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Chapter 1

The Cognitive Approach

It has been said that beauty is in the eye of the beholder. As a hypothesis about localization of function, the statement is not quite right—the brain and not the eye is surely the most important organ involved. Nevertheless it points clearly enough toward the central problem of cognition. Whether beautiful or ugly or just conveniently at hand, the world of experience is produced by the man who experiences it.

This is not the attitude of a skeptic, only of a psychologist. There certainly is a real world of trees and people and cars and even books, and it has a great deal to do with our experiences of these objects. However, we have no direct, *im*mediate access to the world, nor to any of its properties. The ancient theory of *eidola*, which supposed that faint copies of objects can enter the mind directly, must be rejected. Whatever we know about reality has been *mediated*, not only by the organs of sense but by complex systems which interpret and reinterpret sensory information. The activity of the cognitive systems results in—and is integrated with—the activity of muscles and glands that we call "behavior." It is also partially—very partially—reflected in those private experiences of seeing, hearing, imagining, and thinking to which verbal descriptions never do full justice.

Physically, this page is an array of small mounds of ink, lying in certain positions on the more highly reflective surface of the paper. It is this physical page which Koffka (1935) and others would have called the "distal stimulus," and from which the reader is hopefully acquiring some information. But the sensory input is not the page itself; it is a pattern of light rays, originating in the sun or in some artificial source, that are reflected from the page and happen to reach the eye. Suitably focused by the lens and other ocular apparatus, the rays fall on the sensitive retina, where they can initiate the neural processes that eventually lead to seeing and reading and remembering. These patterns of light at the retina are the so-called "proximal stimuli." They are not the least bit like *eidola*. One-sided in their perspective, shifting radically several times each second, unique and novel at every moment, the proximal stimuli bear little resemblance to either the real object that gave rise to them or to the object of experience that the perceiver will construct as a result.

Visual cognition, then, deals with the processes by which a perceived, remembered, and thought-about world is brought into being from as unpromising a beginning as the retinal patterns. Similarly, auditory cognition is concerned with transformation of the fluctuating pressure-pattern at the ear into the sounds and the speech and music that we hear. The problem of understanding these transformations may usefully be compared to a very different question, that arises in another psychological context. One of Freud's papers on human motivation is entitled "Instincts and their Vicissitudes" (1915). The title reflects a basic axiom of psychoanalysis: that man's fundamental motives suffer an intricate series of transformations, reformulations, and changes before they appear in either consciousness or action. Borrowing Freud's phrase—without intending any commitment to his theory of motivation—a book like this one might be called "Stimulus Information and its Vicissitudes." As used here, the term "cognition" refers to all the processes by which the sensory input is transformed, reduced, elaborated, stored, recovered, and used. It is concerned with these processes even when they operate in the absence of relevant stimulation, as in images and hallucinations. Such terms as *sensation, perception, imagery, retention, recall, problem-solving,* and *thinking,* among many others, refer to hypothetical stages or aspects of cognition.

Given such a sweeping definition, it is apparent that cognition is involved in everything a human being might possibly do; that every psychological phenomenon is a cognitive phenomenon. But although cognitive psychology is concerned with all human activity rather than some fraction of it, the concern is from a particular point of view. Other viewpoints are equally legitimate and necessary. Dynamic psychology, which begins with motives rather than with sensory input, is a case in point. Instead of asking how a man's actions and experiences result from what he saw, remembered, or believed, the dynamic psychologist asks how they follow from the subject's goals, needs, or instincts. Both questions can be asked about any activity, whether it be normal or abnormal, spontaneous or induced, overt or covert, waking or dreaming. Asked why I did a certain thing, I may answer in dynamic terms, "Because I wanted . . . ," or, from the cognitive point of view, "Because it seemed to me . . ."

In attempting to trace the fate of the input, our task is both easier and harder than that of dynamic psychology. It is easier because we have a tangible starting point. The pattern of stimulation that reaches the eye or the ear can be directly observed; the beginning of the cognitive transformations is open to inspection. The student of motivation does not have this advantage, except when he deals with the physical-deprivation motives like hunger and thirst. This forces him to rely rather more on speculation and less on observation than the cognitive theorist. But

by the same token, the latter has an additional set of responsibilities. He cannot make assumptions casually, for they must conform to the results of 100 years of experimentation.

Recognition of the difference between cognitive and dynamic theory does not mean that we can afford to ignore motivation in a book like this one. Many cognitive phenomena are incomprehensible unless one takes some account of what the subject is trying to do. However, his purposes are treated here primarily as independent variables: we will note that they can affect one or another cognitive mechanism without inquiring closely into their origin. This strategy will break down in the final chapter; remembering and thinking are too "inner-directed" to be treated in such a fashion. As a consequence, the last chapter has a different format, and even a different purpose, from the others.

