

A REVIEW OF INCENTIVE (1972)

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“Incentive is a hypothetical concept referring to what might popularly be described as the subject’s expectation of reward” (Logan, 1960, p. 3).

An incentive theory is one which emphasizes that organisms can in some sense anticipate reinforcement and that such an anticipation serves in, some way to facilitate instrumental behavior.

While a variety of incentive theories of reinforcement have been proposed, they have in common the assumption that rewards, in one way or another, add to the *S*’s level of motivation or arousal. Hull (1952) for example was led to modify his views in the direction of incentive interpretation of reward as a result, at least in part, of experiments which involved shifts in the magnitude of reward. “Hull’s final position with respect to reward might be described as being both associative and motivational (i.e., incentive in character)” (Black, 1969, p. 197).

Many theorists and researchers are not using a drive model in motivational theory. They are placing their emphasis on the characteristics of the reward process itself, regardless of the drive condition of the organism.

The definitions of rewards by the drive model are just as explicit as those of drives. A reward is described as any stimulus event that increases the probability that associated responses will occur. This definition does not require any statement regarding why certain stimuli (such as food) have this property. It is a totally empirical definition. Rewards can be primary in that they will result in changes in probability without prior experience with the reward or secondary, meaning that they must be paired with primary rewards (such as a bell with food) before they will increase the probability of associated responses.

Initially, three different approaches, two rather new and one based on nearly forty years of work will be reviewed. All three of these positions are different from the basic building blocks of drives, though the first position is an outgrowth of the drive model, in the sense that drives and incentives are seen as working together.

The first approach studied is closely allied with the drive model conception, particularly as elaborated by Spence. Spence has added to the basic Hullian theory the importance of incentives as an independent variable in the prediction of behavior. The particular formulation he has chosen

contains drive as a multiplicative factor, thus requiring drive to be greater than zero before a response will occur, regardless of the strength of incentive.

A study by Kraeling (1961) represents the results of one of the most careful separations of the particular parameters of incentives — nutritive value, consummatory response and affective value. While Spence would expect that the incentive value would be primarily due to the strength of the consummatory response, Kraeling finds instead that the affective value, varied by the concentration of the taste solutions, is the primary determinant of incentive value. Davis and Keehn's (1959) data are also consistent with Kraeling's findings and they suggest other relationships between consummatory response and incentive value. Trapold (1962) explores another line of derivation from Spence's work, in which he examines the effects of an incentive, learned in one context upon unlearned responses tested in another context.

In an independent line of work, Kessen (1963) has examined the reward value of sucking in the human newborn. The classical explanation is that sucking has acquired incentive value because of its association with food — a primary reward. Kessen's results seem to imply the opposite, that sucking may be an innate reinforcer, whose power to quiet an infant is independent of prior association with food and hunger reduction. Perhaps food is a secondary reward based on its pairing with sucking?

Quite a different theory centered around the work of McClelland (1951) provides the basis for discussion on a second approach to incentive motivation. McClelland does not focus on drive states at all, he is most concerned with the association of certain rewards, defined in terms of the affective states they produce with specific patterns of behavior in childhood. One of the most difficult problems of any theory of motivation to handle is to explain the strength of learned motivational processes. Drive-based theories have tended to base them entirely on fear — the only major secondary drive. The first paper by McClelland (1951) is designed to show that great strength of early learning is really to be expected, particularly the learning of motives. Thus, this is not a problem at all, given his analysis.

Feather (1963) has attempted to avoid some of the problems attendant on the identification of affect states. He presents alternatives to Mowrer's (1960) concepts of fear, hope, relief and disappointment. The four concepts he presents are not defined as increments or decrements in fear responses (as in Mowrer) but are developed within the framework of a motive-expectancy value model. Fear motivation is defined as motivation to avoid a negative incentive or punishment, hope motivation as motivation to approach a positive incentive or reward, motivational relief as reduction in fear motivation following nonconfirmation or partial confirmation of an

expectation of punishment and motivational disappointment as reduction in hope motivation following nonconfirmation or partial confirmation of an expectation of reward. This alternative conceptualization makes a clear distinction between cognitive expectancies and hope and fear motivation in that an expectation is assumed to be a necessary but not a sufficient condition of motivation.

