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# THE EFFECT OF THE SIZE OF THE TEST ENVIRONMENT ON BEHAVIOR UNDER TWO TEMPORALLY DEFINED SCHEDULES

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The effect of the size of the floor area of the operant test chamber on behavior was tested using a standard-size test chamber and a test chamber with one-fourth of the floor area of the standard chamber. Two groups of pigeons were tested under a differential-reinforcement-of-low-rate 15-sec schedule or a variable-interval 60-sec schedule. Both groups of pigeons had higher response rates while in the smaller floor area. Pigeons under the differential-reinforcement-of-low-rate schedule also showed a decrease in rate of reinforcement, an increase in ratio of responses to reinforcements, and an alteration in interresponse-time-per-opportunity distributions when tested in the reduced floor-area condition. These effects are similar to those found under physical restraint, indicating that amount of floor space available for locomotion interacts with schedule behavior and that physical restraint may be regarded as the lower limiting value of amount of floor area available for locomotion.

As a result of the biological interpretations of recent experiments in the area of animal learning (Seligman and Hager, 1972; Staddon and Simmelhag, 1971), it has been suggested that an analysis of the interaction of biological factors and the arbitrary experimental conditions of these experiments can and should be a fruitful area of research (Schwartz, 1974). Some of these arbitrary and standardized aspects of the operant-conditioning experiment involve the static physical properties of the experimental chamber itself—in a sense its architecture. These architectural properties (*e.g.*, area, volume, and shape) may interact with species response characteristics to predefine the interaction between the behaving organism and the dynamic stimuli of the environment. Since the architectural properties of the test environment have generally not been systematically varied, the effects of such factors on ongoing behavior have not been determined. This is especially true for certain types of operant tasks. Indeed, in a recent review of behavior maintained by the DRL (differential-reinforcement-of-low-rate) schedule of reinforcement, Kramer and Rilling (1970) suggested that variations in the size of the experimental chamber may affect the pigeon's performance under this schedule and indirectly reveal something about the pigeon's characteristically "poor" performance under the DRL schedule. More recently, Sprott and Symons (1974) suggested that the difficulties encountered during attempts to condition bar pressing in mice may also be due to the size of the chamber.

The static environmental properties of area and/or volume may be viewed as defining the amount of space available to the organism. Theoretically, the amount of available space surrounding the organism can vary from zero to infinity. Most everyday evaluations of available space, however, are made only in terms of floor area; height is held relatively constant. Volume is usually considered with respect to one particular and infrequently encountered condition—physical restraint. In this condition, effective volume of space and floor area approach values equal to that of the restrained organism itself.

Recently, research on the effects of physical restraint on the performance of pigeons under a DRL schedule of reinforcement has been reported (Richardson and Loughead, 1974). Contrasted with their performance in the standard chamber, restrained pigeons showed higher response rates, altered frequency distributions of IRTs (interresponse times), and

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lower rates of reinforcement. If physical restraint is an end-point on a continuum of available space, then it may be possible to define the function that obtains between ongoing behavior and other values along this continuum.

The present study attempted to determine whether manipulating floor space at values between zero and the standard chamber dimensions would produce much the same behavioral effects that physical restraint produced in the Richardson and Loughead (1974) study.

## METHOD

### *Subjects*

Six homing pigeons were maintained at 75% of their free-feeding weights. Three subjects (P1, P2, P3) were giant homing pigeons and were previously trained under a DRL 30-sec schedule of reinforcement; the other three subjects (P4, P5, P6) were racing homing pigeons and were previously trained under a variable-interval (VI) 60-sec schedule.

### *Apparatus*

Subjects P1, P2, and P3 were tested in three identical BRS-Foringer test chambers, 49.5 by 35.6 by 35.6 cm (L by W by H—internal dimensions). Subjects P4, P5, and P6 were tested in three identical chambers 51.7 by 35.6 by 37.8 cm (L by W by H—internal dimensions). For both sets of chambers, a force of 15 to 20 g (0.15 to 0.20 N) was required to operate a Plexiglas paddle manipulandum mounted behind a 2.5-cm opening on the wall of the chambers. The rear side of the paddle was painted flat black, except for a circle 1 cm in diameter centered behind the keyhole. Reinforcement for P1, P2, and P3 was a lighted 3-sec access to mixed grain through an opening below the key. For P4, P5, and P6, the reinforcer was one 45-mg Noyes pigeon pellet delivered to a Scientific Prototype food tray centered 7.7 cm below and 5 cm to the left of the response key. A shielded bulb located 5 cm above the food cup directed light into the food cup for 1 sec when a reinforcer was delivered. Lamps mounted above the panel walls and shielded by translucent Plexiglas screens provided general illumination. White noise (90 dB) and ventilating fans provided masking noise for both sets of chambers. An IBM-1800 Data Acquisition and Control System controlled experimental events and recorded data (Ellen, DeLoache, and Bonds, 1972).

