

GOAL ATTRACTION AND DIRECTING IDEAS CONCEIVED AS HABIT PHENOMENA

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I

When an animal long without food is first placed in a maze or other problem situation it will usually, after a momentary pause, move about vigorously but more or less at random. These seeking movements are understood without great difficulty as the result of the combination of (*A*) the changing sensory stimulation emanating from the environment as the animal moves from place to place; (*B*) the changing proprioceptive stimulation resulting from the immediately preceding movements of the animal itself; and (*C*) a sensibly *non-changing* dynamic internal core of stimulation emanating from the continually recurring hunger cramps of the digestive tract. The changing stimulus components account to a considerable extent for the variability characteristic of the trial-and-error seeking behavior, the particular acts taking place at each instant being determined by the nature of the habituation tendencies set up in the previous history of the organism. The unchanging stimulus component, on the other hand, gives the various action segments of the behavior flux its characteristic unity by tending largely to limit the behavior to acts which in the past have been associated with the securing of food and which are therefore more likely than pure chance to result in securing it again. And when, at length, the food is found and eaten and the digestive crampings have ceased, the food-seeking behavior naturally comes to an end because its stimulus motivation has ended. Such, in brief, is the account of trial-and-error behavior conceived as motivated primarily by physiological drive.

But this is by no means the whole story. While probably

accurate enough so far as it goes, the above account presents but the first part of the learning process. Experimenters report that once the animal has found food at the end of the maze a few times, his behavior undergoes a striking qualitative change. The new behavior is often characterized as appearing to be more 'purposeful' than at the beginning; he acts, as Gengerelli remarks, as if he were 'going somewhere.' Beneath this rather vague characterization there may be discerned certain fairly concrete and definite behavior tendencies, the most notable of which involve anticipatory movements. When an animal is approaching his goal (the food box) he is apt progressively to speed up his pace. Another significant observation is that when an animal is approaching a familiar 90° turn in a maze, he quite generally begins his turning movements some time before he reaches the corner. Perhaps most significant of all is the phenomenon observed not only in all sorts of vertebrates but in young children and naive adults as well, that as a food goal is neared the organism tends to make mouth movements of a masticatory nature. It is probably not without significance that such movements are particularly prominent in cases where the sequence of acts leading to the goal is, for some reason, interrupted.

To casual observation such acts as the premature or anticipatory movements just cited are likely to appear as interesting symptoms of an obscure psychic tendency but in themselves to be of no functional value whatever to the organism. If this were the case they would, of course, be positively detrimental, since they would involve a wasteful expenditure of energy. In direct contrast to this view, it is the purpose of the present paper to elaborate the hypothesis that anticipatory goal reactions, as distinct from organic drives, play an indispensable rôle in the evolution of certain of the more complex forms of mammalian adaptive behavior and that the understanding of this rôle will render explicable on a purely naturalistic and physical basis the profoundly significant influence of rewards, goals, and guiding ideas upon behavior sequences.

II

Let it be assumed that a relatively isolated inorganic world flux takes place in time. Characteristic phases of the world sequence, separated from each other by but a few seconds each, are represented by S_1, S_2, S_3 , etc., as they appear in Fig. 1. In the neighborhood of this world sequence is a

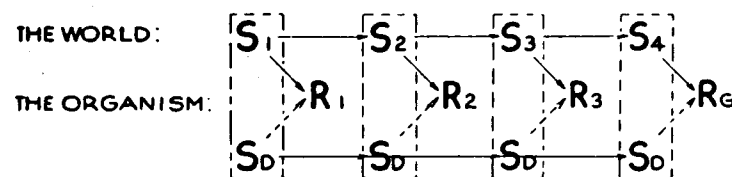


FIG. 1.

sensitive redintegrative organism provided with distance receptors and so constituted as to respond characteristically to the several phases of the world flux with a parallel behavior flux. Phases of the response flux corresponding to the world-stimulus flux are represented in Fig. 1 by R_1, R_2 , etc., the final or goal reaction being indicated by R_G . Let it be assumed, further, that within the organism there is a source, such as hunger, which produces the continually recurring stimulation represented in Fig. 1 by S_0 . Now, according to the principle of redintegration, all the components of a stimulus complex which may be impinging on the sensorium at or near the time that a response is evoked tend themselves independently to acquire the capacity to evoke substantially the same response. The stimulus complexes in Fig. 1 which fall under this principle are each enclosed within a dotted rectangle. It may be seen from an examination of the diagram that S_0 , owing to the fact that it persists throughout the entire behavior sequence, will acquire a tendency to the evocation of R_1, R_2, R_3 , and R_G , *i.e.*, to the evocation at any moment of every part of the reaction sequence. These newly acquired excitatory tendencies are indicated in the diagram by dotted arrows.

