KNOWLEDGE AND PURPOSE AS HABIT MECHANISMS

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It is only with the greatest difficulty that scientists are able to maintain a thoroughly naturalistic attitude toward the more complex forms of human behavior. Our intellectual atmosphere is still permeated in a thousand subtle ways with the belief in disembodied behavior functions or spirits. The situation is aggravated by the fact that the details of the more complex action patterns are so concealed as to be almost impossible of observation. Even so, the outlook is hopeful. The work of many ingenious investigators is bringing to light important details of the hidden processes, and enough evidence has already accumulated to enable us in a number of cases to discern with tolerable clearness the broad naturalistic outlines of their operation.

I

One of the oldest problems with which thoughtful persons have occupied themselves concerns the nature and origin of knowledge. How can one physical object become acquainted with the ways of another physical object and of the world in general? In approaching this problem from the point of view of habit, it is important to recognize that knowledge is mediated by several fairly distinct habit mechanisms. In the present study but one of these will be elaborated.

Let us assume a relatively isolated inorganic world sequence taking place as shown in Fig. 1. Here S_1, S_2, etc.,

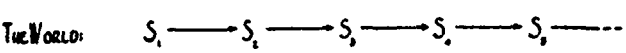

FIG. 1

represent typical phases of a sequential flux, the time intervals between successive S's being uniform and no more than a few

seconds each. Let us suppose, further, that in the neighborhood of this world sequence is a sensitive redintegrative organism. The latter is provided with distance receptors and is so conditioned at the outset as to respond characteristically to the several phases of the world sequence. Each S accordingly becomes a stimulus complex impinging simultaneously on numerous end organs. As a result, each phase of the world sequence now becomes a cause, not only of the succeeding phase in its own proper series, but also of a functionally parallel event (reaction) within the neighboring organism. The organismic responses of the series thus formed have no direct causal relationship among themselves.[1] R_1 in itself has no power of causing (evoking) R_2. The causal relationship essential in the placing of R_2 after R_1 is that of the physical world obtaining in the S-sequence; R_2 follows R_1 because S_2 follows S_1. The situation is represented diagrammatically in Fig. 2.

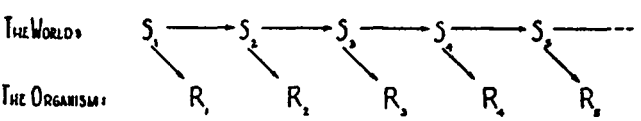

FIG. 2

Now a high-grade organism possesses internal receptors which are stimulated by its own movements. Accordingly each response (R) produces at once a characteristic stimulus complex and stimuli thus originated make up to a large extent the internal component of the organism's stimuli complexes. Let these internal stimulus components be represented by s's. If we assume, in the interest of simplicity of exposition, that the time intervals between the phases of the world flux selected for representation are exactly equal to those consumed by the $S \rightarrow R \rightarrow s$ sequences, the situation

[1] This neglects the original dynamic influence of the ever-present internal component of the organismic stimulus complex into which each phase of the world sequence enters to evoke the corresponding organismic reaction. The excitatory potency of this internal component is here supposed to be minimal. Its influence is neglected in the interest of simplicity of exposition. Its undeniable presence clearly introduces an element of subjectivity into reactions which appear superficially to be evoked purely by the external world.

will be as shown in Fig. 3, S_2 coinciding in time with s_1, S_3 with s_2 and so on.

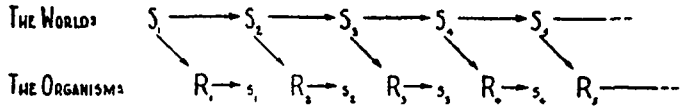

FIG. 3

Now, by the principle of redintegration, all the components of a stimulus complex impinging upon 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. We will let a dotted rectangle indicate that what is enclosed within it constitutes a redintegrative stimulus complex; and a dotted arrow, a newly acquired excitatory tendency. After one or more repetitions of the world sequence, the situation will be as shown in Fig. 4.

