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Choice in Free-Ranging Wild Pigeons

Abstract. *A flock of free-ranging wild pigeons were trained to peck at buttons which, when operated, allowed brief access to grain. Although only one bird at a time could have access to the buttons, the pecks of the group were treated as an aggregate. When they chose between two buttons, each of which could occasionally produce grain, the ratios of pecks at the buttons approximately equaled the ratios of the grain presentations obtained from them. This accords with a relation well substantiated in the laboratory, the matching law. It suggests that the matching law may apply to the behavior of higher organisms in natural environments.*

In a typical laboratory or wildlife situation, an animal generally can engage in any of several alternative activities. Since at any moment one alternative occurs to the exclusion of others, behavior generally implies choice. This does not mean that behaving organisms have free will, but that the laws of behavior must be laws of choice among alternatives.

A law of behavioral distribution that has been well established in the laboratory is the matching law

$$\frac{B_1}{B_2} = \frac{r_1}{r_2}$$

where B_1 and B_2 are the rates of engaging in two alternative activities, and r_1 and r_2 are the rates of reinforcement (for example, food presentation) obtained from the two alternatives. The ratio of choices matches the ratio of reinforcement (*1*). Originally found with pigeons obtaining food by pecking at two buttons, the law has been extended to more alternatives, other types of activities, rats and human beings, and other reinforcers (*2, 3*).

The laboratory conditions that have produced these findings differ substantially from the natural situations of behaving organisms. Pigeons and rats in the laboratory are typically maintained at a fixed body weight, a certain percentage of that maintained by free feeding. The animals are exposed to the experimental situation for a small fraction of the day, and are never allowed to eat their fill. One may question, therefore, whether the matching law could apply to behavior outside these peculiar conditions.

An earlier study (*4*) provided a partial answer. Pigeons living continuously in the experiment, allowed to satiate and grow hungry again according to the needs of the body, distributed their choices between two sources of food according to the matching law.

A pigeon isolated from the world at large and others of its kind, however, remains in a highly artificial situation. In the experiment described here the inquiry was extended to wild pigeons in a natural habitat. It differed additionally from laboratory research in treating an aggregate of organisms, instead of isolated individuals.

The subjects belong to a flock of about 20 pigeons that live in a wooden-frame house in Cambridge, Massachusetts. An opening about 10 cm high and 1.5 m long allows them to freely enter and leave the attic of the house. The space in which they live, between the finished rooms, the roof, and the eaves, is roughly prismatic in shape, about 1.5 m at the high side, 1.5 m across, and 9 m long.

A version of the standard laboratory apparatus was placed in the living space, opposite the opening to the outside. The front panel contained three translucent buttons (response keys) and an opening through which a hopper full of mixed grain could be made available. Initially, a platform allowed the birds to stand in front of the panel at a height where they could reach the keys and grain hopper.

Preliminary training consisted of a modified form of autoshaping (*5*). The two side keys were covered, leaving only the center key available. At irregular intervals, averaging 1 minute, the key was transilluminated for 8 seconds, during which a peck at the key produced the reinforcer, access to grain for 4.5 seconds. If no peck occurred, the grain was presented at the end of the interval. The response key was dark during grain presentation. If a peck produced the grain, a new 8-second illumination of the key began as soon as the grain was withdrawn. This procedure continued for 6 days, until it appeared that the number of pecks and the amount of food eaten each day had reached a maximum. A perch wide enough (7 cm) to allow only one pigeon at a time access to keys and food replaced the platform. The schedule of grain presentation changed to one in which the key was lit continuously, except during grain presentation, and each peck produced grain. This continued for 3 days, and then the schedule became one which allowed grain presentation once every 30 seconds on the average, at variable intervals. This continued for 16 days, and then the center key was covered, the two side keys uncovered, and the first choice introduced.

Henceforth, pecks at each of the two keys produced grain on an independent schedule at variable time intervals. At first, each schedule allowed pecks to produce food at an average interval of 1 minute. In the succeeding choices, the average intervals for the left versus the right key, respectively, were 2 minutes versus 40 seconds, 2 minutes versus 30 seconds, and

2 minutes versus 1 minute. Several days after the last pair of schedules mentioned, the left response key went out of adjustment, producing a strong bias in its favor. The effects of the bias were studied, and then the keys were readjusted to operate with approximately equal force and excursion. A last pair of schedules was introduced then, with average intervals between opportunities for grain presentation of 4 minutes for the left key and 30 seconds for the right key. The pairs were maintained from 9 to 50 days, until the ratio of pecks at the two alternatives appeared stable from day to day. Any or all of the pigeons could contribute to the counts of pecks.