To amplify this part of the picture, there must be added the fact that each act, as R_1 , gives rise to a proprioceptive stimulus, s_1 . These proprioceptive stimuli are added to the

diagram in Fig. 2. Through the operation of redintegration, they likewise tend to acquire the capacity to evoke the reactions immediately following them. This second group of

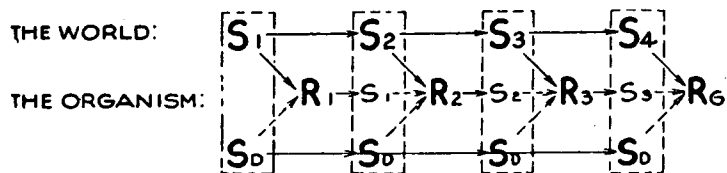


FIG. 2.

newly acquired excitatory tendencies is also represented by dotted arrows.

III

It has been shown elsewhere¹ that under certain conditions, notably when the behavior sequence is made up of symbolic or pure-stimulus acts, the multiple excitatory tendency of the persisting stimulus, S_D , may evoke the final or goal reaction of the series almost or quite at the outset of the movement, thus dropping out the useless and actually wasteful intervening acts formerly leading to the goal. But in cases where the intervening acts are mainly instrumental in nature, as is obviously the case with the locomotor activities involved in maze running, it is physically impossible to drop out any of the acts involved in traversing the *true* pathway and at the same time reach the goal.² With the maze remaining con-

¹ C. L. Hull, Knowledge and purpose as habit mechanisms, *PSYCHOL. REV.*, 1930, 37, 511-525.

It should be noted that the mechanism of short circuiting behavior sequences there described is not adequate, as it stands, to explain the dropping of blind-alley entrances in maze learning. Space is here lacking for the elaboration of the particular mechanism involved in that specialized form of behavior sequence. Contrary to what seems to have been assumed by some, maze learning, instead of being a relatively simple process, is in reality one of great complexity. See C. L. Hull, The goal gradient hypothesis and maze learning, *This journal*, (In press).

² Perhaps this difference in short circuiting of pure-stimulus acts as contrasted with instrumental acts is their most revealing distinction. Pure-stimulus acts are defined as acts whose sole function is to evoke other acts through the proprioceptive stimuli which they give rise to. They thus conform in a physical sense to the concept of symbolism though the entire process may be confined to a single organism in contrast to communicational symbolism which involves the acts of one organism serving as stimuli to another. The pure stimulus acts considered in the present paper are entirely of the first or individual type.

stant, the space between the starting point and the goal must, somehow, be gotten over if the food is to be obtained. Consequently, if the anticipatory invasion by the goal reaction of the instrumental behavior sequence normally leading to the goal should result in the interruption of the sequence, the actual goal will never be reached and the episode will be biologically abortive. Such an interruption will inevitably take place either when (A) the invading goal reaction is of such a nature that it cannot be performed by the organism at the same time as the antecedent instrumental acts leading up to it, or (B) when the execution of the goal reaction results in the removal of the source of the physiological drive stimulus (S_D).

In view of the ever-present potentiality of a strong drive stimulus for producing anticipatory invasions of behavior sequences by goal reactions, it should not occasion surprise if these invasions should occasionally take place even in genuinely instrumental sequences. Those common wish-fulfilling delusions so characteristic of certain forms of dementia precox are probably cases where the miscarriage of this mechanism has led to its natural maladaptive issue. Indeed, all wish-fulfillments appear to be of this nature, which doubtless explains their bad repute among psychopathologists. The sexual orgasm which takes place during the ordinary erotic dream is evidently of the same nature. Extreme *ejaculatio precox* in anticipation of the sex relationship is a still clearer example of the abortive results of the goal reaction being displaced forward in time, producing the typical biologically disastrous result of preventing the completion of a reproductive cycle.