Feather's paper is valuable for its explicit statements and comparisons of two major motivational positions.

A third viewpoint reviewed regarding the nature of incentive and rewards was developed by Festinger (1961). The dissonance theory by Festinger argues that adherence to the secondary reward model of Hull, for example, overlooks the problems that occur when rewards are felt to be insufficient. It is suggested that when an individual finds oneself in such a situation one often has to psychologically re-evaluate the reward upwards, so that one now sees its value as commensurate with the effort one is investing in order to attain it. Thus, one of the determinants of rewards is quite independent of an individual's previous history of rewards — in fact a paucity of prior reward may increase the incentive value of a stimulus. Two other experimenters, Carlsmith and Aronson (1963), in related studies show that correctly anticipating a bad outcome is preferred to having an unexpected good outcome occur, that is, the agreement with expectancy is more important than incentive value of the outcome per se.

Miller (1963), has more recently suggested an interpretation of reinforcement which is essentially incentive-motivational in character, although he relates it more explicitly than prior theorists to hypothesized events in CNS. Specifically, Miller assumes "that there are one or more 'go' or activating mechanisms in the brain which act to intensify ongoing responses to cues and traces of immediately preceding activities, producing a stronger intensification the more strongly the 'go mechanism' is activated" (p. 95). He further assumes that this "go mechanism" can be activated in a variety of different ways, including "the taste of food to a hungry animal, possibly by feedback from still central effects of eating" (p. 96). He also states that the "go mechanism" will depend largely upon the strength of the UCR (presumably consummatory activity). Finally, he assumes that the "go mechanism" will be weakened or extinguished if it is repeatedly elicited without reinforcement from the UCS (e.g., food) with the exception of its emphasis on a central as opposed to a peripheral locus, Miller's "go mechanism" has most of the properties of the conditionable components of consummatory behavior r_g as discussed by Spence, Sheffield or Seward.

More recently, S-R theorists have tended to define a reinforcer or reward empirically or to focus attention upon the consummatory reaction as

the critical factor in developing a theory of behavior. This position has been taken by those theorists who are more concerned with elaborating and refining Hull's second principle, the principle of motivation of performance. In the work of Spence and Sheffield the increasing importance of anticipatory goal reactions as a source of general excitement is seen, which, together with habit, motivates performance. This interest in incentive motivation (K), the anticipation of reward, as a determinant of appetitional or approach behavior parallels the earlier innovation by Mowrer and Miller in treating fear, the anticipatory reaction to a noxious stimulus, as a potent determinant of behavior. "Thus the anticipation of both reward and punishment, which Lewin had captured in the concepts of positive and negative valence, are now embraced in the S-R conceptual scheme and the convergence of fundamental ideas about motivation becomes increasingly apparent" (Atkinson, 1964, p. 267).

One implicit aspect of incentive motivation in most interpretations is that it is supposed to depend upon the animal's relatively recent history of reinforcement conditions. Therefore, it might be possible to supply incentive motivation concepts to any case where variation in performance is not attributable to the animal's drive conditions or to permanent modifications of its habit structure. Collier and Marx (1959) have shown rather convincingly that performance can be a function of a rat's specific history of reinforcement independently of the number of reinforcements or the current drive conditions.

All of the studies that have made use of runways have invariably reported some effect of reinforcement magnitude on performance. By contrast, studies using maze situations usually find little or no effect of reinforcement magnitude (Heyer, 1951; Furchgott and Rubin, 1953; Maher and Wickens, 1954; McKelvey, 1956), although there are exceptions.