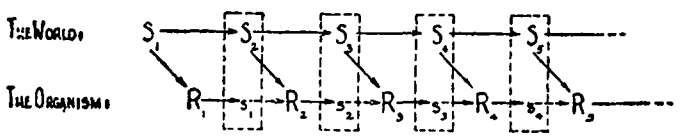

FIG. 4

As a result of the joint operation of the several factors summarized in Fig. 4, the organismic reactions (R's) which at the outset were joined only by virtue of the energies operating in the outer world sequence of S's, are now possessed of a genuine dynamic relationship lying within the organism itself. To make this clear, let it be assumed that the world sequence begins in the presence of the organism, but is at once interrupted. The resulting situation is shown diagrammatically in Fig. 5. The newly acquired excitatory tend-

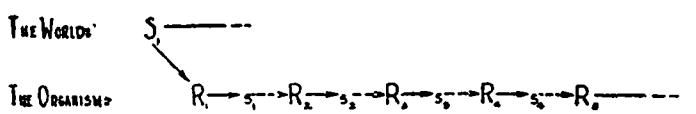

FIG. 5

encies, unless interrupted by some more potent influence, should continue the organismic sequence of responses very much as when they were first called forth as the result of the stimulation by the world sequence.

In summary it may be said that through the operation of a variety of principles and circumstances, the world in a very important sense has stamped the pattern of its action upon a physical object. The imprint has been made in such a way that a functional parallel of this action segment of the physical world has become a part of the organism. Henceforth the organism will carry about continuously a kind of replica of this world segment. In this very intimate and biologically significant sense the organism may be said to know the world. No spiritual or supernatural forces need be assumed to understand the acquisition of this knowledge. The process is entirely a naturalistic one throughout.

II

Once the organism has acquired within its body this subjective parallel to the ways of the physical world, certain other activity patterns or habit mechanisms at once become operative. One of the more important of these is the power of foresight or fore-knowledge. A great deal of mystery has surrounded this problem. Foresight may be defined for our present purpose as *the reaction to an event which may be impending, but which has not as yet taken place.* The difficulty seems largely to have been concerned with the problem of how an organism can react to an event not yet in existence. The reasoning runs: An event not yet in existence cannot be a stimulus; and how can an organism react to a stimulus which does not exist? In terms of our diagram, how can R_5, which is a reaction to the stimulating event S_5, take place before S_5 itself has occurred?

An important circumstance connected with foresight is the fact that the tempo of the acquired subjective parallel to the outer world sequence is not limited to that of the latter. Indeed, there is evidence indicating a tendency for a primary conditioned reaction to run off at a higher speed than that of the master world sequence which it parallels.[2] Thus it comes

[2] C. L. Hull, A functional interpretation of the conditioned reflex, PSYCHOL. REV., 1929, 36, p. 507 *ff.* A quite distinct mechanism serving much the same function as that here emphasized has its basis in the peculiar advantage afforded by distance

about that, even when both series begin at the same instant, the end-reaction of the subjective series may actually antedate the stimulus in the world sequence which exclusively evoked it previous to the conditioning shown in Fig. 4. It is evident that this possibility of the heightened tempo on the part of the organismic act sequence is intimately connected with the possession by the organism of knowledge of events before they actually take place.

The biological advantage of antecedent knowledge of impending events is great. This is particularly clear in the case of defense reactions. These latter fall into two main types—flight and attack. Let us suppose that in the example elaborated above, S_5 is a seriously nocuous stimulus and R_5 is a successful flight reaction. Foresight will result from the reeling off of the *R*-series faster than the *S*-series so that s_4 will evoke R_5 before S_5 has occurred. In this event S_5, when it does occur, will not impinge on the organism for the reason that the latter will have withdrawn from the zone of danger as the result of the act R_5. In case R_5 is an act of attack rather than flight it must, to be successful, bring the organismic series into contact with the world sequence in such a manner as to interrupt the latter before S_5 is reached. In this case also, the organism clearly escapes the injury. Thus the supposed impossibility of an organismic reaction to a situation before it exists as a stimulus is accomplished quite naturally through the medium of an internal substitute stimulus.