That this abortive anticipatory invasion of the antecedent instrumental sequence by the goal reaction does not take place with as great frequency as does the biologically valuable short-circuiting of pure-stimulus-act sequences raises an important theoretical question. A plausible explanation of this difference is found in the nature of the stimuli complexes operative in the two cases. Except for remote excitatory tendencies, which are here neglected in the interest of simplicity of exposition, the typical stimulus complex of the in-

strumental sequence leading to a goal is shown in Fig. 2. Consider, for example, the stimulus complex immediately preceding R_2 . It consists of the external stimulus S_2 , the proprioceptive stimulus, s_1 , arising from the preceding activity, and the persisting or drive stimulus, S_D . The typical symbolic series, on the other hand, being ordinarily an internal process, characteristically lacks in its stimulus complex the external factor, S_1 , at least as a dynamic and coercive component. The significance of this stimulus difference becomes apparent when it is observed that the S_2 - and s_1 -components operate in the direction of a simple and stable chain-reaction tendency whereas the S_D , in addition to a chaining tendency, may have at the same time a very strong tendency to evoke other reactions, and especially the goal reaction. The relative potentialities of the two stimulus systems may be seen very readily by an inspection of Fig. 3, where arbitrary nu-

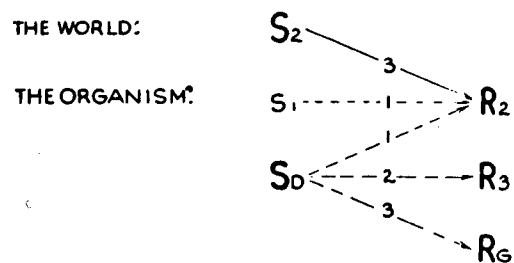


FIG. 3.

merical values have been assigned to the several excitatory tendencies. The simple summation of the potentialities of the several excitatory tendencies of the instrumental stimulus complex, $S_2 s_1 S_D$, yields the following values:

$$R_2 = 5$$

$$R_3 = 2$$

$$R_G = 3$$

Here R_2 is definitely prepotent and the original sequence will not be interrupted. Clearly the chaining tendency is greatly stabilized by the presence of S_2 . A similar casting up of the

action potentialities when S_2 is neutral or functionally absent (as in symbolic sequences) shows the following:

$$R_2 = 2$$

$$R_3 = 2$$

$$R_G = 3$$

In this case, R_G becomes prepotent. Here the chaining tendency is very obviously threatened with disruption as the result of R_G following immediately after R_1 with the consequent dropping out of R_2 and R_3 .

From the foregoing it is evident that in genuinely instrumental sequences the goal reaction is not likely to be displaced backward in the behavior sequence if it is of such a nature as seriously to compete with the latter for control of the final common path. The powerful influence of the external component of the stimulus complex (S_2) ought normally to prevent this. But in case the goal reaction does not, either as a whole or in part, compete with the instrumental sequence, there seems to be no reason why the former should not undergo such displacement. In that case, the anticipatory goal reaction would not disrupt the instrumental sequence, but the two would take place concurrently. Presumably, however, goal reactions spread rather widely and ordinarily involve a large part of the organism. A wide involvement of the organism in the goal act would naturally tend strongly to interfere with any other complex concurrent activities with which it might be associated. Thus the appearance of complete goal reactions simultaneously with what previously were their antecedents should be rare.

There remains the more likely alternative that a split-off portion of the goal reaction which chances not to be in conflict with the antecedent instrumental series may be so displaced. Unfortunately, little is known experimentally of the dynamics of this fascinating possibility. Observation, however, supporting theoretical expectation, seems to indicate that anticipatory goal reactions appearing in the midst of normally antecedent instrumental act sequences are generally incomplete, fractional, imperfect, and feeble. Fortunately, with

pure-stimulus acts, weakness within limits is of no disadvantage.³

Moreover, anticipatory goal reactions appear to manifest themselves with special frequency, vigor and completeness on occasions when, for any reason, the smooth flow of the instrumental sequence has been interrupted. This, again, is in harmony with theoretical expectation, since at such times there would presumably be less competition for the final common path. As an illustration of this there may be mentioned a recent observation made in a Boston restaurant. A man and woman were leisurely eating their dinner. Sitting bolt upright at the table on a third chair was a handsome bull terrier. Throughout the meal the dog watched his master and mistress consuming the tempting morsels without himself making the slightest overt instrumental act leading to the obvious goal. Moreover, all overt anticipatory goal reactions (such as masticatory movements) appeared also to have been inhibited, quite in accordance with the best New England traditions. After a time, however, an implicit fractional component of the anticipatory goal reaction manifested itself; a long, thick thread of saliva was observed hanging from each corner of the dog's mouth. The carefully studied salivation of Pavlov's dogs evidently also represents anticipatory goal or terminal reactions. The less inhibited Russian dogs executed gross mouth movements such as vigorous licking of the lips as well.⁴

