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"Superstition" in the Pigeon

To say that a reinforcement is contingent upon a response may mean nothing more than that it follows the response. It may follow because of some mechanical connection or because of the mediation of another organism; but conditioning takes place presumably because of the temporal relation only, expressed in terms of the order and proximity of response and reinforcement. Whenever we present a state of affairs which is known to be reinforcing at a given level of deprivation, we must suppose that conditioning takes place even though we have paid no attention to the behavior of the organism in making the presentation. A simple experiment demonstrates this to be the case.

A pigeon is reduced to 75 per cent of its weight when well fed. It is put into an experimental cage for a few minutes each day. A food hopper attached to the cage may be swung into place so that the pigeon can eat from it. A solenoid and a timing relay hold the hopper in place for five sec. at each presentation.

If a clock is now arranged to present the food hopper at regular intervals *with no reference whatsoever to the bird's behavior,* operant conditioning usually takes place. In six out of eight cases the resulting responses were so clearly defined that two observers could agree perfectly in counting instances. One bird was conditioned to turn counter-clockwise about the cage, making two or three turns between reinforcements. Another repeatedly thrust its head into one of the upper corners of the cage. A third developed a "tossing" response, as if placing its head beneath an invisible bar and lifting it repeatedly. Two birds developed a pendulum motion of the head and body, in which the head was extended forward and swung from right to left with a sharp movement followed by a somewhat slower return. The body generally followed the movement and a few steps might be taken

From *The Journal of Experimental Psychology,* 1948, *38,* 168–172.

when it was extensive. Another bird was conditioned to make incomplete pecking or brushing movements directed toward but not touching the floor. None of these responses appeared in any noticeable strength during adaptation to the cage or until the food hopper was periodically presented. In the remaining two cases, conditioned responses were not clearly marked.

The conditioning process is usually obvious. The bird happens to be executing some response as the hopper appears; as a result it tends to repeat this response. If the interval before the next presentation is not so great that extinction takes place, a second "contingency" is probable. This strengthens the response still further and subsequent reinforcement becomes more probable. It is true that some responses go unreinforced and some reinforcements appear when the response has not just been made, but the net result is the development of a considerable state of strength.

With the exception of the counter-clockwise turn, each response was almost always repeated in the same part of the cage, and it generally involved an orientation toward some feature of the cage. The effect of the reinforcement was to condition the bird to respond to some aspect of the environment rather than merely to execute a series of movements. All responses came to be repeated rapidly between reinforcements—typically five or six times in 15 sec.

The effect appears to depend upon the rate of reinforcement. In general, we should expect that the shorter the intervening interval, the speedier and more marked the conditioning. One reason is that the pigeon's behavior becomes more diverse as time passes after reinforcement. A hundred photographs, each taken two sec. after withdrawal of the hopper, would show fairly uniform behavior. The bird would be in the same part of the cage, near the hopper, and probably oriented toward the wall where the hopper has disappeared or turning to one side or the other. A hundred photographs taken after 10 sec., on the other hand, would find the bird in various parts of the cage responding to many different aspects of the environment. The sooner a second reinforcement appears, therefore, the more likely it is that the second reinforced response will be similar to the first, and also that they will both have one of a few standard forms. In the limiting case of a very brief interval the behavior to be expected would be holding the head toward the opening through which the magazine has disappeared.

Another reason for the greater effectiveness of short intervals is that the longer the interval, the greater the number of intervening responses emitted without reinforcement. The resulting extinction cancels the effect of an occasional reinforcement.

According to this interpretation the effective interval will depend upon

the rate of conditioning and the rate of extinction, and will therefore vary with the deprivation and also presumably between species. Fifteen sec. is a very effective interval at the level of deprivation indicated above. One min. is much less so. When a response has once been set up, however, the interval can be lengthened. In one case it was extended to two min., and a high rate of responding was maintained with no sign of weakening. In another case, many hours of responding were observed with an interval of one min. between reinforcements.