The cognitive and the dynamic viewpoints are by no means the only possible approaches to psychology. Behaviorism, for example, represents a very different tradition, which is essentially incompatible with both. From Watson (1913) to Skinner (1963), radical behaviorists have maintained that man's actions should be explained only in terms of observable variables, without any inner vicissitudes at all. The appeal to hypothetical mechanisms is said to be speculative at best, and deceptive at worst. For them, it is legitimate to speak of stimuli, responses, reinforcements, and hours of deprivation, but not of categories or images or ideas. A generation ago, a book like this one would have needed at least a chapter of self-defense against the behaviorist position. Today, happily, the climate of opinion has changed, and little or no defense is necessary. Indeed, stimulus-response theorists themselves are inventing hypothetical mechanisms with vigor and enthusiasm and only faint twinges of conscience. The basic reason for studying cognitive processes has become as clear as the reason for studying anything else: because they are there. Our knowledge of the world *must* be somehow developed from the stimulus input; the theory of *eidola* is false. Cognitive processes surely exist, so it can hardly be unscientific to study them.

Another approach to psychological questions, a world apart from behaviorism, is that of the physiologist. Cognition, like other psychological processes, can validly be studied in terms of the underlying neural events. For my part, I do not doubt that human behavior and consciousness depend entirely on the activity of the brain, in interaction with other physical systems. Most readers of this book will probably have the same prejudice. Nevertheless, there is very little of physiology or biochemistry in the chapters ahead. At a time when these fields are making impressive advances, such an omission may seem strange. An example may help to justify it. For this purpose, let us consider recent work on the physical basis of memory.

No one would dispute that human beings store a great deal of

information about their past experiences, and it seems obvious that this information must be physically embodied somewhere in the brain. Recent discoveries in biochemistry have opened up a promising possibility. Some experimental findings have hinted that the complex molecules of DNA and RNA, known to be involved in the transmission of inherited traits, may be the substrate of memory as well. Although the supporting evidence so far is shaky, this hypothesis has already gained many adherents. But psychology is not just something "to do until the biochemist comes" (as I have recently heard psychiatry described); the truth or falsity of this new hypothesis is only marginally relevant to psychological questions. A pair of analogies will show why this is so.

First, let us consider the familiar parallel between man and computer. Although it is an inadequate analogy in many ways, it may suffice for this purpose. The task of a psychologist trying to understand human cognition is analogous to that of a man trying to discover how a computer has been programmed. In particular, if the program seems to store and reuse information, he would like to know by what "routines" or "procedures" this is done. Given this purpose, he will not care much whether his particular computer stores information in magnetic cores or in thin films; he wants to understand the program, not the "hardware." By the same token, it would not help the psychologist to know that memory is carried by RNA as opposed to some other medium. He wants to understand its utilization, not its incarnation.

Perhaps this overstates the case a little. The hardware of a computer may have some indirect effects on programming, and likewise the physical substrate may impose some limitations on the organization of mental events. This is particularly likely where peripheral (sensory and motor) processes are concerned, just as the input-output routines of a program will be most affected by the specific properties of the computer being used. Indeed, a few fragments of peripheral physiology will be considered in later chapters. Nevertheless they remain, in the familiar phrase, of only "peripheral interest."

The same point can be illustrated with quite a different analogy, that between psychology and economics. The economist wishes to understand, say, the flow of capital. The object of his study must have some tangible representation, in the form of checks, gold, paper money, and so on, but these objects are not what he really cares about. The physical properties of money, its location in banks, its movement in armored cars, are of little interest to him. To be sure, the remarkable permanence of gold has some economic importance. The flow of capital would be markedly different if every medium of exchange were subject to rapid corrosion. Nevertheless, such matters are not the main concern of the economist, and knowledge of them does not much simplify economic theory.

Psychology, like economics, is a science concerned with the interdependence among certain events rather than with their physical nature. Although there are many disciplines of this sort (classical genetics is another good example), the most prominent ones today are probably the so-called "information sciences," which include the mathematical theory of communication, computer programming, systems analysis, and related fields. It seems obvious that these must be relevant to cognitive psychology, which is itself much concerned with information. However, their importance for psychologists has often been misunderstood, and deserves careful consideration.

Information, in the sense first clearly defined by Shannon (1948), is essentially *choice*, the narrowing down of alternatives. He developed the mathematical theory of communication in order to deal quantitatively with the transmission of messages over "channels." A channel, like a telephone line, transmits information to the extent that the choices made at one end determine those made at the other. The words of the speaker are regarded as successive selections from among all the possible words of English. Ideally, the transmitted message will enable the listener to choose the same ones; that is, to identify each correctly. For practical purposes, it is important to measure the *amount* of information that a system can transmit, and early applications of information theory were much concerned with measurement. As is now well known, amounts of information are measured in units called "bits," or binary digits, where one "bit" is represented by a choice between two equally probable alternatives.

