facial stimuli in experiments on categorization, revealing the prototype-matching process described earlier. At the same time, a number of social psychologists (e.g., Ekman, Friesen, & Ellsworth, 1972; Izard, 1971) have been concerned with the facial expression of emotion. From early infancy onward, others' faces are among the most powerful social stimuli, and there is some evidence for cross-cultural consistency in the way that certain facial expressions are evaluated. However, there is not by any means complete consensus -- developmentally, within a culture, or across cultures -- about the meaning of facial expressions. Perhaps a more thoroughgoing adoption of the prototype view of categorization would help clarify the processes underlying the perception and expression of emotions in faces.

In the last decade, research on social cognition has been characterized by a wholesale adoption of the methods and principles of contemporary cognitive psychology. For example, Hastie and Carlston (1981) have organized all the research on social cognition within the framework of the classic multistore model of memory, modified to take account of recent developments in the "levels of processing" tradition, and the distinctions between procedural and declarative, and episodic and semantic, memory. Cantor (Cantor & Mischel, 1979; Cantor, Mischel, & Schwartz, 1982) has applied the probabilistic view of categorization to the analysis of concepts concerning persons and social situations, and Hamilton (1979) has applied similar concepts to the problem of social stereotyping. Nisbett and Ross (1981) have documented the role of judgmental heuristics and biases in impression-formation and causal attribution, and Synder (1980) has shown that confirmatory biases pervade hypothesis-testing about other people, just as they pervade other problem-solving situations.

This research is directly relevant to research on psychopathology because whatever other difficulties these people may have, it is problems in the interpersonal sphere which have brought them to the attention of clinicians. The same psychological deficits which affect their ability to perceive and attend to nonsocial stimuli also, of course, affect the processing of social information. These deficits may be especially prominent when patients are asked to deal with the kind of stimuli which they encounter in the ordinary course of everyday living (and which, arguably, bring them to the attention of clinicians in the first place), rather than the sterile, artificial stimuli commonly employed in laboratory studies of perception.

Noncognitive Aspects of Perception

The most salient advance in the psychology of perception over the past decade has been its assimilation to the general information-processing framework of contemporary cognitive psychology. This tendence is most clearly demonstrated in research on reading and speech, with its emphasis on feature-detection and pattern recognition, the obvious importance of pre-existing phonetic and semantic representations stored in memory, and the central role played by inference and problem-solving in comprehension. On topics within classical perception, such as movement, depth, size, form, constancy, and illusion, these tendencies are most clearly represented in the work of Hochberg, Rock, and their collaborators. Thus, research on motion and form perception has revealed the cognitive activity involved in integrating successive glances at a stimulus, or at different portions of it, and the contribution that expectations and other mental representations make to the construction of the final percept (e.g., Hochberg, 1979; Peterson & Hochberg, 1983). Similarly, research on constancies and illusions reveals the problem-solving nature of perception, as the observer (typically unconsciously) generates and tests hypotheses concerning the kind of object that could produce the currently impinging pattern of proximal stimuli (e.g., Rock, 1973; 1977). Recently, the study of auditory perception has moved into a new nonlinguistic domain, music, and explored the applicability of various spatial models of perceptual structure and categorization (e.g., Krumhansl & Kessler, 1982; Shepard, 1982). These and related lines of investigation compliment the research on reading and listening treated earlier in this review, by showing how the information-processing framework can be used to shed new light on some of psychology's oldest problems.

However, adherence to the information-processing model is far from complete. Substantial progress has been made in many traditional areas even in the absence of a thoroughgoing cognitive point of view, so that one way or another some classic problems seem to be on the verge of solution once and for all: the perception of depth and motion, of constancy despite changing stimulation, and of illusions and other perceptual anomalies. It is conceivable that these phenomena, being essentially nonlinguistic, are not amenable to the concepts and methods of a cognitive psychology that is so dominated by language -- though, it must be said, the attempt at a reconciliation would probably enhance both psychologies, of perception and of cognition. In any event, the frequent reports of perceptual difficulties -- loss of depth, disorientation, changes in perceived size and distance, etc. -- given by individuals in the acute stage of schizophrenia and other psychoses led to a great deal of classic work on schizophrenia performed in the 1960s. These topics have largely disappeared from the journals, but in light of recent advances it would seem appropriate to reopen this line of investigation.