In the latter case, the response showed a noticeable drift in topography. It began as a sharp movement of the head from the middle position to the left. This movement became more energetic, and eventually the whole body of the bird turned in the same direction, and a step or two would be taken. After many hours, the stepping response became the predominant feature. The bird made a well-defined hopping step from the right to the left foot, meanwhile turning its head and body to the left as before.

When the stepping response became strong, it was possible to obtain a mechanical record by putting the bird on a large tambour directly connected with a small tambour which made a delicate electric contact each time stepping took place. By watching the bird and listening to the sound of the recorder it was possible to confirm the fact that a fairly authentic record was being made. It was possible for the bird to hear the recorder at each step, but this was, of course, in no way correlated with feeding. The record obtained when the magazine was presented once per minute resembles in every respect the characteristic curve for the pigeon under fixed-interval reinforcement of a standard selected response. A well-marked temporal discrimination develops. The bird does not respond immediately after eating, but when 10 or 15 or even 20 sec. have elapsed, it begins to respond rapidly and continues until the reinforcement is received.

In this case it was possible to record the "extinction" of the response when the clock was turned off and the magazine was no longer presented at any time. The bird continued to respond with its characteristic side to side hop. More than 10,000 responses were recorded before "extinction" had reached the point at which few if any responses were made during a 10 or 15 min. interval. When the clock was again started, the periodic presentation of the magazine (still without any connection whatsoever with the bird's behavior) brought out a typical curve for reconditioning after fixed-interval reinforcement, shown in Figure 1. The record has been essentially horizontal for 20 min. prior to the beginning of this curve. The first reinforcement had some slight effect and the second a greater effect.

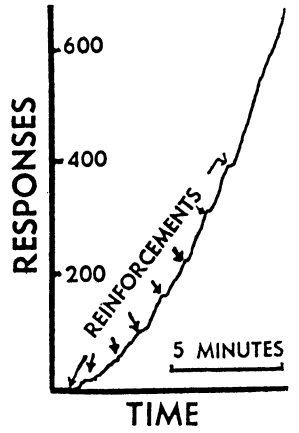

FIG. 1. "Reconditioning" of a superstitious response after extinction. The response of hopping from right to left had been thoroughly extinguished just before the record was taken. The arrows indicate the automatic presentation of food at one-min. intervals without reference to the pigeon's behavior.

There is a smooth positive acceleration in rate as the bird returns to the rate of responding which prevailed when it was reinforced every minute.

When the response was again extinguished and the periodic presentation of food then resumed, a different response was picked up. This consisted of a progressive walking response in which the bird moved about the cage. The response of hopping from side to side never reappeared and could not, of course, be obtained deliberately without making the reinforcement contingent upon the behavior.

The experiment might be said to demonstrate a sort of superstition. The bird behaves as if there were a causal relation between its behavior and the presentation of food, although such a relation is lacking. There are many analogies in human behavior. Rituals for changing one's luck at cards are good examples. A few accidental connections between a ritual and favorable consequences suffice to set up and maintain the behavior in spite of many unreinforced instances. The bowler who has released a ball down the alley but continues to behave as if he were controlling it by twisting and turning his arm and shoulder is another case in point. These behaviors have, of course, no real effect upon one's luck or upon a ball halfway down an alley, just as in the present case the food would appear as often if the pigeon did nothing—or, strictly speaking, did something else.

