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MOTIVATIONAL AND EMOTIONAL CONTROLS OF COGNITION [1]

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The central nervous system is a serial information processor that must serve an organism endowed with multiple needs, and living in an environment that presents unpredictable threats and opportunities. These requirements are met by 2 mechanisms: (a) goal-terminating mechanisms, permitting goals to be processed serially without any 1 monopolizing the processor, (b) interruption mechanism, having the properties usually ascribed to emotion, allowing the processor to respond to urgent needs in real time. Mechanisms of these kinds, to control the direction of attention and activity, have been incorporated in some information-processing theories of human cognition, and their further elaboration will permit these theories to explain wider ranges of behavior.

Considerable progress has been made in the last decade in accounting for human cognitive performances in terms of organizations of simple information processes (Reitman, 1965; Simon & Newell, 1964). Information-processing theories, however, have generally been silent on the interaction of cognition with affect. Since in actual human behavior motive and emotion are major influences on the course of cognitive behavior, a general theory of thinking and problem solving must incorporate such influences.

Critics of information-processing theories and of computer simulation of human thinking point, quite correctly, to this lacuna as a major deficiency of the theories. Neisser (1963), whose views on simulation are perceptive and informed, argues that "the view that machines will think as man does reveals misunderstanding of human thought." He observes that:

> Three fundamental and interrelated characteristics of human thought . . . are conspicuously absent from existing or contemplated computer programs:
>
> 1) human thinking always takes place in, and contributes to, a cumulative process of growth and development;
>
> 2) human thinking begins in an intimate association with emotions and feelings which is never entirely lost;
>
> 3) almost all human activity, including thinking, serves not one but a multiplicity of motives at the same time [p. 195].

Our purpose here is to discuss the behavior of humans, not the capabilities of computers. Nonetheless, Neisser has characterized correctly some of the visibly gross differences between human behavior and the behavior of existing simulation programs. Even if it were to be argued that the differences are quantitative rather than qualitative, they would prove conspicuous nonetheless. Developmental processes play a small role in existing simulation programs, emotions play almost no role, and most such programs appear to be

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[1] Discussions with my colleague, Walter R. Reitman, about the relations of serial and parallel processing provided much of the motivation for the approach of this paper. I alone accept responsibility for the particular form of the theory of emotional behavior proposed here. Reitman (1963) has described part of his own theory. An earlier version of this paper provided the basis for one of my William James Lectures at Harvard University, March 1963. Its completion has been aided by research grants from the Carnegie Corporation and the National Institutes of Health (MH-07722).

driven by a single top-level goal, or motive. Progress in theory construction will require us to remove these differences.

This paper will attempt to show how motivational and emotional controls over cognition can be incorporated into an information-processing system, so that thinking will take place in "intimate association with emotions and feelings," and will serve a "multiplicity of motives at the same time." The expanded system will therefore meet Neisser's second and third objections. (Growth and development will be left to another paper.)

In its assumptions about the mechanisms of motivation and emotion, the theory will follow lines already laid down by Hebb, Lindsley, and others, for which there is considerable empirical support. The proposed theory contains elements of novelty mainly by showing how relatively familiar mechanisms of motivation and emotion can be integrated in a simple and natural way with the mechanisms that have been postulated in information-processing theories of cognition.

"MOTIVATION" OF BEHAVIOR IN A SERIAL PROCESSOR

Two assumptions are central to most of the existing information-processing theories of thinking:[2] (*a*) The central nervous system (CNS) is basically organized to operate in serial fashion; and (*b*) the course of behavior is regulated, or motivated, by a tightly organized hierarchy of goals.

Serial Organization

It is not easy to state rigorously what is meant by a "serial" as contrasted with a "parallel" processor. A serial processor, of course, is one in which only a few things go on at a time, while a parallel processor is one in which many things go on at a time. This distinction is meaningless, however, until we specify how to count "things"—how to recognize a unitary process or object.