Negative results have been found repeatedly with rats in brightness discrimination problems; they do not learn the discrimination any faster with large amounts of reinforcement than they do with small amounts of reinforcement (Reynolds, 1949, 1950; Hopkins, 1955; Schrier, 1956). Most of these writers have reported that rats run faster for a large incentive value but that they do not learn the discrimination any sooner. On the other hand, incentive effects have been demonstrated with primates in discrimination problems (Fletcher, 1940; Schrier, 1958). Superficially, this looks like a species difference but a better solution of the dilemma was suggested by Meyer (1951) and apparently confirmed by Lawson (1957; also Schrier, 1958). It seems that in primate studies, experiments are economical of animals and tend to use the same ones over and over again under different conditions, thereby permitting each subject eventually to find out about large and small amounts of reinforcement. In rat studies, however, different subjects are used under the different conditions, each under a fixed amount

of reinforcement. This difference in methodology, the difference between absolute vs. differential training or between shift and nonshift learning has been shown to be an important variable by both Lawson (1957) for rats and Schrier (1958) for monkeys. It seems safe to conclude that the training method is an important variable here; animals that are trained under differing amounts of reinforcement show much clearer incentive-magnitude effects in selective learning situations than do groups of animals that are trained under constant amounts of reinforcement.

The amount of reinforcement usually facilitates responses such as running in an alley but usually does not facilitate more complex selective-learning performance, although sometimes it may. Perhaps greater amounts of reinforcement lead to greater incentive motivation which makes the rat run faster in complex problems so that it does not have an opportunity to make the appropriate discriminations. Experiments in this area have largely focused upon the acquisition of discriminations; perhaps once a discrimination has become well established incentive magnitude would be found to affect the asymptotic level of performance.

Discrimination learning under different amounts of reinforcement should not be confused with the learning to discriminate different amounts of reinforcement. Festinger (1943), Denny and Kling (1955), Pereboom (1957), Reynolds and Anderson (1961) and Davenport (1963) have all demonstrated that rats in a simple two-choice situation can learn to go to that side which offers a greater amount of reinforcement as against a small amount of reinforcement on the alternate side. Denny and Kling, Pereboom and Davenport, ran reversal training with the large and small incentive sides reversed. Their rats were able to learn both the original discrimination and the reversal; but it is of some interest to note that the reversal required 10 trials or so in contrast with one or two trials necessary to obtain shifted performance in a noncompetitive situation such as Crespi (1942) used and that reversal learning gets worse with practice (Davenport 1963). It is not known regarding behavior in competitive situations or in selective-learning situations, why the shift should be so slow. Nor is enough known about the behavior occurring in bar-pressing situations to be able to explain the fact that the rate of bar pressing is correlated with the amount of reinforcement it provides on an FI schedule with small amounts (Hutt, 1954) but not with FR schedules and larger amounts (Keesey and Kling, 1961).

Changes in reward magnitude have been the subject of intensive empirical and theoretical interest. Crespi (1942) brought forth the original report of "elation" and "depression" effects.

There are two forms of procedures popular for studying reward magnitude effects which are forms of discrimination learning: successive differential and simultaneous differential. There is a third paradigm that is

nondifferential, in the sense that different environmental cues are not used to signal different amounts of reward.

The successive nondifferential procedure was historically the first procedure to be used, (i.e. Crespi, 1942). While Crespi reported both positive (elation) and negative (depression) contrast effects, his experiment has been criticized on methodological grounds (Spence, 1956) and subsequent experimentation has rarely been able to demonstrate positive contrast while negative contrast seems to occur with a fair degree of regularity (Dunham, 1968).

The suggestion offered for this lack of positive contrast effect was that the control group, from which it was determined if a positive contrast effect occurred, might be running so fast that the shifted group was unable to exceed the speed of the control. This is referred to as the ceiling effect.

The results of Mellgren (1971) found in his experiment were consistent with the argument that positive contrast has only rarely been observed in the successive nondifferential procedure because of the ceiling effect problem. The use of delayed reinforcement in the straight runway solves this problem and positive contrast did emerge in three separate comparisons.

A crucial difference between this experiment and other experiments which deal with extinction or decreases in reward magnitude to a non-zero level, as a function of trials was the use of a control in the former but not the latter experiments. This experiment was dissimilar in design to the extended training extinction experiment in that the shifted groups were not compared to one another as in the extinction experiments. The shifted groups were compared to a control group at a similar stage of training. If the shifted groups in this experiment were compared with one another, then there would be a positive relationship between number of preshift trials and the absolute speeds on postshift trials.