It is perhaps not quite correct to say that conditioned behavior has been set up without any previously determined contingency whatsoever. We have appealed to a uniform sequence of responses in the behavior of the pigeon to obtain an over-all net contingency. When we arrange a clock to present food every 15 sec., we are in effect basing our reinforcement upon a limited set of responses which frequently occur 15 sec. after reinforcement. When a response has been strengthened (and this may result from one reinforcement), the setting of the clock implies an even more restricted contingency. Something of the same sort is true of the bowler. It is not quite correct to say that there is no connection between his twisting and turning and the course taken by the ball at the far end of the alley. The connection was established before the ball left the bowler's hand, but since both the path of the ball and the behavior of the bowler are determined, some relation survives. The subsequent behavior of the bowler may have no effect upon the ball, but the behavior of the ball has an effect upon the bowler. The contingency, though not perfect, is enough to maintain the behavior in strength. The particular form of the behavior adopted by the bowler is due to induction from responses in which there is actual contact with the ball. It is clearly a movement appropriate to changing the ball's direction. But this does not invalidate the comparison, since we are not concerned with what response is selected but with why it persists in strength. In rituals for changing luck the inductive strengthening of a particular form of behavior is generally absent. The behavior of the pigeon in this experiment is of the latter sort, as the variety of responses obtained from different pigeons indicates. Whether there is any unconditioned behavior in the pigeon appropriate to a given effect upon the environment is under investigation.

The results throw some light on incidental behavior observed in experiments in which a discriminative stimulus is frequently presented. Such a stimulus has reinforcing value and can set up superstitious behavior. A pigeon will often develop some response such as turning, twisting, pecking near the locus of the discriminative stimulus, flapping its wings, and so on. In much of the work to date in this field the interval between presentations of the discriminative stimulus has been one min. and many of these superstitious responses are short-lived. Their appearance as the result of accidental correlations with the presentation of the stimulus is unmistakable.

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A Second Type of "Superstition" in the Pigeon

(WITH W. H. MORSE)

When food is given to a hungry organism, any behavior in progress at the moment must be assumed to be reinforced by this event. When small amounts of food are repeatedly given, a "superstitious ritual" may be set up. This is due not only to the fact that a reinforcing stimulus strengthens any behavior it may happen to follow, even though a contingency has not been explicitly arranged, but also to the fact that the change in behavior resulting from one accidental contingency makes similar accidents more probable. In an earlier experiment the automatic operation of a food-magazine every 15 sec. was found to induce hungry pigeons to engage in such ritualistic behavior as bowing, scraping, turning, and dancing [see page 524]. In some cases the behavior was stable, in others the topography slowly changed; but in all cases superstitious effects survived indefinitely. Similar effects from the adventitious reinforcement arising from the presentation of discriminative stimuli have recently been observed.[1] Such effects must always be allowed for in designing experiments on complex behavior.

Accidental, but nevertheless effective, relationships may arise in the *sensory* control of operant behavior. For example, a stimulus present when a response is reinforced may acquire discriminative control over the response even though its presence at reinforcement is adventitious. Suppose, for example, that an organism is responding at a moderate rate on a variable-interval schedule of reinforcement, and let an incidental stimulus (A) occasionally appear for a brief period. Even though there is no explicit temporal relation between the appearance of A and the program of reinforcement, a response will occasionally be reinforced in the presence of A.

From *The American Journal of Psychology*, 1957, *70*, 308–311.

[1] Morse, W. H. An analysis of responding in the presence of a stimulus correlated with periods of non-reinforcement. Unpublished doctoral dissertation, Harvard University, 1955.

For a brief period the frequency of such reinforcement may be appreciably greater than in the absence of *A*. An organism which is sensitive to slight differences in rate of reinforcement will form a discrimination; its rate of responding in the presence of *A* will become greater than in the absence of *A*. This might be called a positive sensory superstition. If, on the other hand, reinforcements happen to occur relatively infrequently in the presence of *A*, a discrimination will develop in the opposite direction, as the result of which the rate in the presence of *A* will be relatively low—a sort of negative sensory superstition.