The ambiguity extends not only to defining the symbolic units, but to defining the time units as well. Any serial system, given enough time, can do many things. If we only look at its behavior periodically, we cannot tell whether the processes have been carried out in serial or parallel fashion.

When we say that the human CNS is organized as a serial processor, we must have in mind, therefore, some notion of an "elementary" symbol and an "indivisible" time unit. Since the simplest reflex actions require about 100 milliseconds, we may take this as the approximate relevant time interval. Since in some memory experiments, the "chunk" (i.e., a single familiar symbol, like a familiar nonsense syllable, a digit, or a familiar short word) appears to be the significant processing unit, we may consider it the elementary symbol.

Then the postulate that the human CNS is serial can be rendered roughly as follows: The processes that operate during 1/10 second affect only a few chunks (about seven, according to Miller, 1956) among all those in short- and long-term memory. More macroscopic processes are synthesized from sequences of elementary processes, organized to operate over longer time intervals. For anything "interesting" to happen in the CNS may require quite long times—for example, about 30 seconds to memorize a nonsense-syllable pair of low association value. During a relatively short interval of time during which one such process

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[2] Reitman (1965, Ch. 8) outlines a model, ARGUS, that is highly parallel in operation. Development of this model has not yet reached a point where its adequacy to simulate cognitive behavior can be evaluated.

is going on, not much else can or does happen.

The plausibility of this postulate rests on several kinds of evidence. First, there is a large mass of behavioral evidence, both from everyday observation and from laboratory experiments, for a phenomenon called "attention"; and there is evidence that the span of attention—the number of things that can be attended to simultaneously—is only a few chunks. To be sure, not everything that happens in the CNS goes on at the level of consciousness. Nevertheless, certain cognitive processes, at least, require attention; the number that can be within the scope of attention at one time is very limited.

A second kind of argument for serial processing is of a more a priori character: It is difficult to specify how to organize a highly parallel information-processing system that would behave coherently. The basic problem is this. Suppose a system, C, has two components, C_1 and C_2, operating in parallel, which interact. From time to time the behavior of C_1 depends on the current state of C_2, and vice versa. In a simple case, we might have two memories, M_1 and M_2, for communication between the two components. At certain times, C_1 would store information in M_1, and C_2 in M_2; likewise, from time to time, C_1 would take information from M_2, and C_2 from M_1.

To obtain coherent behavior from such a system, there would have to be a certain measure of temporal coordination between its components. If C_1 takes inputs from M_2, which have been placed there by C_2, then C_1 must, in some sense, "know" how recently the contents of M_2 have been updated. The higher the frequency of interaction, the more precise is the requirement of temporal coordination.

In general, if the components of a parallel system are to operate with a high degree of interdependence, there must be a correspondingly adequate system of coordination or synchronization among them. And then the coordinating or synchronizing system will itself be a serially organized system. In the case of an organism like a human being, the requirements for coordination are fairly obvious. Most behaviors call upon a considerable part of the whole sensory and motor system for their successful performance. Hence, patting one's head while rubbing one's stomach becomes feasible only under the guidance of a supervisory synchronizing program. Even extreme cases of schizophrenia take the form of alternation, rather than parallelism, of personalities.

Control Hierarchy

The obvious way to govern the behavior of a serial processor is by a hierarchy of subroutines, with an interpreter capable of executing the instructions in the proper order (Newell & Simon, 1963, pp. 380–384). For example, the program, "Walk the length of a block," could consist of a list of instructions to be executed in the following sequence:

Walk the length of a block.
1. Step with left foot, then 2.
2. Step with right foot, then 3.
3. If end of block, do 4; if not, do 1.
4. Terminate.

A similar sequence of instructions could correspond to the program, "Cross an intersection." Now by combining these two programs in a larger one we could construct, "Walk to the 1400 block, thus:

Walk to the 1400 block.
1. Walk the length of a block, then 2.
2. Cross an intersection, then 3.