Previous research has indicated that contrast effects may be transitory or relatively durable (Collier and Marx, 1959). The data, however, presented in this experiment indicate contrast effect is not a temporary phenomenon.

Recent work on the behavioral influence of quality of reinforcement stems largely from the attempt to isolate the several dimensions of the consummatory response that are confounded in most studies of the amount of reinforcement.

In much of the preceding research on the effects of parameters of reinforcement upon consummatory activity, the primary interest was that of relating the strength of an instrumental response to the various parameters of

consummatory activity, the most important of which seemed to be the length of time in the goal box, the proportion of that time spent in consummatory and nonconsummatory behavior and the actual amount of reward which the subject consumed. Unfortunately, in those experiments, it was not possible to place more than one of these variables simultaneously under the direct control of the experimenter. For example, one could vary the amount of reward which *S* consumed by making a specific amount of reward available in the goal box and leaving *S* there until it consumes all of it. This procedure leaves it up to the subject to determine how long it will remain in the goal box and what percentage of that time it spends in consummatory vs. other activities. The most common alternative to this reinforcement procedure is to allow *S* to remain in the goal box for some fixed period of time and to make available an essentially limitless quantity of food. Neither procedure, however, gives the experimenter much direct control over the animal's behavior during the reward period. These procedures obviously leave much to be desired in the degree to which the experimenter can precisely control the behavior of the animal. Black (1969) has attempted to design an apparatus and experimental procedure to allow the control of the rate and frequency with which reward becomes available to *S*, while at the same time monitoring the animal's consummatory and nonconsummatory behavior.

The apparent reinforcement value of a reward appears to depend not only on its magnitude or the amount of consummatory behavior it evokes but upon the consistency with which such behavior occurs. Thus, measures of the strength of the instrumental response such as running speed, etc., are not always accurate or appropriate indices of the "incentive value" or the extent to which one reward is "preferred" over another. Nominally large rewards, if they tend to "encourage" the *S* to engage in other forms of responding, may produce considerable incentive motivation and still have relatively low apparent reinforcement value. Similarly, small rewards which result in vigorous and consistent consummatory activity may have greater apparent reinforcement value than larger rewards, even though *S* "prefers" (i.e., will learn to choose) the latter. Black (1969) suggests a "two-factor" interpretation of reinforcement in instrumental appetitive conditioning.

Increasing reward magnitude or the amount of consummatory activity facilitates performance. Decreasing the consistency of consummatory activity or conversely, increasing the amount of nonconsummatory activity, depresses performance and the apparent reinforcement value of the reward. This depression may result either from the development of responses which interfere with the instrumental response or by virtue of the fact that, an inconsistently consumed reward will provide little "protection" for the association between the test situation and the instrumental response. In either case, this depression in performance is sometimes sufficient to actually produce a reversal in the usual "magnitude-of-reward" effect. In such circumstances, however, the greater "incentive-value" associated with

the larger reward can sometimes be demonstrated by allowing *S* a wide choice between large and small rewards by shifting the magnitude of reward.

The sources of reward appear to be multiple. While the efforts to reduce the number of sufficient characteristics of rewarding stimuli to a single necessary one have been intense, such attempts have typically failed to prove convincing. Even theorists who have associated themselves with one of the molar positions regarding reward (e.g., drive reduction, consummatory response or stimulus theories) have been forced to acknowledge their inability to identify in an *a priori* way those specific stimuli which will prove rewarding.

Research, however, to attempt to isolate the dimensions of the consummatory response continue. It has been found that when sucrose concentration is shifted suddenly, performance shifts appropriately. Collier and Marx (1959), Pieper and Marx (1963) and Marx et al. (1963) have reported effects that appear similar to elation and depression effects when sucrose concentrations are shifted upward or downward. These contrast effects are quite large in magnitude, highly reliable and quite durable. They seem, therefore, to be something different from the elation and depression effects reported by Crespi. In all of these studies, as well as in those which obtain incentive-shift effects without the contrast effects, the effects develop slowly, over the course of 10 trials or so. This slowness also suggests that they are governed by different mechanisms than those that come into play when the amount of solid food is varied experimentally. Under some circumstances, sucrose-concentration shift effects fail to appear (Spear, 1965). Ison (1964) did an incentive reversal study in a T-maze; he found significant effects on postshift performance of preshift incentive, postshift incentive and the interaction. Evidently, variation in sucrose concentration has behavioral effects quite different than those produced by variation in food deprivation conditions.