Two areas of floor space were selected as values of the independent variable. Condition Reg was the regular amount of floor space provided by the test chambers—1762 $cm^2$ for the BRS-Foringer chambers, 1840.5 $cm^2$ for the other chambers. In the other condition (Small), the subject was contained in an insert positioned inside the standard test chambers. The insert was a three-sided cardboard rectangle 22.8 by 20.3 by 35.6 cm (L by W by H) that reduced the available space of the subjects' chamber to 465 $cm^2$. The cardboard insert was placed so that the relative positions of feeder apparatus and keys to the sides of the insert were the same as obtained in the standard chambers. The insert was fitted flush against the panel wall and snug to the chamber's floor and ceiling.

### *Procedure*

Table 1 presents the experimental conditions (Small *verus* Reg) and the number of sessions in each of the phases for each subject. For all subjects, the house and response-key lights were illuminated at the beginning of the session and were extinguished at the end of the session.

*DRL subjects.* For Subjects P1, P2, and P3 throughout the experiment, each response with an IRT longer than or equal to 15 sec resulted in 3-sec access to mixed grain (DRL 15-sec). Sessions were 32 min in duration and normally

Table 1

Experimental phases in the order administered, experimental condition in each phase, and the number of sessions per phase (in parentheses) for each subject.

| | | Phases | | | | |
|---|---|---|---|---|---|---|
| | *Subjects* | *1* | *2* | *3* | *4* | *5* |
| DRL 15-sec | P1 | Small (10) | Reg (10) | Small (10) | Reg (10) | Small (7) |
| | P2 | Small (10) | Reg (10) | Small (10) | Reg (10) | Small (7) |
| | P3 | Reg (10) | Small (10) | Reg (10) | Small (10) | Reg (7) |
| VI 60-sec | P4 | Reg (15) | Small (16) | Reg (12) | | |
| | P5 | Reg (15) | Small (16) | Reg (12) | | |
| | P6 | Small (15) | Reg (16) | Small (12) | | |

occurred each day. The subjects were pretrained for seven sessions in the standard-sized chamber before the experiment proper began.

*VI subjects.* For Subjects P4, P5, and P6 throughout the experiment, a VI 60-sec schedule was in effect. Sessions were 40 min in duration and normally were conducted each day.

## RESULTS

Figure 1 presents the mean response and reinforcement rates in blocks of two sessions over all phases for subjects trained under the DRL schedule. All subjects responded at higher rates during the initial exposure to condition Small when compared to the following (and preceding—P3) condition Reg. P1 and P2 consistently responded at a higher rate across all experimental phases when in condition Small, and in Phases 2, 3, and 4 this Reg-Small rate difference increased. P3 showed a substantial increase in response rate when first tested in condition Small (Phase 2). Responding then decreased in the following condition Reg of Phase 3, but the obtained high rates in Phase 2 were not recovered in condition Small of Phase 4.

All subjects consistently had a higher rate of reinforcement when under condition Reg than under condition Small (see Figure 1). The difference in reinforcement rate between conditions Small and Reg generally increased across phases for all subjects.

The number of responses emitted per reinforcer obtained was also calculated. Averaged across experimental phases for the last five sessions of each condition, P1 emitted 7.4 responses per reinforcer in condition Reg and 178.0 in condition Small. P2 emitted 65.0 responses per reinforcer in condition Reg and