3. If 1400 reached, do 4; if not, do 1.
4. Terminate.

The interpreter in such a system starts to execute the executive program—the program at the highest level in the hierarchy. Each instruction in this program will be, in general, a subprogram to be executed in the same way. Thus the interpreter must proceed downward through the hierarchy of subprograms, or subroutines, until it reaches an "elementary" process that can be executed immediately. While it is doing this, it must keep its place in the routine it is executing at each level of the hierarchy.

Now a system organized in this simple, straightforward way is likely to reveal, in its behavior, considerable single-mindedness and unity of purpose. Whatever elementary task it is performing at a given instant was assigned to it by a subroutine which was itself, in turn, called for by a higher level subroutine. Thus, everything that is done is done in the service of the highest level executive program through successive levels of delegation.

This apparently single-minded, single-purpose behavior of most existing simulations of information-processing systems provides a striking contrast with human behavior. Under many circumstances, human behavior can be interrupted by imperative demands entirely unrelated to the goal hierarchy in current control—by hunger, fear, noticing sudden motion, etc. Moreover, even when not actually interrupted, human behavior appears to be responsive not to just one, but to a multiplicity of goals. A speaker not only attends to the content of what he is saying, but also responds in many gross and subtle ways to the feedback he gets from the facial expressions and postures of his listeners. While he is seeking to inform, he may also be seeking to please, to impress, or to earn love.

Goal Completion

Even in a purely serial system, there must be some way in which a particular subroutine can be terminated and control returned, at the next higher level, to the routine that called for its execution. What are the criteria of completion of a subgoal that might initiate this termination? There are a number of possible alternatives:

Aspiration achievement. A subroutine may terminate when its subgoal has been achieved. The subgoal may be, for example, to discover a proof for a certain theorem or to discover a move in a chess game that leads to checkmate.

Satisficing. A subroutine may terminate when its subgoal has been achieved "well enough." A subroutine may search for a course of action that will yield at least *k* dollars profit or for a chess move that will win at least a pawn.

Impatience. A subroutine may terminate when a certain amount of time has been used up in trying to achieve it, perhaps then selecting the alternative that is "best so far."

Discouragement. A subroutine may terminate after a certain set of processes for attaining the subgoal has been tried and has failed.

Thus, aspiration levels, satisficing criteria, impatience, and discouragement constitute mechanisms for terminating subroutines which can be combined in a variety of ways. Existing information-processing systems, for example, theories of problem solving in chess, already incorporate these kinds of goal-completion mechanisms.[3]

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[3] Schemes of this general kind are described in Simon (1957, Ch. 14, 15). Some

MULTIPLE GOALS

Even if a system is organized in the serial hierarchic fashion described, it may be able to respond to several goals simultaneously. There are at least two ways in which multiple goals can be introduced into such a system without altering basically its serial character. The first is by queuing—attending to several goals in sequence. The second involves generalizing the notion of goal to encompass multifaceted criteria against which possible problem solutions are tested. We shall consider these in order.

Queuing of Goals

At a minimum a living organism like a human being has to satisfy, periodically, its biological needs. A goal (e.g., seeking food or water) is then evoked by a drive. If the organism is quiescent at the time a new goal is evoked, a program appropriate to a goal of this kind is put into execution. If the organism is already occupied with achieving another goal, the new goal may be postponed and activated when the program associated with the earlier goal has been terminated.[4]

This scheme will accommodate any number of needs provided the total time required to realize the goals that are evoked by drives is, on the average, a small fraction of the total time available to the organism. It is necessary, also, that goals be evoked a sufficient time before their achievement becomes essential for survival. That is, the hunger mechanism must be adapted to the organism's storage capacity for food and the expected length of search to find food once the goal has been evoked.

If goals are evoked more or less periodically (e.g., the need for sleep), then the queuing system can be supplemented or replaced by a time-allocation system: a fixed cycle of processing, with each phase of the cycle assigned to a particular goal.