Despite the superficial appearance of a lack of physiological conflict between two such processes as locomotion and the goal activity of mastication, general observation leads rather strongly to the expectation that there would be considerable interference even in such cases. Carefully controlled experiments will probably show, for example, that salivation is more active when the normally antecedent instrumental acts are temporarily interrupted than when they are proceeding in full vigor. If this principle can be established experimentally it will have special theoretical significance.

³ C. L. Hull, Knowledge and purpose as habit mechanisms, *PSYCHOL. REV.*, 1930, 37, p. 515.

⁴ I. P. Pavlov, *Conditioned reflexes*, p. 22.

IV

Having the phenomenon of the anticipatory goal reaction clearly before us, we may proceed to the consideration of some of its functional potentialities. Let us assume that in the dynamic situation represented in the diagram of Fig. 3, one portion of the goal reaction is not in conflict (competition) with its antecedent reactions, whereas the remainder is so. For convenience we may designate this non-conflicting component as r_G and the conflicting component as R'_G . It is assumed that as learning proceeds, S_D gets conditioned to the several phases of the reaction sequence and with an intensity roughly proportional to the proximity of each to the goal, the goal reaction itself possessing the most strongly conditioned excitatory tendency of all.⁵ It is assumed, further, that this tendency, at least occasionally, will be sufficiently strong to evoke a weak r_G -reaction even at the outset of the series. This movement of the fractional goal reaction to the beginning of the behavior sequence together with its subsequent persistence throughout the cycle is indicated diagrammatically in Fig. 4. The persistence of r_G is due to the parallel persistence of S_D which continuously evokes it.

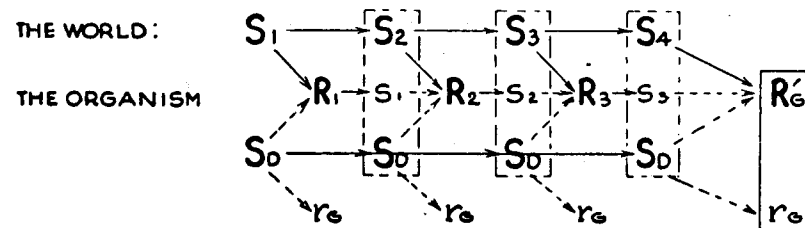


FIG. 4.

Like all other movements, r_G causes characteristic proprioceptive stimulations to arise from the muscles involved. This complex of stimulation flowing from r_G may be represented conveniently by s_G (Fig. 5). It is obvious that since r_G persists throughout the behavior sequence, s_G must also do so.

⁵ C. L. Hull, Knowledge and purpose as habit mechanisms, *PSYCHOL. REV.*, 1930, 37, p. 521. This as yet hypothetical drive stimulus excitatory gradient will be taken up in some detail in a forthcoming paper. A rather numerous and varied assortment of experimental observations substantiates the hypothesis.

It thus comes about that our dynamic situation is possessed of two persisting stimuli, S_D and s_G . Some of the potentialities of the drive stimulus (S_D), have been elaborated elsewhere.⁶ The second persisting stimulus (s_G), by way of con-

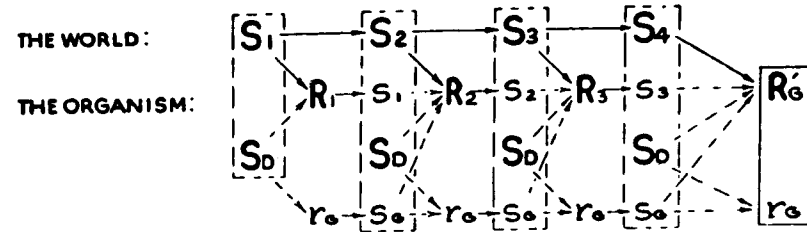


FIG. 5.

trast, will be called the *goal stimulus*.

It is at once apparent from an examination of Fig. 5 that, just as in the case of the drive stimulus, the principle of reintegration ought to set up excitatory tendencies from s_G to every reaction of the behavior sequence including, apparently, tendencies to both components of the goal reaction, the one to r_G being circular. The multiple excitatory tendencies in question are represented diagrammatically in Fig. 6.