Early attempts to apply information theory to psychology were very much in this spirit (e.g., Miller, 1953; Quastler, 1955), and even today many psychologists continue to theorize and to report data in terms of "bits" (e.g., Garner, 1962; Posner, 1964a, 1966). I do not believe, however, that this approach was or is a fruitful one. Attempts to quantify psychological processes in informational terms have usually led, after much effort, to the conclusion that the "bit rate" is not a relevant variable after all. Such promising topics as reaction time, memory span, and language have all failed to sustain early estimates of the usefulness of information measurement. With the advantage of hindsight, we can see why this might have been expected. The "bit" was developed to describe the performance of rather unselective systems: a telephone cannot decide which portions of the incoming message are important. We shall see throughout this book that human beings behave very differently, and are by no means neutral or passive toward the incoming information. Instead, they select some parts for attention at the expense of others, recoding and reformulating them in complex ways.

Although information measurement may be of little value to the cognitive psychologist, another branch of the information sciences,

computer *programming*, has much more to offer. A program is not a device for measuring information, but a recipe for selecting, storing, recovering, combining, outputting, and generally manipulating it. As pointed out by Newell, Shaw, and Simon (1958), this means that programs have much in common with theories of cognition. Both are descriptions of the vicissitudes of input information.

We must be careful not to confuse the program with the computer that it controls. Any single general-purpose computer can be "loaded" with an essentially infinite number of different programs. On the other hand, most programs can be run, with minor modifications, on many physically different kinds of computers. A program is not a machine; it is a series of instructions for dealing with symbols: "If the input has certain characteristics . . . then carry out certain procedures . . . otherwise other procedures . . . combine their results in various ways . . . store or retrieve various items . . . depending on prior results . . . use them in further specified ways . . . etc." The cognitive psychologist would like to give a similar account of the way information is processed by men.

This way of defining the cognitive problem is not really a new one. We are still asking "how the mind works." However, the "program analogy" (which may be a better term than "computer analogy") has several advantages over earlier conceptions. Most important is the philosophical reassurance which it provides. Although a program is nothing but a flow of symbols, it has reality enough to control the operation of very tangible machinery that executes very physical operations. A man who seeks to discover the program of a computer is surely not doing anything self-contradictory!

There were cognitive theorists long before the advent of the computer. Bartlett, whose influence on my own thinking will become obvious in later chapters, is a case in point. But, in the eyes of many psychologists, a theory which dealt with cognitive transformations, memory schemata, and the like was not *about* anything. One could understand theories that dealt with overt movements, or with physiology; one could even understand (and deplore) theories which dealt with the content of consciousness; but what kind of a thing is a schema? If memory consists of transformations, what is tranformed? So long as cognitive psychology literally did not know what it was talking about, there was always a danger that it was talking about nothing at all. This is no longer a serious risk. *Information* is what is transformed, and the structured pattern of its transformations is what we want to understand.

A second advantage of the "program analogy" is that, like other analogies, it is a fruitful source of hypotheses. A field which is directly concerned with information processing should be at least as rich in ideas

for psychology as other fields of science have been before. Just as we have borrowed atomic units, energy distributions, hydraulic pressures, and mechanical linkages from physics and engineering, so may we choose to adopt certain concepts from programming today. This will be done rather freely in some of the following chapters. Such notions as "parallel processing," "feature extraction," "analysis-by-synthesis," and "executive routine" have been borrowed from programmers, in the hope that they will prove theoretically useful. The test of their value, of course, is strictly psychological. We will have to see how well they fit the data.

The occasional and analogic use of programming concepts does not imply a commitment to computer "simulation" of psychological processes. It is true that a number of researchers, not content with noting that computer programs are *like* cognitive theories, have tried to write programs which *are* cognitive theories. The "Logic Theorist," a program developed by Newell, Shaw, and Simon (1958), does more than find proofs for logical theorems: it is intended as a theory of how human beings find such proofs. There has been a great deal of work in this vein recently. It has been lucidly reviewed, and sympathetically criticized, by Reitman (1965). However, such models will not be discussed here except in passing. In my opinion, none of them does even remote justice to the complexity of human mental processes. Unlike men, "artificially intelligent" programs tend to be single-minded, undistractable, and unemotional. Moreover, they are generally equipped from the beginning of each problem with all the cognitive resources necessary to solve it. These criticisms have already been presented elsewhere (Neisser, 1963c), and there is no need to elaborate them now. In a sense, the rest of this book can be construed as an extensive argument against models of this kind, and also against other simplistic theories of the cognitive processes. If the account of cognition given here is even roughly accurate, it will not be "simulated" for a long time to come.