These two mechanisms, queuing and allocation, are used continually by human beings to reconcile the competing claims upon their serial processing capacities of the multiple needs they must satisfy—not only biological needs, but the whole range of goals that characterize adult human existence.

Multifaceted Criteria

A goal need not be a unitary thing, and in actual fact it seldom is. For example, the only behaviors a human being normally regards as suitable for satisfying hunger are behaviors that lead to ingesting foods of culturally acceptable kinds in a culturally acceptable manner. A gentleman dresses for dinner and eats with knife and fork roast beef that has been obtained in a legal way (e.g., by purchase) and treated at high temperatures.

Achievement of a goal, then, characteristically calls for behavior that meets a whole set of criteria. In fact, there is no need to treat these criteria asymmetrically, to single out one of them and call it "the goal." We could as well say that the gentleman's goal is to dine in his dinner jacket as to say that his goal is to satisfy his hunger.[5] The hierarchy of programs that is associ-

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of these mechanisms are realized in the programs described in Newell, Shaw, and Simon (1963) and in Simon and Simon (1962).

[4] For further discussion, see Simon (1957, Ch. 15).

[5] This is not to say that the set of criteria that specifies goal achievement may not change from one situation to another or that there is not some sense in which "satisfying hunger" is a more fundamental goal than "dining in one's dinner jacket." We are considering here only short-run considerations: the set of criteria that is applied by the goal-achievement program to determine when processing should terminate. For further discussion of multifaceted goals, see Simon (1964).

ated with the goal will be responsive to the whole set of criteria.

Therefore, a hierarchically organized serial system need not single-mindedly pursue a simple goal. The chess-playing simulations constructed by Newell et al. (1963, p. 402) and by Simon and Simon (1962), though serial programs, take into account such goals as protection of pieces, development of pieces, control of the center, and restriction of the opponent's mobility in selecting a move. They limit themselves, of course, to considering only legal moves, and there is no reason why they could not take into account additional criteria, even aesthetic ones.

In conclusion, our review of the basic principles of organization of existing information-processing theories reveals that, in spite of their serial hierarchic character, they permit behavior to respond to a multiplicity of motives at the same time, in agreement, at least qualitatively, with the observed facts of human behavior. Activity toward specific goals is terminated by aspiration, satisficing, impatience, and discouragement mechanisms; distinct tasks may be queued or handled within individual time allocations; choices among alternatives may respond to multiple criteria. If the behavior of existing models frequently appears "single-minded," as compared with human behavior, this is due in considerable part to the fact that the substantive content of the choice criteria has been excessively simplified or abstracted, and not to the absence from the models of fundamental mechanisms that permit multifaceted activity in the human being.

INTERRUPTION AND EMOTION

A serial processor can respond to multiple needs and goals without requiring any special mechanisms to represent affect or emotion. We can use the term *motivation,* in systems like those described, simply to designate that which controls attention at any given time.[6] The motivation may be directed toward a single goal, or, more commonly, toward multiple goals.

But this is not the whole story. The mechanisms we have considered are inadequate to deal with the fact that, if the organism is to survive, certain goals must be achieved by certain specified times. The environment places important, and sometimes severe, real-time demands upon the system. In a queuing system, for example, if a new goal is evoked, it is placed on a waiting list until current goal programs have been terminated. In a mild, benign environment, a leisurely response of this kind is adequate. In the real world, it sometimes is not.

If real-time needs are to be met, then provision must be made for an *interrupt system.* Such a system sets two requirements:

1. A certain amount of processing must go on continuously, or almost continuously, to enable the system to *notice* when conditions have arisen that require ongoing programs to be interrupted. The noticing processes will be substantially in parallel with the ongoing goal-attaining program of the total system, although this parallelism may be realized, in fact, by the high-frequency time sharing of a single serial processor.

2. The noticing program must be capable of *interrupting* and setting aside ongoing programs when real-time needs of high priority are encountered. The programs thus set aside may simply be abandoned, or they may be resumed after the real-time need has been met.