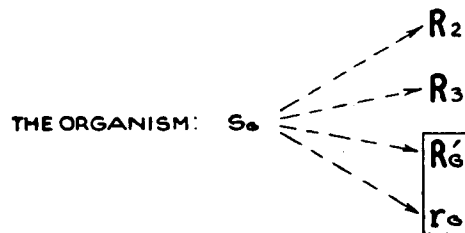


FIG. 6.

Despite the very significant similarity of the goal stimulus to the drive stimulus there are equally significant differences which need carefully to be noted. In the first place, the two stimuli differ radically in their source, or origin. The drive stimulus, in the typical case of hunger already before us, evidently has its origin in the physico-chemical processes involved

⁶ C. L. Hull, Knowledge and purpose as habit mechanisms, *PSYCHOL. REV.*, 1930, 37, p. 519. In that article the drive stimulus, here represented by S_D , was represented by S_p . The present notation is believed to be the more appropriate.

in nutrition. The goal stimulus, on the other hand, is dependent, in the main at least, upon the existence of the drive stimulus and the conditioning of it to the goal reaction. The drive stimulus thus has an essentially non-redintegrative origin, whereas the goal stimulus is preeminently a redintegrative phenomenon. The drive stimulus is not likely to be greatly disturbed by either the presence or absence of the goal stimulus, but anything which terminates the drive stimulus will automatically bring the goal stimulus to an end.⁷

A second significant difference between the drive stimulus and the goal stimulus arises from the fact that from a single drive stimulus there may evolve many tolerably distinct goals. A rat, for example, will, when hungry, eat many different kinds of food. The eating of each kind of food may become a different goal with the goal reaction in each case presumably in some sense distinct. Moreover, the same kind of food may constitute the goal in many different mazes. It is evident that this possibility of a multiplicity of goal stimuli for each drive stimulus has important dynamic potentialities, especially in view of the small number of drives as contrasted with the immense variety of mammalian goals.

V

With the contrasted concepts of the drive stimulus and the goal stimulus well before us, we may now turn to the consideration of the rôles played by them in certain typical situations which are known rather well on the basis of specific experiment. The first situation to be studied is the well known one where an animal which has learned a maze with a reward of food consistently given, for a number of trials receives no reward of any kind. Under such circumstances the maze habit progressively disintegrates. Our interest is concerned with the mode of this disintegration. There is, of course, nothing surprising in the fact that a food reaction should suffer experimental extinction upon consistent failure of rein-

⁷ This neglects the possibility that once S_D has brought r_G into the antecedent reaction sequence, stimuli there resident may acquire a tendency to evoke r_G themselves and thus bring into existence s_G independently of S_D . An example of such a possibility would be the excitatory tendency represented by $s_1 \rightarrow r_G$.

forcement. Nothing is more common in the conditioned reflex literature.⁸ But this, as it stands, would seemingly account for nothing but the inhibition of the act immediately preceding the failure of the customary reward. The particular question which primarily interests us here is: Why does the habit sequence disintegrate as a whole? Why should an event (failure to receive food) taking place at the conclusion of a long series of reactions produce a disintegration of those habit segments most remote from the active origin of disintegration, quite as promptly and completely as of the segment (goal reaction) immediately adjacent? In terms of our diagrams (Figs. 4 and 5) why should an event taking place at S_4 produce a disintegration of habit organization at S_1 ?

The first hypothesis which appears to offer anything in the way of explaining this extensive disintegration is that the drive stimulus might acquire generalized inhibitory properties. Specifically, once the drive stimulus (S_D) has suffered experimental extinction as regards its goal reaction, this inhibition might conceivably spread to every other reaction into which S_D enters as a stimulus. But since S_D is present throughout the series the tendency to inhibition would thus spread from the termination of the sequence at once throughout its whole length and might, therefore, produce the generalized disintegration known to exist.⁹

As yet our knowledge of secondary inhibitory tendencies is too meager for us to express an opinion with any confidence as to whether a spread of inhibition would be brought about by the mechanism sketched above, and, if so, whether the tendency would be strong enough to produce the disintegration just referred to. The following consideration makes it seem doubtful: If the inhibitory tendency to reactions emanating from S_D were strong enough to over-ride the chaining excita-

⁸ It is here tacitly assumed as a useful working hypothesis that principles found to be operative in conditioned reflexes are also operating in maze learning. This paper may be regarded as essentially an exploration of what might be expected in a complex learning situation in case this were true. Once the implications have been drawn, the way will be open for the setting up of critical experiments which may clarify the present unfortunate uncertainty concerning the relationship between the two phenomena.