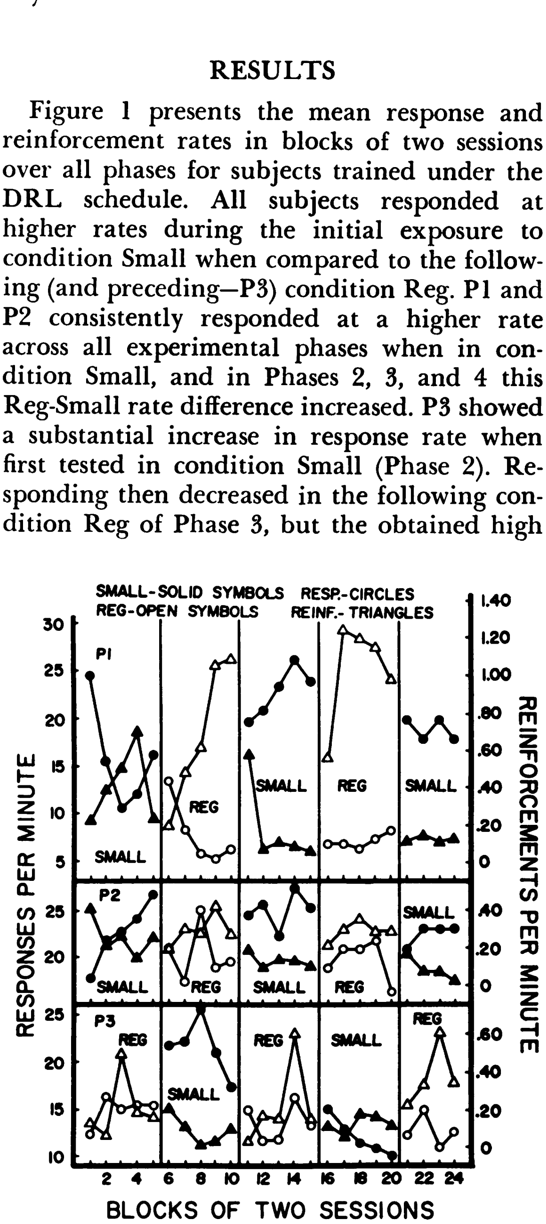


Fig. 1. Responses per minute (left y-axis) and reinforcements per minute (right y-axis) across blocks of two sessions for individual subjects. The last datum point represents one session.

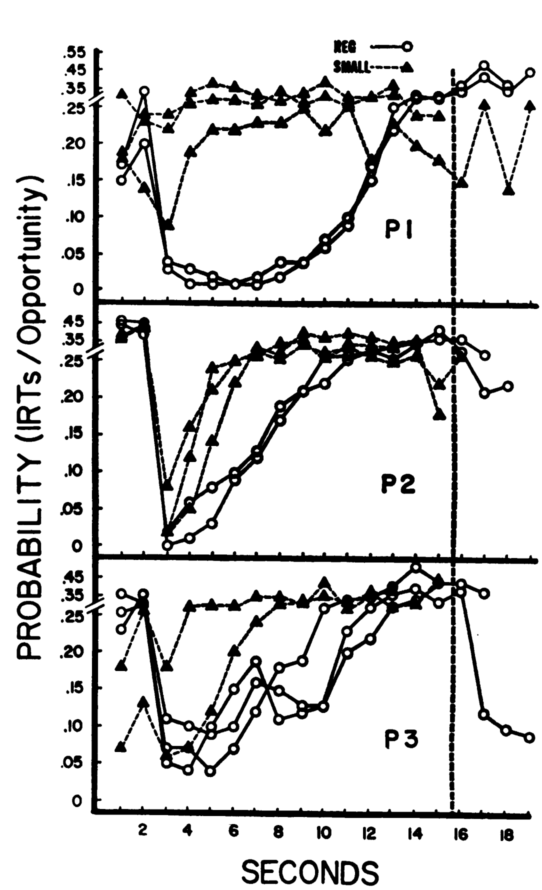


Fig. 2. Response-probability distributions (IRTs/Opportunity) of IRT values. Each curve represents the mean of the last five sessions of each experimental phase. Solid lines—condition Reg. Dashed lines—condition Small. Only intervals with at least 20 opportunities were plotted. Each interval is 1-sec wide. The numbers on the x-axis represent the nominal upper limit of the interval, *e.g.*, interval 15 contains all IRTs from 14.00 through 14.99 sec in duration. Responses to the right of the vertical dashed line were reinforced.

208.0 in condition Small. The results for P3 were 57.6 for condition Reg and 200.5 for condition Small.

Figure 2 presents the response-probability distributions for responses terminating IRT values across 1-sec class intervals for subjects tested under the DRL 15-sec schedule (IRTs per opportunity statistic; after Anger, 1956). In condition Reg, all subjects showed peaked bimodal response-probability distributions with one mode at 2 sec and the other mode at or near the DRL value of 15 sec. In condition Small, all three subjects showed a "flat" function from IRTs of 6 sec through the DRL value; *i.e.*, an increase in the probability of unreinforced IRTs between the peak at 2 sec and the DRL value when compared to condition Reg. The differences in the shapes of the distributions are easiest to see in the data of P1. For this subject, the smaller area effectively eliminated the bimodal nature of the baseline distribution.