Simple noticing and interruption programs of this general kind are al-

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[6] This point of view toward motivation is developed at length in Taylor (1960).

ready incorporated in some information-processing theories. EPAM, a theory of rote learning, for example, notices the turning of the memory drum and is capable of interrupting its learning processes to attend to the new syllable that has appeared on the drum (Feigenbaum, 1963).

A somewhat different kind of interrupt system fits the hunger-thirst example mentioned earlier. For each drive, the *drive level* is an increasing function of the number of hours of deprivation. The need having the smaller storage capacity will generally have the higher time gradient. Further, a *threshold* for each drive determines at what drive level the goal becomes "urgent" and interrupts the ongoing program.[7]

Real-Time Needs

What are the principal kinds of real-time needs that the interruption system serves in human beings. We can distinguish three classes:

1. Needs arising from uncertain environmental events—"loud" stimuli, auditory, visual, or other, that warn of danger.
2. Physiological needs—internal stimuli, usually warning of the impending exhaustion of a physiological inventory.
3. Cognitive associations—loud stimuli evoked not by sensory events, but by associations in memory, for example, anxiety arousal.

The capacity of stimuli from these sources to interrupt attention is a commonplace of daily experience. With respect to the first class of stimuli, it is especially clear that they will be more likely noticed to the extent that they are both intense and unexpected.

Sudden intense stimuli have easily observable effects on behavior. They also have well-substantiated effects on the CNS. These are described at length, for example, by Lindsley (1951). These effects produce substantial disruption of the electroencephalogram pattern (pp. 496–500). A plausible, and not novel, interpretation of these CNS effects is that they amount to an interruption of the interpreter that manages the goal hierarchy; that is, they supplant the present goals with a new hierarchy. This interpretation has become increasingly popular as more has been learned of the role of the lower brain centers in motivation.

Second, sudden intense stimuli often produce large effects on the autonomic nervous system, commonly of an "arousal" and "energy marshaling" nature. It is to these effects that the label "emotion" is generally attached.[8] The weight of evidence today is that the effects result from, rather than cause, the changes in the CNS described in the previous paragraph. Thus, substantial destruction of the connections of CNS with the autonomic nervous system does not prevent normal displays of emotional behavior in animals (Lindsley, 1951, pp. 484–485).

Third, in human beings sudden intense stimuli are commonly associated with reports of the subjective feelings that typically accompany emotional behavior. We shall not be particularly concerned here with these reports, but shall assume, perhaps not implausibly, that the feelings reported are produced,

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[7] A system of this kind is described in Simon (1957, Ch. 15). More recently, Tomkins (1963) has described a system with some similar characteristics.

[8] "Emotion" like "learning" and other traditional categories, refers to a mixed bag of phenomena, which may involve diverse mechanisms. Thus, the present theory probably does not account for intense aesthetic emotion (e.g., which may occur while listening to music) where arousal of the autonomic system does not stem from interruption.

in turn, by internal stimuli resulting from the arousal of the autonomic system.

Emotional Behavior

We see that all the evidence points to a close connection between the operation of the interrupt system and much of what is usually called emotional behavior. Further, the interrupting stimulus has a whole range of effects, including (*a*) interruption of ongoing goals in the CNS and substitution of new goals, producing, inter alia, emotional behavior, (*b*) arousal of the autonomic nervous system, (*c*) production of feelings of emotion. We will be concerned with the first of these effects and will largely ignore the others.

The system comprises both performance and learning processes. In the performance system, emotion is aroused (the interrupt mechanism is activated) by sensory stimuli, memory images, and drives. What response program will replace the interrupted program will also depend on the nature of the interrupting stimulus. The response program may, and often will, activate the autonomic nervous system, producing a feeling of emotion.

As Hebb (1949, pp. 238–240, 250–258) and others have emphasized, the emotional stimulus is to be regarded as more often *interrupting* than *disrupting* behavior. The responses to interruption are largely adaptive, either because they are genetically determined or because the adaptation has been learned. Interruption is not limited to simple responses like "startle," but may evoke an elaborate goal-oriented chain of activity (e.g., the reactions of a trained soldier to the sound of approaching aircraft).