⁹ I. P. Pavlov, *Conditioned reflexes*, pp. 48, ff.

tory tendencies holding the behavior segments together in the series in which the frustration took place, it should also be strong enough to produce a similar disintegrative tendency in every other sequence which this drive (S_D) enters as a stimulus. This means that if the organism were consistently disappointed in finding food in one accustomed place until it would no longer seek it in that location there would also result a similar paralysis of all attempts to seek food in any place at all, at least until the inhibitory tendency should have subsided. And in that event the organism would be about as likely to seek food in the place previously proven disappointing as in some alternative place which has consistently yielded food. Since these deductions are obviously contrary to fact, at least in this extreme form,¹⁰ we must seek some further or supplementary mechanism for the explanation of habit disintegration which results from withdrawal of reward.

A second mechanism which appears with somewhat greater probability as mediating the generalized disintegration of maze habit organization at the failure of the reward is the *goal stimulus*. We have already pointed out in connection with the discussion of the rôle of the drive stimulus that the goal reaction (r_G) would naturally be the one to be eliminated at once as the result of failure of reinforcement by food. But when r_G is eliminated, there is automatically eliminated s_G also, together with the influence of its multiple excitatory tendencies (Fig. 5). And, since s_G is a stimulus component of all the reactions of the sequence, they will all be correspondingly weakened by its absence, thus accounting for the spread of the effects of the failure of reward so effectively throughout the entire series.

The extent to which this weakening takes place will de-

¹⁰ The *a priori* probability that the inhibition resulting from failure of reward in one situation should inhibit to a certain extent other tendencies to action from the same drive stimulus, at least for a time, is sufficient to warrant the setting up of a carefully controlled experiment to determine whether or not it exists. If, for example, a rat has learned two distinct mazes to a known and equal degree and then the habit of running maze No. 1 is disintegrated by failure of reward, the rat should show a perceptible tendency to disintegration of the second maze habit when comparison is made with a suitable control. A fundamental principle of considerable importance may thus merge.

pend to a considerable degree upon whether the stimuli throughout the action sequence are in the state of mere unorganized complexes or whether they are organized more or less perfectly into stimulus patterns. In the former case any stimulus component, by dropping out of the complex, will withdraw from its joint excitatory tendency no more than what it would exert if acting alone. But in case the stimuli have become organized into patterns the dropping out of any customary component may result in the profound weakening of the joint excitatory tendency and even its complete abolition.¹¹

Our main objective, however, is to emphasize a radical and significant difference between the habit mechanisms of drive stimulus and goal reaction stimulus respectively. We have already seen that a strictly generalized inhibitory tendency from S_D alone, if such exists, would spread alike to all reaction sequences which are mediated by this drive and would not permit of the differentiation of a successful series from an unsuccessful one. This would present an impossible biological dilemma. The goal stimulus supplies the key to the situation. Since r_G is peculiar to the one sequence of which it is the terminal action, the effect of its inhibition will weaken its own series alone. This will leave all other series, even when motivated by the same drive, essentially intact except possibly for weak inhibitory radiation effects. Thus an animal disappointed in finding food at one place, will no longer seek it there but will, nevertheless, proceed to seek it elsewhere. The disintegration of maze habits under the influence of withdrawal of reward thus serves nicely to illustrate both the inadequacy of the drive stimulus as a sole explanatory concept and the distinct explanatory possibilities of the goal-stimulus concept.

VI

The concept of anticipatory or premature goal reactions appearing in fragmentary form concurrently with acts origi-

¹¹ Presumably habits range everywhere between these two extremes of degree of patterning and any given stimulus may be in a constant state of flux in this respect. The experimental determination of the factors governing this fundamental tendency offers a rich field for systematic exploration.

nally antedating them presents a very striking similarity to what has long been known as *ideo-motor* action. Some concrete cases of what is meant by this latter term may assist in the grasping of this point. A familiar example of *ideo-motor* action is found in the pressure of the inexperienced billiard player against the edge of the table while observing the movement of a ball which he has just activated, particularly when the ball threatens not quite to reach the mark at which he has aimed. A somewhat similar example is seen in the common tendency of people when watching a football game to lean and even push in the direction that they wish the play to move.