III

A reflective consideration of the habit mechanisms involved in anticipatory defense reactions reveals a phenomenon of the greatest significance. This is the existence of acts whose sole function is to serve as stimuli for other acts. We shall accordingly call them *pure stimulus acts*. Under normal conditions practically all acts become stimuli, but ordinarily

receptors. The stimulus of a distant object through a distance receptor is often sufficiently like that when the object is near and nocuous to evoke a successful defense reaction before the source of danger can get near enough to produce injury. This has been discussed in detail by Howard C. Warren, *J. Phil., Psychol. & Scient. Meth.*, 1916, 13, p. 35 *ff*.

the stimulus function is an incidental one. The consideration of the approach of an organism to food may clarify the concept. Each step taken in approaching the food serves in part as the stimulus for the next step, but its main function is to bring the body nearer the food. Such acts are, therefore, primarily instrumental. By way of contrast may be considered the anticipatory defense sequence presented above. R_5, the actual defense reaction, obviously has instrumental value in high degree. R_4, on the other hand, has no instrumental value. This does not mean that it has no significance. Without R_4 there would be no s_4, and without s_4 there would be no R_5 *i.e.* no defense. In short, R_4 is a pure stimulus act. In the same way R_3 and R_2 serve no instrumental function but, nevertheless, are indispensible as stimulus acts in bringing about the successful defense response.

A simple experiment which can be performed by anyone in a few moments may still further clarify the concept of the pure stimulus act. Ask almost any psychologically naïve person how he buttons his coat with one hand—which finger, if any, he puts through the buttonhole, what the last act of the sequence is—and so on. The average person can tell little about it at first. If wearing a coat, he will usually perform the act forthwith. If warned against this, the hand may quite generally be observed to steal close to the position at which the buttoning is usually performed and to go through the buttoning behavior sequence *by itself*. After this the nature of the final buttoning act may be stated with some assurance. Clearly, the earlier acts of this pseudo-buttoning sequence are pure stimulus acts since they serve no function whatever, except as stimuli to evoke succeeding movements and ultimately, the critical final movement which is sought.

It is evident upon a little reflection that the advent of the pure stimulus act into biological economy marks a great advance. It makes available at once a new and enlarged range of behavior possibilities. The organism is no longer a passive reactor to stimuli from without, but becomes relatively free and dynamic. There is a transcendence of the limitations of habit as ordinarily understood, in that the organism can

react to the not-here as well as the not-now. In the terminology of the *Gestalt* psychologists, the appearance of the pure stimulus act among habit phenomena marks a great increase in the organism's 'degrees of freedom.' The pure stimulus act thus emerges as an organic, physiological—strictly internal and individual—symbolism.[3] Quite commonplace instrumental acts, by a natural reduction process, appear transformed into a kind of *thought*—rudimentary it is true, but of the most profound biological significance.

Thus the transformation of mere action into thought, which has seemed to some as conceivable only through a kind of miracle, appears to be a wholly naturalistic process and one of no great subtlety. Indeed, its obviousness is such as to challenge the attempt at synthetic verification from inorganic materials. It is altogether probable that a 'psychic' machine, with ample provision in its design for the evolution of pure stimulus acts, could attain a degree of freedom, spontaneity, and power to dominate its environment, inconceivable alike to individuals unfamiliar with the possibilities of automatic mechanisms and to the professional designers of the ordinary rigid-type machines.

IV

Pure stimulus-act sequences present certain unique opportunities for biological economy not possessed by ordinary instrumental-act sequences. In the first place, there is the ever present need of reducing the energy expenditure to a minimum while accomplishing the ordinary biological functions in a normal manner. It is clear that pure stimulus-act sequences, since they no longer have any instrumental function, may be reduced in magnitude to almost any degree consistent with the delivery of a stimulus adequate to evoke

[3] This peculiarly individual form of symbolism is not to be confused with the purely stimulus acts of social communication. Neither is it to be confused with what appears to be a derivative of the latter by a reduction process, the subvocal speech emphasized by Watson. The special stimulus-response mechanisms by which the evolution of these latter forms of symbolism take place, together with their peculiar potentialities for mediating biological adjustment and survival, are so complex as to preclude consideration here.

the final instrumental or goal act.[4] Observation seems to indicate that this economy is operative on a very wide scale. It may even be observed in the buttoning experiment previously cited. The hand while going through the buttoning sequence by itself will ordinarily make movements of much smaller amplitude than when performing the instrumental act sequence with a real button.