Different concentrations define a new dimension of quality, although they are often described as “amounts” of reinforcement. The mistake probably stems from the idea that since the animals are hungry and need calories they receive a bigger reward with a higher concentration. But many of the same incentive effects have been demonstrated in satiated animals. The variable that does seem to be crucial with sucrose is sweetness. Guttman (1954) has determined equal reinforcing values for sucrose and glucose and found that it is not concentration (and hence calories) that produces equivalent reinforcement values but judged sweetness. Guttman determined the reinforcement threshold for concentration and found that it lies very close to the sensory detection threshold. Further evidence, both behavioral and physiological, has been summarized by Pfaffmann (1960). The conclusion seems inescapable that the reinforcing effect of sugars is the sensory stimulation they provide or in other words, their sweetness.

The data from the study of quality of reinforcement indicate the need for a small amount of interpretive caution: in almost every respect in which quality has been compared with quantity or delay, there has been found different functional properties of these dimensions of reinforcement. More specifically, it seems almost certain that the laws of incentive motivation, which have been worked out primarily from studies of amount of reinforcement for hungry rats, will turn out not to be applicable to the other dimensions or to non-hungry animals.

Hull (1952) proposed that K (motivation) and D (drive) multiply to determine the organism's total motivation. Spence (1956), however, proposed that D and K should add together and jointly multiply habit strength to determine behavior. Results of studies (Reynolds, Marx and Henderson, 1952; Stabler, 1962; Ehrendfreund and Badia, 1962; Pavlik and Reynolds, 1963) indicate multiplicative, additive or combinations of the two. In these studies their conclusion is based upon the *a priori* assumption about how effective reaction potential (sEr) is to be measured.

Normally it is assumed that sEr is linearly related to response speed and to response probability and the usual conclusion is that D and K add. The point is that any quantitative analysis of performance curves presupposes a quantitative scaling of performance.

Implicit in theoretical interpretations of incentive motivation is that it is mediated by a hypothetical construct called the anticipatory goal reaction (rG). Spence's contention that incentive motivation results from the elicitation of rG by environmental stimuli to those which Rg becomes conditioned in the goal box can be easily tested indirectly by experimentally manipulating the similarity of alley and goal box cues in a runway and determining what effect this similarity has on the animal's motivation.

Nissen (1950) has pointed out that in the traditional discrimination learning situation the organism's behavior is often defined in terms of the stimuli to be discriminated. He suggests as an alternative that in these situations the organism has at its disposal only 2 responses, approach and avoidance and that what is involved in a typical discrimination problem is the competition between approach and avoidance responses as they are associated with the correct stimulus on one hand and the incorrect stimulus on the other. The majority of studies done with the rat have been in locomotion situations. Usually studies involve examination of drive discrimination, the effect of secondary reinforcers and of incentive variables in situations where the rat is required to run to one stimulus and not to run to the other. Perhaps it is not just coincidence that it is in these situations that incentive motivation interpretations have gained the greatest currency and apparent applicability. It is possible that the basic incentive motivation mechanisms involve incipient approach and avoidance tendencies rather

than salivation and the like. Schneirla (1959) has suggested the dominant role such tendencies must have in biological adaption. Should such an interpretation be valid, this might also permit the application of incentive theory to aversive learning. There has been a serious neglect of the study of negative incentives. Amsel (1962) has given r_g and r_f (fear and anger) the property of being aversive but more frequently they are assumed merely to have an energizing role; they usually are assumed to contribute to drive or to be acquired drives. In either case fear serves as a generalized energizer rather than as an anticipatory escape tendency or as a specific tendency to withdraw. Skinnerian psychologists often refer to acquired aversiveness and are quite willing to attribute such a property to the stimulus feedback from covert and anticipatory responses; however, they consider aversiveness to be a condition of reinforcement rather than a variety of motivation. The animal is not motivated to turn away from aversive stimuli, it is merely reinforced for doing so.