To most psychologists in the past, *ideo-motor* action has been regarded as no more than an interesting curiosity—a kind of abortive activity having no functional value in itself but serving, perhaps in large part by virtue of its very maladaptive nature, to indicate strikingly the existence of a tendency which might be really adaptive under other circumstances.¹² From the point of view of instrumental behavior the maladaptive nature of most *ideo-motor* acts is evident. Nothing could well be conceived as more stupid and less calculated to influence the course of a billiard ball than a gentle pressure on the side of the billiard table. Few things could be imagined which would be more futile as regards the outcome of a football play than the sympathetic movements on the part of the spectators. In this, *ideo-motor* action presents an exact parallel to implicit anticipatory goal reactions such as the licking of the lips and the salivation of the dogs of the conditioned reflex experiments. Indeed if we consider that the pressure delivered to the side of the billiard table really would function on the ball if the hand had traversed the distance from the edge of the table to the position of

¹² This seems to have been true even of William James, despite the fact that he regarded *ideo-motor* action as intimately related to will. "Wherever movement follows *unhesitatingly and immediately* the notion of it in the mind, we have *ideo-motor* action. . . We think the act and it is done. . . Dr. Carpenter, who first used, I believe, the name of *ideo-motor* action, placed it, if I mistake not, among the curiosities of our mental life. The truth is that it is no curiosity but simply a normal process stripped of disguise." (William James, *Principles of psychology*, 1908, Vol. II., p. 522.)

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the ball, and that the movements of the spectator of a football game really would affect the outcome of the play if he had traversed the distance separating him from the players, these movements appear quite literally as anticipatory goal reactions. As instrumental acts they are, and must always be, abortive, maladaptive, wasteful and stupid.

It by no means follows from the foregoing, however, that ideo-motor action is really maladaptive. On the contrary the view is here put forward that ideo-motor reactions and anticipatory goal reactions in general are really guiding and directing pure-stimulus acts and as such perform the enormously important functions ordinarily attributed to ideas. Considered merely as acts they are negligible; as pure-stimulus acts and sources of stimuli to control other action, they at once take on the very greatest importance. While indubitably physical they occupy at the same time the very citadel of the mental. The classical view was that a non-physical idea of an act preceded the act and somehow commanded the energy to evoke it, such act in consequence being called ideo-motor. In contrast to that view, the hypothesis here put forward is (1) that ideo-motor acts are in reality anticipatory goal reactions and, as such, are called into existence by ordinary physical stimulation; and (2) that these anticipatory goal reactions are pure-stimulus acts and, as such, guide and direct the more explicit and instrumental activities of the organism. In short, ideo-motor acts, instead of being *evoked* by ideas, *are* ideas. Thus the position of the classical psychology in this field is completely inverted.

Healthy individuals, uncontaminated by psychological and metaphysical theory, generally have quite simply and naturally held that ideas were dynamic—that somehow they exert a physical control over instrumental activity. The prevailing metaphysics, with its roots far back in the unscientific past, has insisted that ideas are not physical. The combination of the two points of view produced the logical absurdity of hypothesizing a physical interaction where one of the two entities involved was non-physical. Among other difficulties, such an interaction found itself in direct conflict

with the principle of the conservation of energy. The present hypothesis, according to which the idea¹³ is physical and at the same time an action and a stimulus, completely dissolves this logical absurdity, opens the door for an objective study of ideas, and offers a legitimate and unambiguous status for them in science.

But granting, for the sake of argument, that a non-physical idea could somehow evoke physical movements, there still remains the fundamental question of how, in detail, such an idea could evoke the particular actions which would be necessary to lead to a particular goal even in the relatively simple situations considered above. Schools of psychology dominated by metaphysical idealism have been peculiarly insistent upon the obligation of physical psychological theories to explain the guidance or control of action by ideas. The fact that the mentalists themselves have not been able to do this seems hardly to have been noticed, either by themselves or anyone else. Possibly in a system already filled with the incredible an additional incredibility attracts little notice. The fact remains that there exists no magic which absolves *any* system which purports to give a thoroughgoing account of human nature from the obligation of showing how purposive ideas¹⁴ are able automatically to guide and direct action to the realization of a goal or reward. The problem is admittedly a difficult one. However, considerations already put forward in this paper furnish some grounds for optimism concerning its final solution on a strictly physical basis. At any rate the challenge is accepted.