The present volume is meant to serve a double purpose. On the one hand, I hope to provide a useful and current account of the existing "state of the art." In discussing any particular phenomenon—immediate memory, or understanding sentences, or subception, or selective listening —an attempt is made to cover the significant experiments, and to discuss the major theories. On the other hand, it must be admitted that few of these discussions are neutral. When the weight of the evidence points overwhelmingly in one direction rather than another, I prefer to say so frankly. This is especially because in most cases the indicated direction seems (to me) to be consistent with a particular view of the cognitive processes. Some of the chapters only hint at this theory, while in others it emerges explicitly. When it does, the first person singular is used rather

freely, to help the reader distinguish between the facts and my interpretation of them. In the end, I hope to have presented not only a survey of cognitive psychology but the beginnings of an integration.

The title of this book involves a certain deliberate ambiguity. In one sense, "cognitive psychology" refers generally to the study of the cognitive mechanisms, quite apart from the interpretations put forward here. In another sense, "cognitive psychology" is a particular theory to which I have a specific personal commitment. By Chapter 11, it will have become so specific that Rock and Ceraso's (1964) "Cognitive Theory of Associative Learning" will be rejected as not cognitive enough! If the reader finds this dual usage confusing, I can only say that it seems unavoidable. Such double meanings are very common in psychology. Surely "Behavior Theory" is only one of many approaches to the study of behavior, just as "Gestalt Psychology" is not the only possible theory of visual figures (Gestalten), and "Psychoanalysis" is only one of many hypothetical analyses of psychological structure.

The present approach is more closely related to that of Bartlett (1932, 1958) than to any other contemporary psychologist, while its roots are at least as old as the "act psychology" of the nineteenth century. The central assertion is that seeing, hearing, and remembering are all acts of *construction*, which may make more or less use of stimulus information depending on circumstances. The constructive processes are assumed to have two stages, of which the first is fast, crude, wholistic, and parallel while the second is deliberate, attentive, detailed, and sequential.

The model is first elaborated here in five chapters on visual processes. These chapters include an account of the very temporary, "iconic" memory which stores the output of the first stage of construction; a review of various theories of pattern recognition together with relevant data; a specific presentation of the constructive theory as applied to visual recognition; a survey of reading and tachistoscopic word-perception insofar as they are understood; and a discussion of visual memory, imagery, and hallucination. Four subsequent chapters on hearing [1] cover the perception of words, considered in terms of both acoustics and linguistics; various theories of auditory attention, including one which interprets it as a constructive process; the classical "immediate memory" for strings of words; and an account of linguistic structure together with its implications for psychology.

The final chapter on memory and thought is essentially an epilogue, different in structure from the rest of the book. Because of the tremendous scope of these higher mental processes, no attempt is made to cover the relevant data, or to refute competing theories, and the views put forward are quite tentative. Nevertheless, the reader of a book called

[1] Sense modalities other than vision and hearing are largely ignored in this book, because so little is known about the cognitive processing involved.

Cognitive Psychology has a right to expect some discussion of thinking, concept-formation, remembering, problem-solving, and the like; they have traditionally been part of the field. If they take up only a tenth of these pages, it is because I believe there is still relatively little to say about them, even after 100 years of psychological research.

There is another respect in which this book may seem incomplete. The cognitive processes under discussion are primarily those of the American adult, or at least of the college student who is so frequently the subject of psychological experiments. Although there will be occasional references to the developmental psychology of cognition, it will not be reviewed systematically. In part, this is because the course of cognitive growth is so little understood. However, even in areas where development is being actively studied, such as concept formation and psycholinguistics, I have not felt qualified to review it.

One last word of explanation is necessary, before concluding an introduction that is already overlong. Many topics that the reader may have expected to find have now been set aside. We will consider neither physiological mechanisms nor information measurement nor computer simulation nor developmental psychology; even remembering and thought are to receive short shrift. Despite these omissions, it must not be thought that the field which remains to be explored is a narrow one. Although the core of the material presented here is taken from within experimental psychology itself, there is extensive use of data and concepts from other fields, including psychiatry and clinical psychology (especially in connection with hallucinations); hypnosis; the social psychology of the psychological experiment; the physiology and psychology of sleep; the study of reading, which too often has been relegated to educational psychology; computer programming; linguistics and psycholinguistics. The reader may hesitate to follow along a path that seems so full of side alleys, and perhaps blind ones at that. I can only hope he will not be altogether discouraged. No shorter route seems to do justice to the vicissitudes of the input, and to the continuously creative processes by which the world of experience is constructed.