When the emotion-producing stimuli are persistent as well as intense, they sometimes become disruptive and produce nonadaptative behavior. This occurs if the stimuli continue to interrupt, repeatedly, the evoked response program and hence to prevent an organized behavioral response to the original interrupting stimulus.

Learning of Emotional Behavior

Several kinds of learning can occur in relation to an interrupt system:

1. The efficacy of particular stimuli in activating the interrupt system can change. New associations are acquired allowing stimuli not previously effective to interrupt ongoing behavior. Stimuli, on the other hand, that previously had the capacity to interrupt often lose their efficacy.
2. The organism can acquire new or modified response programs associated with the various interrupting stimuli.

In general, the tendency of a particular stimulus to evoke emotional behavior through interruption of ongoing behavior decreases with repetition. For example, an unskilled bicyclist who tries to carry on a conversation frequently interrupts his conversation to attend to the road. With greater skill, he time-shares between the conversation and the cycling without often interrupting the former. In effect the earlier single-purpose program, with frequent interruption, has been replaced with a program having the goal: "Carry on the conversation while keeping your balance." As learning proceeds, not only does the amount of interruption decrease, but evidences of emotional behavior become less and less frequent and intense as well.

Similarly, the response after interruption usually becomes more and more adaptive with repetition. In the early stages of practice, the interrupting response often overcorrects, causing a new interruption. As practice proceeds the response is more adequately controlled and usually does not cause a new interruption.

In two ways, then, we may expect learning to reduce the emotionality of response as a situation becomes more familiar: (*a*) The need for interruption is reduced by incorporation of more elaborate side conditions in the programs associated with ongoing goals; (*b*) the response to interruption becomes more successfully adaptive, thus forestalling new interruptions. Hence, emotionality is associated with meeting real-time needs, particularly those that arise unexpectedly and in unfamiliar circumstances.

Of course learning is not always successful. If interruption occurs and real-time needs are not met, the painful consequences may lead to more precipitous, less adaptive responses when the situation recurs. Indeed, the classical paradigms for producing neurosis experimentally place excessive real-time demands on the organism.

EMOTION AND SOCIAL INTERACTION

In human behavior, situations involving interaction with other human beings are characteristically more heavily laden with emotion than are other situations. A theory of emotional behavior, to be satisfactory, must explain this connection of emotion with social interaction.

In general, real-time needs to respond to the environment arise when the environment can change rapidly and unpredictably. What are the most active and unpredictable parts of the human environment?

Suddenly appearing, rapidly moving objects, for example, flying sticks and stones, are one important class of events calling for interruption. Changes of environment through one's own relative motion, slipping or falling, are another.

But the most active part of the environment of man, and the part most consequential to him, consists of living organisms, particularly other men. Hence, a large part of the complexity of goals arises from the need, while accomplishing tasks, to attend to the responses of other human beings and to do this in real time. Thus, the behavior of problem-solving groups is commonly observed as taking place at two "levels": "task-oriented" behavior and behavior directed toward the group's social-emotional needs.

The degree to which a person exhibits emotional behavior in social interaction will vary with the progress of the two kinds of learning that may modify the interrupt system. A human being, in the course of development and socialization, acquires an increasingly sophisticated set of cues to indicate which responses of another person call for interruption of his own ongoing program. As the set of interrupting social stimuli grows, ceteris paribus, the emotionality of social situations should increase. On the other hand, the maturing individual also learns programs for anticipating (hence forestalling) interrupting stimuli and for responding to them adaptively when they occur. As the behavior of other actors becomes more predictable, the ego's behavior can more readily be planned, and the emotionality of the situation decreases. Thus, the experienced salesman finds his interaction with the customer less stressful as his ability to predict responses to his own behavior improves.