If this is to occur, research on pathological perception will need to take note of the active opposition to cognitive concepts in some quarters of the field of perception. For example, Gibson has long promoted a theory of direct perception which holds that all the necessary information is supplied by the stimulus and extracted by the sensory apparatus, so that there is no need to involve memory, inference, or hypothesis-testing mechanisms in the process. Once considered idiosyncratic, the Gibsonian point of view has received a great deal of favorable attention during the past decade (Gibson, 1979; Turvey, 1977; Shaw & Bransford, 1977; Neisser, 1976; but see Cutting, 1982). In contrast to the information-processing approach, the Gibsonian approach is concerned with events that occur over time rather than with static objects. Many objections have been entered against Gibson's point of view as a complete theory of perception: for example, it has difficulty in accounting for constancies and illusions, where the final perception is very discrepant from the structure of the stimulus itself. However, the approach seems to do a very good job of accounting for certain important spatiotemporal aspects of perception, such as depth and motion. At this point, it would seem that no analysis of pathological perception could be called comprehensive that did not explore some of the phenomena treated by the theory of direct perception -- even if the ultimate theoretical treatment of the findings differed radically from that which would be favored by Gibsonians themselves.

Summary

This survey has identified a number of highly active areas of research within the domain of perception and attention, many of which have a direct bearing on the problems of psychopathology. (a) First and foremost of these is attention. The clinical impression of attentional deficit in schizophrenia is too strong to be ignored, and it seems very likely that an increased understanding of normal attentional processes will lay the foundation for a real breakthrough in this field. Of special interest here is the extent of preattentive processing of meaning, the distinction between controlled and automatic processing (and the means by which one is transformed into the other), and the development of skills of divided attention. The current literature on the pathology of attention gives the impression of being predicated on largely outmoded models, and a wholesale revision of theoretical background seems to be in order. (b) In much the same way, the effort to develop a taxonomy of elementary mental processes such as feature detection and pattern recognition, and the time relations between them, is a promising direction for future research. Although it now seems that the classic multistore model of the cognitive system should be abandoned, this research methodology also promises to help establish the precise locus of psychological deficit in schizophrenia and other major forms of psychopathology. But the strategy cannot be successful without an adequate "map" of the cognitive system, developed through research on normal individuals. In the study of attention and other elementary mental processes, special attention should be given to studies employing evoked potentials and similar electrophysiological techniques. However, the point must be stressed that psychophysiological methods supplement, but do not supplant, the traditional tools of cognitive psychology. Wholesale adoption of either method, to the virtual exclusion of the other, would be an error. (c) A third area of potentially fruitful research has to do with "cognitive" aspects of perception, especially categorization, judgment, and inference, and the memory system which forms the cognitive basis for perception. Categorization and judgment are the final products of the perceptual process, and represent the meaning which the individual assigns to an object or event. We need to know more about how categories, meanings, and experiences are organized in the memory system, before we can begin to understand where the thought processes of disturbed individuals go awry. Moreover, the importance of hallucinations as a major symptom of psychopathology suggests that a full-scale effort be devoted to the study of the structure and function of mental imagery.

Any survey of research on psychological deficit, pathological perception and attention, and the like would reveal that experimental psychopathologists have been largely content to adopt the stimulus materials as well as the concepts, principles, and paradigms of normal cognitive psychology. However, exclusive reliance on the sterile stimulus materials that have served so well in the study of normal cognition may be a serious mistake. After all is said and done, it is problems in the interpersonal sphere which have brought most mental patients to the attention of clinicians. Psychological deficit in psychopathology, if there is any at all, is manifested in a social context. For that reason, it seems important to foster an understanding of social cognition in psychopathology: how patients view themselves and other people, how others view them, the whole panoply of processes involved in interpersonal perception and social judgment. Investigators of "normal" cognition are also showing increased interest in social stimuli, social memory, and social judgments, so that the possibility exists for a "grand synthesis" that will finally unite cognitive, social, and clinical psychology within the framework of a common vocabulary and a common set of explanatory principles.

While these areas would seem to call for some special emphasis in the NIMH extramural and intramural research programs, the point cannot be made too strongly that the cognitive system is a unified one. An advance in understanding in one area will necessarily enhance our understanding in other areas. Moreover, it must be said that 20 years ago few of the areas discussed here would have been identified as areas in which major progress would be made — indeed, some of the areas here were not even legitimate topics for research 20 years ago. In the final analysis, where support is to be offered for basic as opposed to applied research, on normal as opposed to pathological mental processes, it would seem the best policy to identify competent investigators and allow them to pursue whatever area of investigation seems most likely to be profitable. In the salad days of federal largesse this policy led to all the advances described here, and more, which had implications for the nature, treatment, and prevention of both major and minor forms of psychopathology.

Footnotes

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