When reinforcement conditions are considered from a purely empirical viewpoint some extremely well established principles, e.g., rats run faster for larger amounts of food.

There are three fundamental problems involved in some of the more promising approaches toward a theory of incentive motivation that distinguishes the different positions in their treatment of these problems.

- a) The motivation problem: how does the incentive motivating mechanism work? Does it reinforce instrumental behavior, motivate it or simply provide stimulus control for it?
- b) The learning problem: how is the incentive mechanism acquired?
- c) The asymmetry problem: how is one to account for the evident asymmetry between the appetative and aversive cases?

There is a rapidly growing mass of data showing how performance depends upon the conditions of reinforcement. An animal will not respond as vigorously or as surely when reinforcement is delayed or withheld or presented only in small amounts, as when a lot of reinforcement is promptly given. The effects appear to be flexible in the sense that they can change rapidly when the conditions of reinforcement are changed; they seem to depend primarily upon the animals' recent history of reinforcement rather than the whole history or just current conditions.

The flexible nature of these incentive effects, the fact that they obviously involve learning and the fact that they depend upon external stimulus conditions suggest that they are due to the operation of some response system. The leading candidate is r_g , a hypothetical covert factorial

of R_g , the response the animal makes to the reinforcer. Usually r_g is assumed to be much like any other response but there is now enough evidence to suggest that it may be a very unusual sort of response: a) While other responses become associated with drive stimuli only with great difficulty, it is necessary to assume r_g is readily associated in order to account for the rapid changes in behavior that follow a change in the conditions of reinforcement or deprivation (e.g., the latent learning situation; Kendler, 1946; Seward, 1957); b) r_g comes associated with external stimuli by different principles than those that apply to instrumental responses (see evidence cited by Mowrer, 1956; Seward, 1956; Spence, 1956); c) r_g and its stimulus consequences or the stimuli arising from its frustration, are sometimes held to have an energizing function, in addition to whatever part they may play in the associative control of instrumental behavior. Sometimes this energization is assumed to be general or nonspecific but more often it is assumed to have either an appetitive or aversive nature, so as to provide an additional element of control over behavior. Thus, Spence affords K , the incentive motivation which he assumes is based upon r_g , the role of a generalized energizer, like D . But others like Seward, have proposed that r_g has special motivating properties, e.g., that the organism approaches stimuli that elicit it. Mowrer (1960) has argued that incentive motivation is essentially emotional and what r_g is called is very much like what is called hope and that it can have quite diversified effects upon behavior.

Whatever the status of r_g , incentive theories of motivation offer a clear alternative to drive theories. The antecedent conditions are different: drives are anchored in the prior conditions of deprivation whereas incentives are anchored in the conditions prevailing at the time of reinforcement and in the organism's history of reinforcement. The behavioral consequences are similar: both drives and incentives are assumed to provide some combination of energization and associative control of behavior. Thus, incentives can explain anything drives can explain and they can explain a vast number of transient and short-term effects that drives cannot explain.

Rewards or reinforcement, play an important role in determining behavior and there are many ways that rewards can be given. Systematically investigating a variety of conditions of reinforcement, ranging from simple ones to more complex ones, allows one to formulate principles from which to predict effects of new conditions. It is, however, important to make a distinction between incentive and reward. One of the most comprehensive studies of the effects of reward on behavior are expressed by Logan (1960).

Unlike conditions of reinforcement, which can be stated in advance and held constant, incentive is learned and may be changed as the organism becomes familiar with the conditions of reinforcement. In addition "equal differences in reward do not produce equal differences in incentive (Logan,

p. 4).” Finally and perhaps most importantly, according to Logan, “the subjects’ incentive may imperfectly represent the actual conditions of reinforcement. Incentive can be acquired only on the basis of experience with reward in the situations and the subjects’ behavior cannot be affected by the consequences of untried responses; the experimenter’s intentions to reward may not all be reflected in incentive” (Logan, p. 4). Incentive, then, according to Logan “is an intervening variable determined by previous experiences of reward and determining current performance” (Logan, p. 4).