A significant observation made by Thorndike in the early days of animal experimentation illustrates the same tendency, though in a very different setting. He placed cats in a confining box from which they sought to escape. Some he would release only when they licked themselves, others only when they scratched themselves. After an unusually long training period the cats finally learned to perform the required acts and thus to escape fairly promptly. In this connection, Thorndike remarks:

"There is in all these cases a noticeable tendency, of the cause of which I am ignorant, to diminish the act until it becomes a mere vestige of a lick or a scratch. After the cat gets so it performs the act soon after it is put in, it begins to do it less and less vigorously. The licking degenerates into a mere quick turn of the head with one or two motions up and down with tongue extended. Instead of a hearty scratch the cat waves its paw up and down rapidly for an instant." [5]

The ordinary scratch of a cat is an instrumental act. It must have a certain duration and intensity to serve its function. In the present instance the scratch served only as a visual stimulus to Dr. Thorndike. As such, a small movement was presumably quite as effective as a large one.

In the second place there is, particularly in the case of primitive defense acts, the need to economize time so as to increase the promptness of the defense reaction. This de-

[4] Movements greatly reduced in magnitude tend to become vestigial. This suggests a possible explanation of the extreme subjectivity of imagery. Just how far the weakening of pure stimulus acts may go and still serve their stimulus function is a question which may yield to experimental approach. That they should diminish to an actual zero, with nothing but a neural vestige remaining to perform the stimulus function, is conceivable though hardly probable. It is believed that the present hypothesis is general enough to fit either alternative.

[5] E. L. Thorndike, Animal intelligence, MacMillan, 1911, p. 48.

sideratum appears to be accomplished by the same means as the first—the reduction in the magnitude of the acts. A movement of small amplitude should be more quickly performed than one of large amplitude.

But the maximum of economy, both as to energy and as to time, demands not only that the units of the stimulus-act sequence shall be small in amplitude, but that they shall also be as *few* as possible. If a single stimulus-act is sufficient to furnish the necessary stimulus for the defense reaction, the existence of all the other stimulus acts in the series is a sheer waste, both of time and energy. This means that biological efficiency demand on two separate counts the dropping out of large sections of purely stimulus-act sequences.

V

The importance of the serial-segment elimination tendency in pure stimulus-act and other complex learning sequences raises very insistently the question as to what stimulus-response mechanisms may bring it about. Observation suggests that one condition favorable for 'short circuiting' is that the process shall be strongly 'purposive.' *In the present study the purpose mechanism shall be understood as a persisting core of sameness in the stimulus complexes throughout the successive phases of the reaction sequence.* We will symbolize this persisting stimulus by S_p. This may be thought of concretely as a continuous strong red light, or a continuous gripping of a dynamometer, or the continuous knitting of the brows, or (more typically) the continuously recurring crampings of the digestive tract as in hunger.

When the principle of the persisting stimulus is joined to the set of principles represented as operating in Fig. 5, a number of novel consequences at once appear. The situation is represented in Fig. 6. An examination of this diagram shows that S_p has a unique advantage over all the other components in the several stimulus complexes. Thus, S_1, S_2, etc. and s_1, s_2, etc. can get conditioned, except for remote associative tendencies,[6] only to the response in each case

[6] These are here neglected in order to simplify the exposition. Ultimately they must, of course, be taken fully into account.

which immediately follows, *i.e.* to but a single response each. But S_p, since it is present in all the stimulus complexes of the series, *gets conditioned to all the reactions* taking place in it.

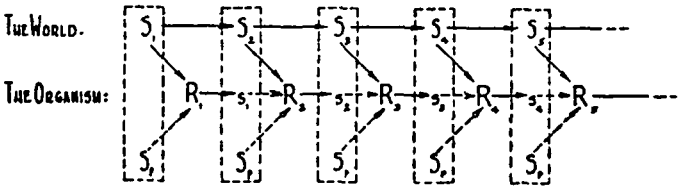

Fig. 6

This multiplicity of excitatory tendencies resulting from the situation shown in Fig. 6, is represented diagrammatically in Fig. 7.