Figure 3 shows the response rates for subjects trained under the VI 60-sec schedule. The response rates are presented for blocks of two sessions. The figure shows that two of the three subjects responded more frequently when in the Small condition. P4 showed a substantially higher response rate when in condition Small than when in condition Reg. During the 12 sessions of return-to-baseline conditions (Reg), P4's response rate decreased but baseline rates were not fully recovered. P6 showed a consistent but smaller increase in response rate when in condition Small. Subject P5 showed little if any effect on response rate of the reduced area.

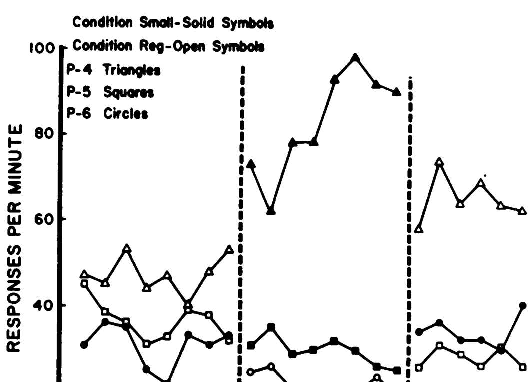


Fig. 3. Responses per minute for individual subjects under the VI 60-sec schedule. The left panel is Phase 1, middle panel is Phase 2, and the right panel is Phase 3. Each point is the mean of two successive sessions except for the last point of Phase 1, which represents one session.

## DISCUSSION

This experiment compared behavior under two temporally defined schedules in the floor space of a standard experimental chamber, and in only one-fourth as much floor space. The rate and distribution of pecking were found to be a function of floor space. Under the DRL schedule, subjects responded at a higher rate and received fewer reinforcements; *i.e.*, their response patterns were clearly less "efficient".

These effects are similar to those obtained by Richardson and Loughead (1974). In that study, physical restraint was used as a way of preventing locomotor behavior by the pigeon that typically occurs under a DRL schedule. The present results indicate that an area less than standard, yet that still permits locomotion, produces much the same, albeit a less-robust effect. Further research with other schedules and parameters of the same schedules used here is necessary before any firm generalizations can be made, but it seems probable that schedules (or parameters, or even subjects) that induce more behavior away from the manipulandum will be more affected by a restriction in available space. Barrera (1974) showed that a major determinant of the persistence of key pecking under a food-omission procedure (automaintenance) is the actual distance of the birds from the response key during trials. As the actual distance of the birds from the key is likely to be a function of chamber size, the magnitude of the automaintenance effect should also be a function of chamber size.

Given that physical restraint and restricted space produce much the same results, it also seems possible that chambers larger than standard may affect performance of pigeons under temporally defined schedules of reinforcement, especially under the DRL schedule. At any rate, it appears that available space may also be an important consideration in assessing conflicting experimental results when temporally defined schedules have been employed.

## REFERENCES

Anger, D. The dependence of interresponse times upon the relative reinforcement of different interresponse times. *Journal of Experimental Psychology*, 1956, **52**, 145-161.

Barrera, F. J. Centrifugal selection of signal-directed pecking. *Journal of the Experimental Analysis of Behavior*, 1974, **22**, 341-355.

Ellen, P., DeLoache, C. H., and Bonds, J. Time-shared control of a variety of psychological laboratories using the IBM 1800 data acquisition and control computer. *Behavioral Research Methods and Instrumentation*, 1972, **4**, 81-85.

Kramer, T. J. and Rilling, M. Differential reinforcement of low rates: A selective critique. *Psychological Bulletin*, 1970, **74**, 225-254.

Richardson, W. K. and Loughead, T. The effect of physical restraint on behavior under the differential-reinforcement-of-low-rate schedule. *Journal of the Experimental Analysis of Behavior*, 1974, **21**, 455-461.

Schwartz, B. On going back to nature: a review of Seligman's and Hager's *Biological boundaries of learning*. *Journal of the Experimental Analysis of Behavior*, 1974, **21**, 183-198.

Seligman, M. E. P. and Hager, J. L. *Biological boundaries of learning*. New York: Appleton-Century-Crofts, 1972.

Sprott, R. L. and Symons, J. P. Operant performance in inbred mice. *Bulletin of the Psychonomic Society*, 1974, **4**, 46-48.

Staddon, J. E. R. and Simmelhag, V. L. The superstition experiment. *Psychological Review*, 1971, **78**, 3-43.

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