¹³ It is not to be understood that the anticipatory goal reaction is the only physical basis for what have in the past been called ideas. There certainly are some others and probably a good many others, particularly with human subjects. What was lumped together by the classical psychologists as a single thing is turning out to include a number of fairly distinct things. Thus the old terminology becomes inadequate for modern needs.

¹⁴ In a previous paper purpose was tentatively identified with the drive stimulus (S_D). Upon more mature consideration the writer is inclined to revise this judgment in favor of the goal stimulus (s_G), largely on the ground that the latter stimulus both represents the goal and provides the more intimate mechanism of its attainment, even though the goal stimulus is ultimately dependent for its existence upon the drive.

VII

We may now briefly summarize the results of our discussion:

The drive stimulus accounts very well for the random seeking reactions of a hungry organism, but alone it is not sufficient to produce the integration of complex behavior sequences such as is involved in maze learning. There must always be a reward of some kind. Once the reward has been given, however, the behavior undergoes a marked change most definitely characterized by evidences of actions anticipatory of the goal, which actions tend to appear as accompaniments to the sequence ordinarily leading to the full overt goal reaction.

It is shown how these fractional anticipatory goal reactions could be drawn to the beginning of the behavior sequence and maintained throughout it by the action of the drive stimulus (S_D). The kinaesthetic stimulus resulting from this persistent anticipatory action should furnish a second stimulus (S_G) which would persist very much like S_D . These two persisting stimuli alike should have the capacity of forming multiple excitatory tendencies to the evocation of every reaction within the sequence. They should differ, however, in that the anticipatory goal reaction stimulus would be dependent for its existence upon the integrity of the drive stimulus. A second difference is that a single drive stimulus may generate many distinct goal stimuli.

The general *a priori* probability of the existence of the goal stimulus finds confirmation in the fact that it affords a plausible explanation of a class of experimentally observed facts hitherto inexplicable. It enables us to understand, for example, why withholding the usual reward at the end of an accustomed maze run will cause a disintegration of that particular habit sequence while leaving the organism free to pursue alternative sequences based on the same drive. It offers an explanation of why, during a maze learning process, the substitution of one reward for another presumably of about the same attractiveness should produce a transitory slump in the learning scores. It throws light on why an animal evidently motivated by the anticipation of one kind of

food will leave untouched a different but otherwise acceptable type of food which has been surreptitiously substituted. There is reason to believe that as the experimental literature on the motivating influence of rewards increases the goal stimulus mechanism will find enlarged application.

Moreover, there is strong reason for believing that the fractional anticipatory goal reaction is the actual basis of what has long been known as *ideo-motor* action. This latter phenomenon emerges from the analysis as a dynamic mechanism, a pure-stimulus act, rather than an end product as was formerly supposed. This means that *ideo-motor* acts are not caused by ideas. On the contrary, they are themselves ideas. It has long been recognized that one of the prime functions of ideas is to guide and control instrumental acts in cases where the situation to which the acts really function is absent and, as a consequence, is unable to stimulate the organism directly. The capacity of anticipatory goal reactions as stimuli to control and direct other activity renders intelligible on a purely physical basis the dynamic guiding power of ideas. This, in turn, makes still more plausible the hypothesis that anticipatory goal reactions are the physical substance of purposive ideas.

For the sake of definiteness and additional clarity the hypotheses elaborated above may be assembled in brief dogmatic form: Pure-stimulus acts are the physical substance of ideas. Ideas, however, are of many varieties. Among them are goal or guiding ideas. The physical mechanism constituting these particular ideas is the anticipatory goal reaction. This appears to be substantially the same as *ideo-motor* action. The anticipatory goal reaction seems also to constitute the physical basis of the somewhat ill-defined but important concept of purpose, desire, or wish, rather than the drive stimulus as has sometimes been supposed, notably by Kampf. This interpretation of purpose explains its dynamic nature and at the same time removes the paradox arising under the classical psychology where the future appeared to be operating causally in a backward direction upon the present. This hypothesis also renders intelligible the 'realization of an anticipation' by

an organism. It is found in situations where a fractional anticipatory goal reaction as a stimulus has motivated a behavior sequence which culminates in a full overt enactment of a goal-behavior complex of which it is a physical component.

[MS. received March 25, 1931]