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AMOUNT CONSUMED VARIES AS A FUNCTION OF FEEDER DESIGN

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Studies of pigeon behavior in which magazine-cycle duration is varied suggest that many researchers assume that feeders of different designs dispense food at roughly the same rate. However, Epstein (1981) showed that, with a commonly used feeder, the amount of grain a pigeon consumes is a negatively accelerated function of magazine-cycle duration. The present experiment shows that, with a different commonly used feeder, amount consumed is roughly a linear function of magazine-cycle duration. At a duration of 60 seconds, the second feeder dispenses roughly 10 times as much food as the first. Thus, reports of studies in which magazine-cycle duration is varied should identify the design of the feeder employed, and in some cases, authors should consider determining the feeding functions for those feeders.

Key words: magazine-cycle duration, feeder design, amount of consumption, pigeons

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Magnitude of reinforcement has long been a variable of interest in studies of operant behavior in pigeons (e.g., Catania, 1963; Neuringer, 1967; Rachlin & Baum, 1969), and interest has been especially great in recent years. Two recent issues of the *Journal of the Experimental Analysis of Behavior,* for example, contain five papers in which amount of reinforcement was varied in pigeon studies (Davison & Hogsden, 1984; Gentry & Eskew, 1984; Logue, Rodriguez, Peña-Correal, & Mauro, 1984; Todorov, Hanna, & Bittencourt de Sá, 1984; Ziriax & Silberberg, 1984). Because standard laboratory equipment makes it difficult to regulate the amount of grain dispensed, amount is typically not manipulated directly. Rather, the duration of operation of standard pigeon feeders is varied. The amount of grain the pigeon consumes is assumed to be some orderly function of the duration of the magazine cycle. Although the assumption is usually not made explicit, many authors seem to believe that the amount consumed is roughly proportional to the magazine-cycle duration.

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Epstein (1981) showed that with a standard pigeon feeder (Gerbrands Model B), the amount of grain a pigeon consumes is a monotonically increasing, negatively accelerated function of the magazine-cycle duration, describable by a hyperbolic function of the form:

$$y = \frac{a(x - x')}{(x - x') + k},$$

where y is the amount (in grams) consumed per cycle, x is the magazine-cycle duration (in seconds), the asymptote a is the maximum amount (in grams) of grain retrievable from the well, x' is the minimum time (in seconds) required for the bird to lower its head and eat, and k determines the curvature of the function due, perhaps, to the decreasing availability of food as the bird continues to eat. With obtained values of 0.4 g for a and 0.5 s for x', and k selected for best fit, the function reduces to:

$$y = \frac{0.4\,x - 0.2}{x + 2.0},$$

which accounts for 97% of the variance in the obtained data. Although the curve is monotonic, for most practical purposes it is reasonable to say that the curve is linear up to a duration of about 7 s and that the birds obtain little or no food after that.

The present experiment shows that another commonly used feeder, manufactured by Lehigh Valley Electronics, produces a strikingly different function that is more consistent with the unstated assumption of proportionality. The fact that these functions are so different is a matter for concern because published studies in which reinforcer amount is a variable of interest do not seem to take into account the fact that amount consumed varies with different feeders.

METHOD

Subjects

Four adult male Racing Homer pigeons (40YP, 42YP, 44YP, and 45YP) served as subjects. Each had had a variety of laboratory experience, and each had been used recently in the chamber employed in the current experiment.

Apparatus

The chamber had one standard key, positioned above the feeder opening. The chamber was equipped with white noise and a ventilating fan. The feeder area was illuminated with white light whenever the feeder was operated. A white keylight and white overhead light were extinguished during reinforcement but otherwise were illuminated during a session. The feeder was manufactured by Lehigh Valley Electronics and was not marked with a model number. The design and dimensions of the food magazine are given in Figure 1a. Events were controlled and recorded by a TRS-80® microcomputer.

The amount of grain consumed in each session could be predetermined using a device attached to the feeder, as in Epstein (1981). The device is pictured in Figure 2.