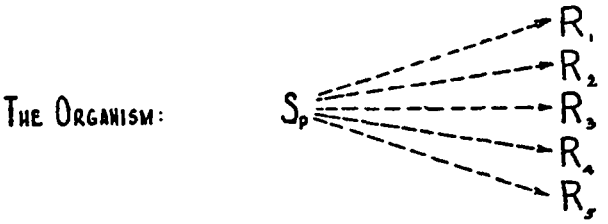

Fig. 7

VI

It is evident that in a situation such as is presented in Fig. 7, a competition of the several excitatory tendencies will follow. Since this competition must be between the several parts of the series, it will be called *intraserial competition.* We may safely assume that the several excitatory tendencies radiating from S_p will have varying strengths. There also enter into this competition, of course, the stimulus elements which may be present in the stimulus complex from other sources at any particular moment. We will simplify the stimulus situation somewhat by assuming that the world sequence is interrupted at once after its first phase, S_1. What, then, will be the state of this intraserial competition at the second stimulus complex of the diagram?

If we assume that s_1 has an excitatory tendency toward R_2 of 2 units, that S_p also has an excitatory tendency toward

R_2 of 2 units, toward R_3 of 3 units, towards R_4 of 4 units and towards R_5 of 5 units, the competition among the several segments of the series will be that shown in Fig. 8. From

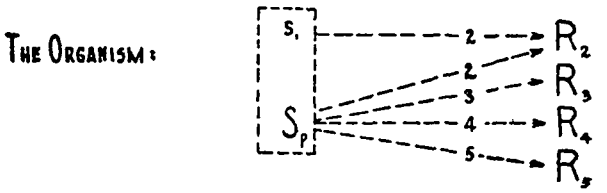

FIG. 8

this diagram it may be seen that the immediately following reaction (R_2) in the original action sequence has the advantage of a double excitatory tendency, whereas the more distant reactions such as R_3, R_4, and R_5, have but a single excitatory tendency each, that arising only from S_p. But if at any time one of the single (S_p) excitatory tendencies should chance to be stronger than the combination of the two tendencies leading to the immediately following act of the original sequence, the elimination of a segment of the pure stimulus-act sequence will take place.

In order to understand how the purposive mechanism, through intraserial competition, may bring about serial segment elimination, let us observe the sequel to the following hypothetical situation. It may very well prove to be the case that S_p gets conditioned more strongly as the final or critical response in a behavior cycle is approached.[7] Accordingly a rough approximation to such a system of excitatory tendencies has been assigned to the bonds presented in Fig. 8. We may summarize the several competing excitatory tendencies radiating from the second stimulus complex as follows:

[7] It would not appear to be an over difficult task to test this hypothesis experimentally. If it should prove true it would have extensive theoretical implications and would clear up a number of questions in the theory of learning. However, almost any other hypothesis which provides considerable variation in the strength of the excitatory tendencies radiating from S_p will produce substantially similar results. It may be added that an irregular distribution of intensities of excitatory tendencies from S_p offers special opportunities for backward serial segment elimination as contrasted with the more usual forward variety here emphasized.

$$R_2 = 4,$$
$$R_3 = 3,$$
$$R_4 = 4,$$
$$R_5 = 5.$$

This shows that the reaction following the second stimulus complex must be, not R_2 as in the original act sequence, but R_5. But if R_5 follows immediately after R_1, the behavior segment shown in Fig. 9 drops completely out of the series. This is inevitable because no stimulus now remains in the series adequate to evoke it.

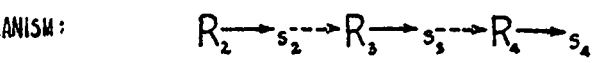

FIG. 9

One of the most baffling theoretical problems related to experimental psychology has been that of explaining how errors or unnecessary acts in behavior sequences get eliminated. Nevertheless, few psychological phenomena are more common. One is asked the product of 49×67. He writes the numbers down on paper, certain multiplication-table and addition-table habits of childhood are evoked in an orderly succession, and at length there is written down by successive stages the number, 3283. If, not too long afterwards, the individual is again asked the product of 49×67, he may respond by saying 3283 at once. In thus passing directly from the question to the answer, the behavior sequence of pure stimulus acts which constituted the detailed multiplication of 49×67 has completely dropped out of the sequence.