Since the one type of learning tends to increase the emotionality of social situations and the other tends to decrease it, and since both types of learning can be expected to go on simultaneously, the theory leads to no definite prediction of whether, netting these two effects, emotionality of social interaction will tend to grow or decline for the individual. Common observation suggests that it typically grows throughout adolescence, then gradually declines throughout adult life.

MOTIVATION AND LEARNING

Learning theories differ widely in the role they assign to motivation in the learning process. These differences were central to the controversy, in the 1930's and 1940's, about latent learning. The issue in its simplest form is whether the organism learns anything about aspects of its environment that are not directly relevant to its currently evoked goal system. For labeling purposes only, let us call the affirmative and negative views on this question Tolmanian and Hullian, respectively.

The theory proposed here gives a qualified Tolmanian answer to the question and predicts some circumstances under which latent learning will occur. When we try to make order out of the chaos of latent learning experiments, as Kimble, Hilgard, and Marquis have done (Kimble, 1961, pp. 226–234), we discover that they are reasonably consistent with the two following generalizations:

1. Learning only occurs when there is knowledge of results, but may proceed in the absence of any obvious reward or punishment. Punishment is often as effective in giving knowledge of results as is reward.
2. Learning without obvious punishment or reward occurs principally under conditions of *low* irrelevant drive.

The simplest explanation of these facts is that motivation is effective primarily in determining *what* goal hierarchy will be activated at any given time; hence it is effective in determining what aspects of the environment will be relevant to the organism for performance of learning. Stated otherwise, motivation controls attention and hence influences learning only through its influence on program control. *Given* the focus of attention and the established goal hierarchy, learning still requires knowledge of results, but does not call for reward or punishment mechanisms. Reward and punishment, and motivation generally, install and replace goal systems.

This explanation leads to three predictions of circumstances under which "latent" learning will occur. First, if while achieving a particular evoked goal the organism encounters an interrupting stimulus, it may learn things that are irrelevant to the original goal, but relevant to the response program activated by the interruption. Thus, a hungry rat can learn where it will receive an electric shock in the maze. But by increasing the intensity of the original drive, we should be able to reduce sensitivity to interruption and hence reduce the amount of learning producible by potentially interrupting stimuli. The fact that the interrupting stimulus does or does not have punishment associated with it is irrelevant.

Second, as goals are elaborated by the incorporation of side constraints, the organism will learn about aspects of the environment that are relevant to meeting the side constraints, as well as aspects relevant to the original goal. Thus, as a novice chess player begins to learn that he must protect his own men while attacking his opponent's, he learns to attend to his opponent's as well as to his own threats.

Third, really a generalization of the first two points, the organism may learn about any aspect of the environment that "happens" to attract its attention. Aspects of the environment with which negligible, or no, rewards and punishments are associated will generally attract attention only when other, more pressing needs are absent. Hence, consistent with the evidence, latent learning should occur principally under conditions of low irrelevant drive.

CONCLUSION

This paper has proposed a theory of the relation of motivation and emotional behavior to man's information-processing behavior. The theory explains how a basically serial information processor endowed with multiple needs behaves adaptively and survives in an environment that presents unpredictable threats and opportunities. The explanation is built on two central mechanisms:

1. A goal-terminating mechanism permits the processor to satisfice, dealing generally with one goal (albeit perhaps a complex one) at a time, and terminating action when a satisfactory situation has been achieved.
2. An interruption mechanism, that is, emotion, allows the processor to respond to urgent needs in real time.

Rudimentary mechanisms of these kinds have already been incorporated in some of the current information-processing theories of human cognition. Elaboration of the mechanisms and assignment to them of a larger and more crucial role in the simulated behavior will permit these theories to be extended to the explanation of wider ranges of human behavior. Thus, information-processing theories must be endowed, as can readily be done, with the properties that Neisser lists as characterizing human thinking: intimate association of cognitive processes with emotions and feelings, and determination of behavior by the operation of a multiplicity of motivations operating simultaneously.

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