Procedure

The device was loaded with 10 g of food (a 50:50 mixture of milo and hard spring wheat) before every session, and sessions were terminated when the 10 g of food had been consumed. Each key peck operated the feeder. Magazine-cycle duration was varied from 1 to 60 s, and nine durations were tested. For all

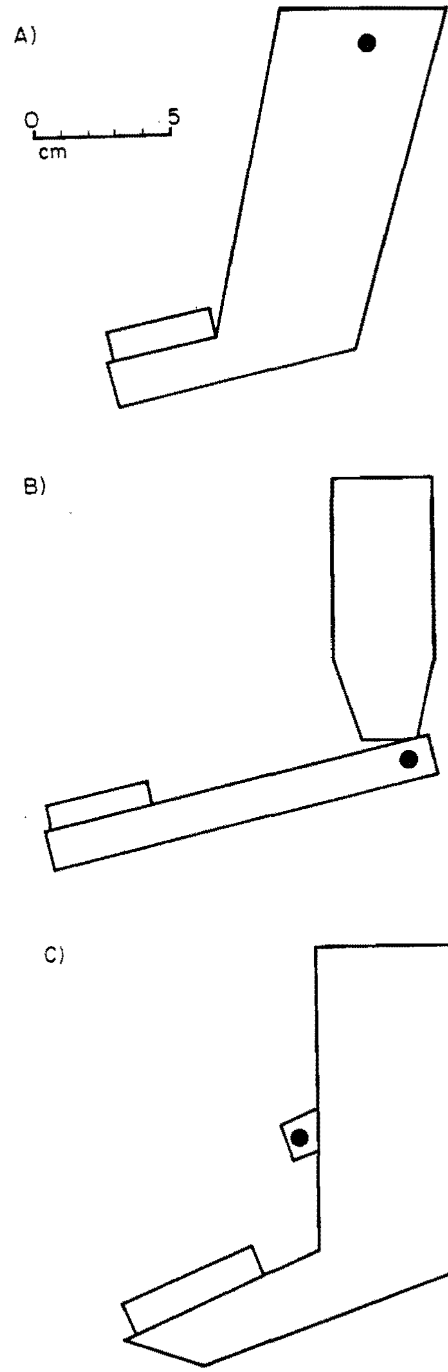

Fig. 1. Three common magazine designs. (a) A one-piece (Design A) magazine, manufactured by Lehigh Valley Electronics. (b) A two-piece (Design B) magazine, Model B of the Gerbrands Corporation. (c) Another one-piece (Design A) magazine, the Gerbrands 5610. The black dot in each diagram identifies the pivot point.

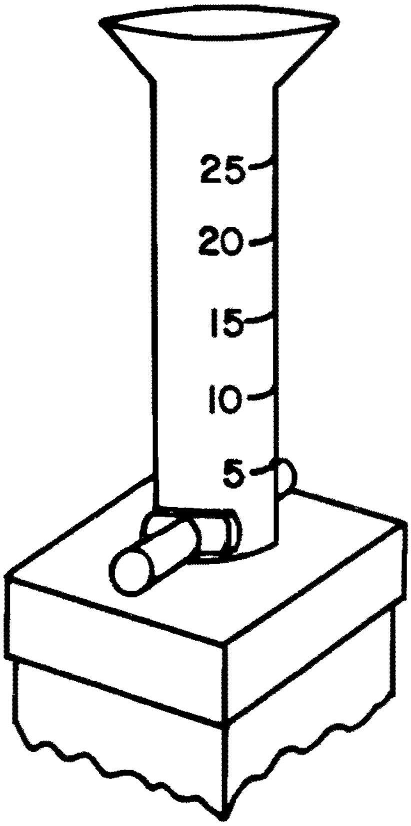

Fig. 2. A simple device that allows the average amount consumed per magazine cycle to be determined. The tube is mounted snugly into the opening of the magazine (the graded markings are helpful but not necessary). A photocell and light bulb are mounted at the base of the tube. A session ends when the photocell is activated, at which point the food is level with the photocell. If a measured amount of food is added at the beginning of the next session, then presumably when the photocell is activated again, that amount of food has been consumed. (The solenoid, springs, and foam rubber must be carefully adjusted to avoid spillage on either side of the panel.)

subjects, the order of durations was: 3, 5, 7, 2, 12, 16, 1, 30, and 60 s. Five daily sessions were run at each duration.

RESULTS AND DISCUSSION

The results are shown in Figure 3 and Table 1. With the Lehigh Valley Electronics feeder, the average amount of grain consumed during each magazine cycle proved to be a reasonably linear function of magazine-cycle duration, especially in the range from 1 to 30 s. A straight line through the obtained points fits them well (Figure 3). The pigeons seemed to have continuous access to grain, even after 60 s of feeding. The curve has no obvious asymptote, although it appears to be slightly concave downward, and presumably an asymptote would appear at the point the birds began to satiate.

