

## TWO "SYNTHETIC SOCIAL RELATIONS"

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About 10 years ago, two demonstration experiments were designed for a General Education course in Human Behavior at Harvard. They were briefly described in an illustrated weekly and are occasionally referred to in the psychological literature. It seems advisable to publish a somewhat more explicit account.

### THE "PING-PONG" PLAYING PIGEONS

There were several versions of this apparatus, in one of which a motor-driven device returned the ping-pong ball to the playing surface so that the apparatus ran without attention. In a less mechanized version, the "ping-pong" table was approximately 8 in. wide, 16 in. long, and 8 in. high (Fig. 1). A pigeon standing at one end could conveniently peck a ball as it arrived at the edge of the table. If the ball rolled off the edge, it fell into a trough and tripped a switch which operated a food dispenser under the opposite edge and

thus reinforced the pigeon which "won the point." Light metal rails prevented the ball from falling off the sides of the table. The surface was slightly canted, sloping from a center line toward each edge so that the ball would not stop on it. Wire barriers prevented the pigeons from jumping up on the table but did not interfere with play.

In the finished performance, the demonstrator would start a ball near the middle of the table. It rolled to one edge and the pigeon on that side pecked it, driving it back across the table. At the other edge it was pecked by the other pigeon and thus returned. The pigeons usually watched the course of the ball as it crossed the table, and maneuvered into position to meet the return. They developed considerable skill in sending the ball straight across. Moving pictures show rallies of as many as five or six shots before a point was made. There is no evidence, however, that either pigeon reached the stage of placing or chang-

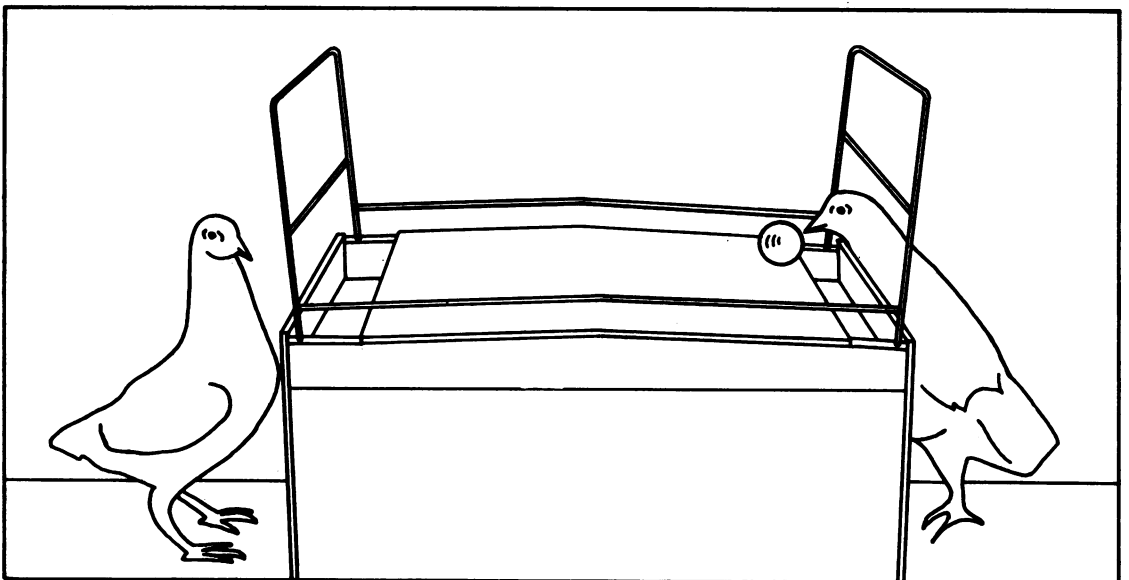


Fig. 1. Two pigeons "playing ping-pong."

ing the pace of its shots so that the opponent would miss.

Conditioning was begun with one pigeon at a time. A standard table tennis ball was fastened at the edge of the table, and a hungry pigeon was reinforced with food when it pecked it. At this stage the ball was not a powerful controlling stimulus; when it was moved to a different part of the edge, the pigeons often pecked the air where it had been. Eventually, however, they pecked the ball regardless of its position. The ball was then made free to roll away from the pigeon when struck. A mechanical reinforcing system was set up in which the ball, rolling up a slight grade, struck a cross-bar operating the food dispenser. The distance to the bar was gradually increased. If the ball failed to reach the bar, it rolled back and came to rest against a raised molding along the edge. The molding was later removed.

As the distance between the pigeon and the reinforcing bar was increased, reinforcement was more and more delayed, and the behavior occasionally suffered. Eventually, however, mediating behavior arose to bridge the temporal gap. Even so, in the final game, in which two pigeons participated, the delay between striking the ball and the successful outcome of getting the ball past the opponent was occasionally troublesome. A deteriorating performance could be rescued by reinforcing a pigeon with a hand-switch at the moment it struck the ball. Eventually the behavior was sustained not only for rallies of several shots at a time but for a full "game."