Logan’s position on incentive motivation is very much like Hull’s, with the main difference being that he has rejected speed of responding as a measure of sE_R , preferring to attribute responses of different speeds to different habits. He has also changed Hull’s treatment of the factors involved in inhibition. He has kept, however, the same variables in motivation. The occurrence of r_g is still held to be the mechanism underlying both secondary reinforcement and incentive motivation.

Logan has described an integrated series of three dozen carefully executed studies of the effects of the parameters of reinforcement all within a single experimental context. For example, it is possible to compare the effects of delay of reinforcement.

It was found that rats ran faster to variable short and long delays than to a constant mean delay. By contrast, varied amounts of reinforcement lead to performance which is about the same as obtained with a constant mean amount and far below performance of animals to run to the larger amount. This is explained on the basis of the assumption that different amounts of reinforcement produce r_g ’s that are not only quantitatively but qualitatively different. Under the varied magnitude condition, the different r_g ’s compete; and the resultant incentive motivation is determined by a compromise r_g . On the other hand, under conditions of varied delayed reinforcement there is no competition since the same r_g can be conditioned to different stimuli or different stimulus traces. The resulting incentive motivation therefore should be at least equal to that produced by conditions of no delay and this advantage should be especially marked in extinction.

It has been suggested that perhaps the quantitative relations involved depend not only upon the relative amounts of reinforcement that are used but upon the absolute amounts as well.

Another feature of Logan’s theory is that incentive motivation ought to have a greater effect as the animal approaches, the goal, where, presumably, stimuli eliciting r_g are more similar to those to which it has been conditioned. Results seem to indicate that this is true for the amount variable but that the delay of reinforcement has effects which are more or less uniform throughout the course of the alley.

When rats run to food in an alley they ordinarily accelerate from one trial to the next — usually this is referred to as learning. If an incentive factor, however, is contained within the theory, improved performance does not necessarily mean an increase in habit strength. When they run faster, reinforcement occurs with less delay. Thus, reinforcement cannot only produce an increment in the strength of the running habit, it can also increase the incentive motivation which alone would make the rat run faster on the next trial. Logan would say that this experimental situation is one in which there is an arbitrary, if more or less natural, positive correlation between speed of running and immediacy of reinforcement. Logan and his students (Bower, 1961) have been able to instrument runway situations in which this positive correlation is abolished or even converted into a negative correlation. This is done by giving the animal increasing amounts of food for correspondingly slower running times. It is found that by 100 trials or so, the rat will reach a stable speed of running which presumably balances the various incentive, habit and inhibition factors determining the behavior. The model describing this balance is complex but it is the best thing contained in the incentive theory aimed at providing a genuinely quantitative account of both response probability and the difficult problem of response vigor.

Judged by productivity relative to other fields, lawfulness of the phenomena achieved under favorable conditions and increasing subtlety of analysis (both experimental and theoretical), the study of quantitative variation of motivational processes is thriving. Complacency is, of course not in order; it is clear that we are only beginning to identify and understand the problems. There are, however, persistent sources of dissatisfaction which need to be pointed out for new revision.

- a) Invention of new experimental conditions, apparatus, deprivation schedules, response measures, etc., where neither theory nor empirical problem demands them, could well be spared in favor of greater standardization.
- b) Parametric experiments should supplant studies designed to determine whether a variable does or does not have an effect.
- c) It is known that central tendencies of groups are sometimes very misleading with respect to the behavior of individuals. This knowledge should be used more often.
- d) The development of mathematical psychology has shown how strong (and consequently, how restrictive) the most innocent-looking theoretical assumption can be, yet assumptions of great strength continue to set forward without much apparent concern for their

implications. Proper distinctions between empirical and definitional questions are fundamental, however, difficult they may be.

Notes

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