When an accidental contingency has produced a higher or lower rate of responding in the presence of an incidental stimulus, a second effect follows. If the rate has fallen in the presence of *A* (because reinforcements have been relatively infrequent), responses will be even less likely to be reinforced in the presence of *A*. In the limiting case no responses will be made in the presence of *A*, and no response, of course, reinforced. Moreover, reinforcements which are made available during *A* are not obtained because responses are not made. The first response following the withdrawal of *A* is then reinforced, and the discrimination is further strengthened. Similarly, when the rate is increased during *A* because of favorable accidental reinforcements, all reinforcements set up during *A* are likely to be obtained, and if the preceding condition commands a relatively low rate, some reinforcements set up at that time may actually be obtained after *A* has appeared, to strengthen the discrimination.

Both types of "sensory superstition" have been demonstrated experimentally in the pigeon. The apparatus consisted of the usual experimental space 13 × 22 × 16 in. A small translucent plastic plate was mounted behind a 1-in. circular opening at head height on one wall. It was lighted from behind by an orange 6-w. bulb. The pigeon pecked this disk to operate the controlling circuit. Food was presented for reinforcement in an opening below this key. Water was available.

Three pigeons, two of which had previously been reinforced on other schedules, were placed on a variable-interval schedule of reinforcement with a mean interval of 30 min. The shortest interval between reinforcements was 1 min., the longest 59 min. Daily experimental sessions varied between 6 and 20 hr. in length. Body weight was maintained at approximately 80% of the *ad lib* weight, and a reinforcement consisted of access to mixed grain for 5 sec. The resulting performance was at a low mean rate of responding with some local irregularity. Against this baseline, an incidental stimulus consisting of a blue light projected on the key instead of orange was introduced for 4 min. once per hour. The schedule of occurrence of this stimulus was independent of the programming schedule. The rate of responding was recorded continuously in the usual cumulative curve. Brief downward movements of the pen marked reinforcements, and the pen remained down during the 4-min. period of the incidental stimulus, thus slightly displacing the record made in the presence of the stimulus without changing its slope.

Segments of records showing superstitious differences in rate under the control of the incidental stimulus are shown in Figure 1. Except for the

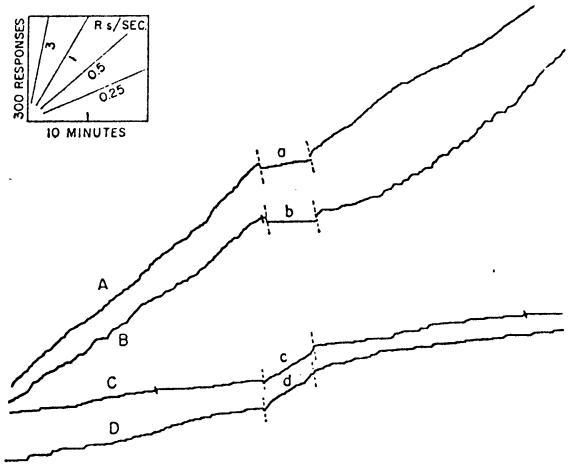

FIG. 1. Superstitious discriminative control of responding by an incidental stimulus. The stimulus is presented for 4 min. once per hour, and is marked by the downward displacement of the recording pen (*a*, *b*, *c*, and *d*). Curves *A* and *B* are segments of cumulative response-curves on a variable-interval schedule (mean interval = 30 min.) for a pigeon with a *lower* rate when the incidental stimulus is present than when it is absent—a "negative superstition." Curves *C* and *D* are segments for another pigeon on the same schedule with a *higher* rate in the presence of the incidental stimulus—a "positive superstition."

portions *a*, *b*, *c*, and *d*, the curves are characteristic of the baselines obtained on the schedule described above. Curves *A* and *B* are for a pigeon which showed sustained periods of negative superstition. The over-all rate generated by the schedule is relatively high (of the order of 0.5 responses per sec.). Whenever the incidental stimulus appears, the rate drops to a low value or to zero (*a* and *b*). Records *C* and *D* are for another pigeon showing a positive superstition. The base rate is relatively low, and the rate