The demonstration offers a convenient example of competition. One bird is reinforced at the expense of another. If one is repeatedly successful, the other suffers extinction ("discouragement"). It was possible to maintain a reasonable balance in successful play by lowering the weight of the relatively unsuccessful bird or raising that of the successful, the principal effect being to sustain attention rather than alter accuracy or power.

### COOPERATING PIGEONS

Two pigeons in adjacent compartments were separated by a pane of glass. Three red buttons were arranged in a vertical row on each side of the glass, as shown in Fig. 2. The buttons were approximately 10 in., 7-1/2 in.,

and 5 in. from the floor, respectively. By pecking a button the pigeon closed a switch. In the final performance, both pigeons were reinforced with food (Fig. 2, below) when they pecked a corresponding pair of buttons so nearly simultaneously that the brief closures of the circuits (each lasting perhaps a tenth of a second) overlapped. At any given time, how-

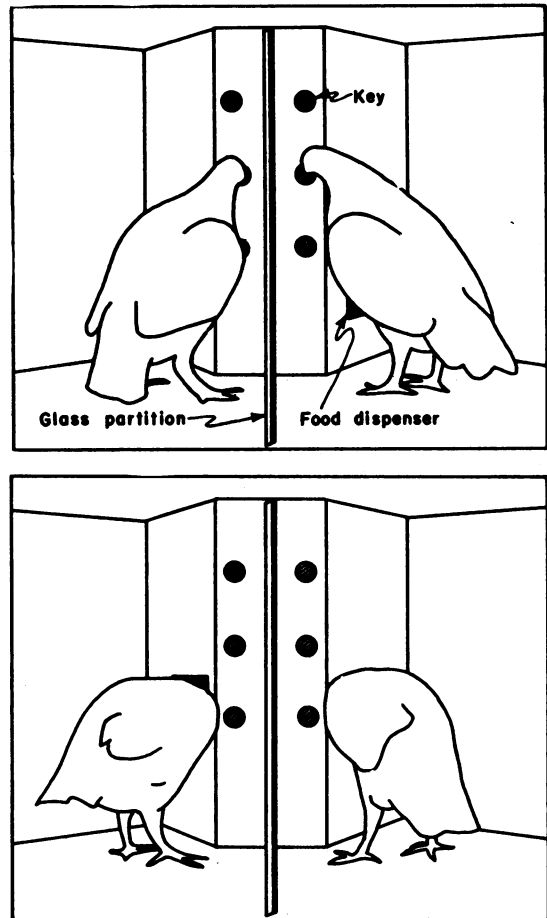


Fig. 2. Above: Two pigeons cooperating by pecking corresponding buttons at the same moment. Below: Pigeons eating from food dispensers.

ever, only one pair of buttons was operative, and the effective pair was scheduled in a roughly random way.

It was necessary for the pigeons to cooperate in two tasks: (1) discovering the effective pair and (2) pecking both buttons at the same time. In general, no pattern of exploration could be observed. The pigeons tested all three pairs of buttons in what was evidently an unsystematic way. In general, there was a division of

labor with respect to the two tasks. One pigeon (the "leader") explored—that is, it struck the three buttons in some order. A similar performance could have been generated in one pigeon alone in the apparatus by requiring simply that a given one of three buttons be struck. The other pigeon (the "follower") struck the button opposite that being struck by the leader. Similar behavior could have been generated in one pigeon alone in the apparatus if one button after another had been marked by a discriminative stimulus.

A well-marked leader-follower relation could be established or reversed by altering the relative level of food deprivation, the more deprived bird assuming the position of leader by moving more alertly to the buttons. However, even a decisive leader was probably to some extent following. A deprived pigeon would usually "wait to be followed" by one less deprived before exploring the buttons vigorously. Under levels of deprivation at which both birds responded quickly and without interruption, performance became so perfect that it gave the impression of one pigeon seen in a mirror.

The performance was established by conditioning each bird separately to peck the three buttons, reinforcement being roughly randomized. When sustained behavior occurred on all three buttons, two birds could be put in the adjacent spaces for the first time. The presence of another bird temporarily disturbed the performance, but both birds

eventually began to respond to the buttons. At this stage responses to corresponding buttons within, say, half a second of each other would trigger both food-dispensers. These contingencies sufficed to build cooperative behavior without further attention. The visual stimulation supplied by one pigeon pecking on a button became a discriminative stimulus controlling a response to the corresponding button on the part of the other.

Prolonged exposure to these conditions made pigeons strongly imitative in other respects. They would often drink from glasses of water in the compartments at the same time, for example. The extent to which their behaviors were mutually controlled was informally demonstrated when the experiment was shown to a group of biologists, one of whom suggested putting the birds in the opposite compartments. The birds immediately lined up alongside the glass plate, facing away from the buttons. They thus assumed their previously effective positions relative to each other, but were now facing the audience through the transparent front wall of the apparatus. Though no buttons were available, they immediately began to cooperate in exploring a corresponding area, bobbing up and down in a perfect mirror-image pattern under the control of each other's behavior. Possibly because the leader-follower relation had frequently been shifted, each bird was evidently largely controlled by the behavior of the other.

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