The procedure omitted a feature common in laboratory studies: the changeover delay. Absence of this contingency, which prevents reinforcement for a period following a change of keys, may count as one more respect in which these conditions were more natural.

Figure 1 shows data from the last 5 days of each situation. The ordinate gives the ratio of pecks at the left key (P_1) to pecks at the right (P_2). The abscissa gives the ratio of grain presentations for pecks at the left key (r_1) to grain presentations for pecks at the right (r_2). On the whole, the ratio of pecks approximately equaled the ratio of grain presentations, in accordance with the matching law. The tendency for the points to lie slightly above the locus of perfect matching (broken line) indicates a small bias in favor of the left key (*3, 6*).

Since the pigeons consumed between 300 and 400 g of food daily, several animals must have contributed to the data. Although the exact number can only be guessed, the food intake suggests that more than 10, and possibly 20, pigeons participated (*7*).

If each bird's pecks conformed to the matching law, so too would the total of their pecks. It is possible, however, for none of the individuals to conform to the law, and yet for the

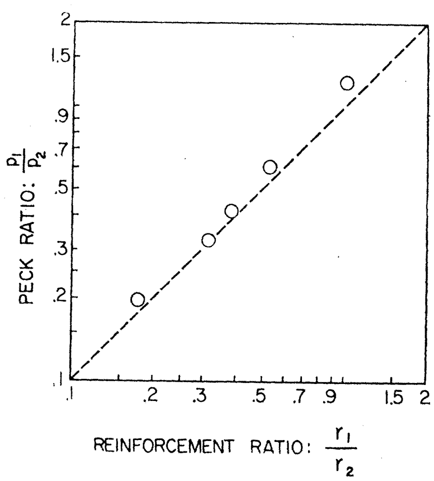

Fig. 1. Ratio of pecks at the left key to pecks at the right key as a function of the ratio of grain presentations (reinforcements) produced by pecks at the left key to grain presentations produced by pecks at the right key. Note the logarithmic coordinates. The broken line represents the relation prescribed by the matching law.

sum still to conform. In the extreme, each bird might have pecked at only one of the keys, but more birds may have chosen the more advantageous key, or those that chose it may have pecked it more. Informal observation ruled out this possibility; the individual animals did seem to distribute their pecks between the alternatives and did seem to prefer the more advantageous key.

If the pigeons pecked infrequently enough, most pecks would produce food, and the matching law would be trivially confirmed. The ratio of pecks to grain presentations ranged from 16 to 32 across the conditions. These ratios indicate that more than 90 percent of the pecks failed to produce food and therefore could have occurred at either key without affecting the distribution of food between the alternatives. In this sense, the pigeons' choices were almost completely unconstrained.

Choice was unconstrained in another sense, as well. Since the pigeons pecked mainly during daylight hours, and even then sometimes allowed hours to pass without a peck, they could have obtained more food from the apparatus than they did. They were, in addition, free to supplement the grain with food obtained outside the attic. It seems likely, therefore, at least in the situations where one alternative could produce food every 30 seconds, that the pigeons could have obtained all the grain they needed by pecking at only one of the keys. That they pecked at both keys suggests that the matching law emerges from properties of the organism, rather than properties of the apparatus.

In sum, these results strengthen the possibility that the matching law, well substantiated in the laboratory, may hold in the natural environment. If so, it may be a basic property of behavior in higher organisms.

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References and Notes

1. This relation differs from and is incompatible with probability matching. The probability of reinforcement equals r/P. Probability matching implies $P_1/P_2 = (r_1/P_1)/(r_2/P_2)$, which reduces to $P_1/P_2 = r_1^{1/2}/r_2^{1/2}$. For further discussion and an overview of findings on the matching law, R. J. Herrnstein, *J. Exp. Anal. Behav.* **13**, 243 (1970).
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7. Homing pigeons about the same size as the birds in this experiment require about 15 g of grain daily to maintain full body weight in the laboratory. When exercised, they require about 20 g. The birds in this experiment probably consumed 15 to 20 g each.

8. Supported by NSF grant GB-28493.

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