The difficulty of accounting for this phenomenon has been due to a considerable extent to the fact that the serial segment elimination must take place in the face of the so-called law of use or frequency. According to this principle (alone) practice or repetition might be expected blindly to fix the undesirable behavior segment in its place more firmly than ever. Perhaps such inadequacies as these have contributed much to bringing the simple chain reaction theory into its deserved ill repute as a universal explanatory principle. As a matter of plain fact,

the principle of redintegration from which may be derived the simple chaining of reactions, implies with equal cogency the evolution of a stimulus-response mechanism which appears to be capable on occasion of completely transcending the chaining tendency.[8] According to this principle any stimulus such as an organic craving which persists as a relatively constant component throughout the otherwise largely changing stimulus complexes of a behavior sequence, must become conditioned to every act of the series. The implications of this for complex adaptive behavior are far reaching. It is our present concern only to point out that the persisting stimulus, through the sheaf of excitatory tendencies emanating from it to every act of the series, provides a unique dynamic relationship between each part of the series and every other part. This, as we have seen above, gives rise to a significant competition among the several potential action tendencies within the series. While final decision must be reserved until the facts are determined by experiment, the probability seems to be that this intraserial competition may easily become sufficiently potent to over-ride the simple chain-reaction tendency and produce a leap in the behavior sequence from the beginning of a series at once to the final or goal reaction, thus eliminating the intervening unnecessary action segment.

VII

The results of the present inquiry may be briefly summarized.

Sequences in the outer world evoke parallel reaction sequences in sensitive organisms. By the principle of redintegration the organismic sequences acquire a tendency to run off by themselves, independently of the original world sequences. The organism has thus acquired an intimate functional copy of the world sequence, which is a kind of knowledge.

In case the two sequences begin at the same time but the organismic or behavior sequence runs off at a faster rate, the knowledge becomes fore-knowledge or foresight. This has great significance in terms of biological survival.

[8] See E. L. Thorndike, The original nature of man, New York, 1913, 186–187.

The possibility of more or less extended functional habit sequences being executed by the organism with an instrumental act only at the end, gives rise to the concept of the pure stimulus act. Such behavior sequences have great biological survival significance because they enable the organism to react both to the not-here and the not-now. Incidentally it accounts for a great deal of the spontaneity manifested by organisms.

The concept of the pure stimulus act appears to be the organic basis of symbolism but is believed to be a more fundamental one than that of symbolism as ordinarily conceived.

Pure stimulus-act sequences offer possibilities of biological economy, both of energy and of speed, through the reduction in the amplitude of the acts in the sequence. Further analysis reveals the fact that both energy and time would be economized with no incidental sacrifice if the acts between the beginning of an action cycle and its goal act should drop out of the sequence. Observation seems to show that the dropping out of such intervening pure stimulus acts occurs very extensively.

The problem arises as to how this dropping out of undesirable behavior segments may come about, since it appears to be a violation of the 'law of use.' A plausible explanation is found in the peculiar potentialities of stimuli which persist relatively unchanged throughout a behavior sequence. A persisting stimulus component is regarded as one of the characteristic mechanisms of purposive behavior. We should expect such a stimulus to get conditioned to every act of the sequence, presumably most strongly to the goal act and those acts immediately preceding the goal act. The resulting multiplicity of excitatory tendencies emanating from the persisting stimulus is found to generate an important phenomenon—the competition among the several potential segments of the behavior series. This intraserial competition, if sufficiently strong, could easily over-ride the simple chaining of contiguous acts produced by the 'law of use' and enable the final act of the original series to be evoked at once after the first act of the series, thus producing what is rather inappropriately

called 'short-circuiting.' Thus may a persistent problem in the theory of mammalian adaptive behavior be on its way to solution.

The general plausibility of the foregoing theoretical deductions as well as the probable biological significance of several of the deduced mechanisms, suggests strongly the desirability of an intensive program of experimental research designed to test their actuality. In that way the true function of theoretical analysis may be realized.

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