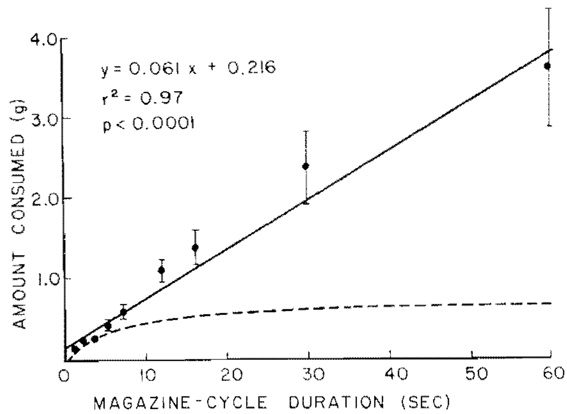

Fig. 3. Average amount of grain consumed per magazine cycle as a function of magazine-cycle duration, determined for a Lehigh Valley Electronics feeder with a one-piece magazine (Figure 1a). Error bars represent one standard deviation to either side of the mean. Each point is based on the last 3 sessions in each condition, averaged across the 4 subjects. The average amount consumed per cycle during each session was calculated by dividing 10 g by the number of feeder operations during that session. The broken line represents the curve reported by Epstein (1981) for the Gerbrands Model B feeder (Figure 1b).

Clearly, different feeders make a difference. A model that can dispense only 0.3 g of grain after 16 s (and that dispenses almost all of it within the first 7 s) should have different effects on behavior than a model that can dispense 1.4 g of food during the same interval (and that dispenses the food at a constant rate). With the two models tested, the differences in effects should become progressively greater at increasingly longer magazine cycles. At a magazine-cycle duration of 60 s, one feeder delivers roughly 10 times as much grain as the other.

As noted above, these results are of concern mainly because some published reports of studies in which duration of reinforcement was varied (and sometimes exceeded 7 s) do not specify the design of the feeder. Among the

Table 1
Regression Data for Individual Subjects

Subject	Slope	Intercept	r^2
40YP	.060	.151	.98
42YP	.050	.250	.95
44YP	.065	.189	.96
45YP	.055	.308	.94

five recent studies mentioned earlier, three provide adequate information about the feeders used or report reinforcement duration less than 7 s: Gentry and Eskew (1984) report hopper durations that only rarely exceeded 7 s and give both the make and the model of the chamber (the design of the feeder normally supplied with that chamber could presumably be determined). Ziriax and Silberberg (1984) give no clues about the design of the feeder but report durations no longer than 6.25 s. Todorov et al. (1984) report durations as long as 15 s, but both the make and the model of the chamber are given (again, the design of the feeder normally supplied with that chamber could presumably be determined).

There is greater cause for concern in the remaining two papers. Logue et al. (1984) report magazine-cycle durations as long as 10 s and give neither the make nor the model of either the feeder or the chamber. Davison and Hogsden (1984) report magazine-cycle durations as long as 10 s, and neither the make nor the model of either the chamber or the feeder is given. The authors state, however, that the feeder was "very similar in design" (p. 178) to the one described by Epstein (1981). They further note a behavioral effect which, they say, is the "exact opposite" (p. 178) of what one might expect from the negatively accelerated function reported by Epstein (1981). The "effect" or "value" of increasingly longer hopper durations was considerably greater than what one might expect if amount eaten were the sole determinant. But Epstein (1981) did not diagram the feeder that was tested and referred to it only as a "Gerbrands Model B," the name the company currently uses for that model. At the time of its manufacture, however, this feeder did not bear a "Model B" label, and it is therefore possible that Davison and Hogsden (1984) were using a feeder that dispensed grain at a more constant rate than the Gerbrands Model B. If so, their claim that the "*effect* or *value* of reinforcer durations . . . may not be linearly related to either arranged durations or to times spent eating" (p. 178) is unsupported by their data. Theoretical issues of this sort cannot easily be resolved unless feeder designs are specified and feeding functions are known.

The two-piece magazine design (Figure 1b) —which, for future reference, we might call Design B—produces the negatively accelerated function given in Epstein (1981). Newer feeders that employ a one-piece magazine design (e.g., Figures 1a and 1c)—which we might call Design A—may yield reasonably linear functions. Unfortunately, Design A magazines also vary. The Gerbrands Model 5610, for example, is proportioned differently than the Lehigh Valley Electronics unit and pivots at a different point (Figures 1a and 1c). Moreover, many investigators use custom-built feeders or modified commercial feeders. Thus, in order to ensure comparability and replicability in studies in which hopper duration is varied, investigators should consider calibrating their feeders using a method such as the one described in Figure 2.

Investigators might also consider arranging long hopper durations by operating a feeder repeatedly for short intervals (say, 2 or 3 s). Thus, the supply of food available at the feeder opening would be repeatedly replenished.

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