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# BRIEF COMMUNICATION

# Schedule-Dependent Effect of d-Amphetamine on Pausing by Pigeons[1]

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ECKERMAN, D. A. AND J. D. EDWARDS. *Schedule-dependent effect of d-amphetamine on pausing by pigeons.* PHARMAC. BIOCHEM. BEHAV. 8(3) 319–321, 1978. – Two pigeons were exposed to a multiple schedule of grain reinforcement where key-pecks were reinforced according to a fixed ratio schedule in the presence of one stimulus and a fixed interval schedule in another stimulus. The fixed interval was adjusted to match average interreinforcer time for the fixed ratio schedule. d-Amphetamine decreased overall rate of responding in the fixed ratio schedule – primarily by increasing pausing, especially just after a change from the fixed interval component. Rate of responding in the fixed interval schedule was increased for one bird and little affected for the other bird by d-Amphetamine. Again, changes in pausing primarily determined rate change. Since pausing was differently affected, a schedule-dependent rather than rate-dependent effect was indicated.

Rate dependency d-Amphetamine Schedule of reinforcement Fixed ratio Fixed interval Pigeons

THE effects of d-Amphetamine and other drugs on behavior are frequently found to be rate-dependent (see [3] for review) in that high-rate behaviors are decreased in frequency and low-rate behaviors are increased in frequency, as long as some minimum tendency to respond is present. Thus, the high-rate behaviors maintained by fixed ratio (FR) schedules of reinforcement (e.g. food provided for each Nth response) are reduced by all behaviorally active doses of d-Amphetamine; low-rate behaviors maintained by fixed interval (FI) schedules of reinforcement (e.g. food presented for the first response after T-sec following the last food presentation) are increased by intermediate doses of d-Amphetamine. If values of the FR and FI are chosen, however, such that the FI produces high-rate and the FR produces low-rate behavior, the drug effect has been found to be appropriate for the rate rather than for the schedule [2].

While the rate-dependency effects typically focus on overall rate of responding (responses per minute), however, an alternate conceptualization of operant behavior focuses instead on the pauses between responses. Weiss and Gott [4], for example emphasize that the effect of d-Amphetamine is to increase the likelihood that the pigeon will cease pecking a key for a while. This occasional disruption of the ratio run results in a decreased average rate even though the typical rate is unaffected. The first pause following the reinforcer was especially liable to this type of disruption in the FR30 schedule studied by Weiss and Gott.

On the other hand, the initial pause was found to be reduced by d-Amphetamine over a wide range of FI schedules [1]. This decreased pausing yielded an increased average rate even though the typical rate while responding was little affected or was even reduced.

The above observations were made using simple reinforcement schedules. Their results stand in partial contradiction ot those found by McMillan [2] who used a multiple reinforcement schedule including both FR and FI schedule components. The present brief note presents data confirming the Weiss and Gott [4] and the Branch and Gollub [1] results, using a multiple FI FR schedule.

The schedule used involved FR and FI schedule values chosen so that (a) the FR was the largest value which maintained consistent, brief pausing for a bird and (b) the FI was continuously adjusted so that the rate of reinforcement was the same as that for the FR. Differences in drug effect between the two components could not, therefore derive from this variable. Also, schedules alternated every five reinforcers so that transient effects of changing from one component to the other could be assesed.

## METHOD

### *Animals*

Two four-year-old male white Carneaux pigeons with extensive experimental histories with the present reinforce-

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ment schedules were maintained at 75% of free-feeding weight.

*Apparatus*

The two-key operant chamber for pigeons measured 30.5 cm(h) x 27.9 cm(w) x 30.5 cm(l). Response keys were 2.2 cm dia. circles spaced 7.6 cm apart at a height of 18.7 cm. In the present experiment, only the left key was used. A white horizontal line or a green field could transilluminate the key. A small white ceiling light provided general illumination. Mixed grain could be presented through an opening centered below the keys. Three-sec access to grain as the feeder opening was illuminated (key-light and house light extinguished) served as reinforcement for pecking the left key.

*Procedure*

*Baseline reinforcer schedule.* A multiple schedule was used, including FR and FI components. When the horizontal line was present, reinforcers were given for every Nth peck. This number was 95 for B628 and was 60 for B945. These values had been determined from prior work as the largest values which would maintain consistent, brief pauses. They were thus functionally equal, though numerically unequal. The horizontal line was present during five successive reinforcers before the stimulus changed.

When the green light was present, reinforcers were presented for the first response emitted after a fixed time had elapsed since the last reinforcer. Though fixed within a session, this time was established for each session by averaging the times between FR reinforcers for the last 5 non-drug sessions. Stabilized performances meant that the FI values were much the same from session to session for a bird. And, for each bird, the average time between FR reinforcers was the time between FI feinforcers. The green light also was present during five successive reinforcers before the stimulus changed.

Daily sessions were terminated after either (a) five presentations of each component (i.e. 50 reinforcers) or (b) 90-min, whichever occurred first. Whether FR or FI was presented as the first component of a session was determined by a scrambled sequence. Drug conditions described below followed over a year's training with procedures similar to these.

*Drug administration.* A three-session cycle repeated: drug administration sessions (IM injection in pectoral muscle 10 min prior to session) were followed by no injection control sessions were followed by vehicle injection (water) control sessions. d–Amphetamine was administered in an increasing series, a decreasing series, and a final increasing series. Values used were 0.3, 1.0, and 3.0 mg/kg (B945) and 0.3, 1.0, 3,0, and 10.0 mg/kg (B628). The 10.0 mg/kg value was added for B628 due to lower drug effect for this bird.

## RESULTS

Overall rate of responding was affected in a manner consonant with the rate-dependency description (see Fig. 1). Responding under the higher-rate FR schedule was decreased for both birds. Responding under the lower-rate FI schedule was increased (B628) or at least unchanged in rate (B945) across intermediate doses of d-Amphetamine.

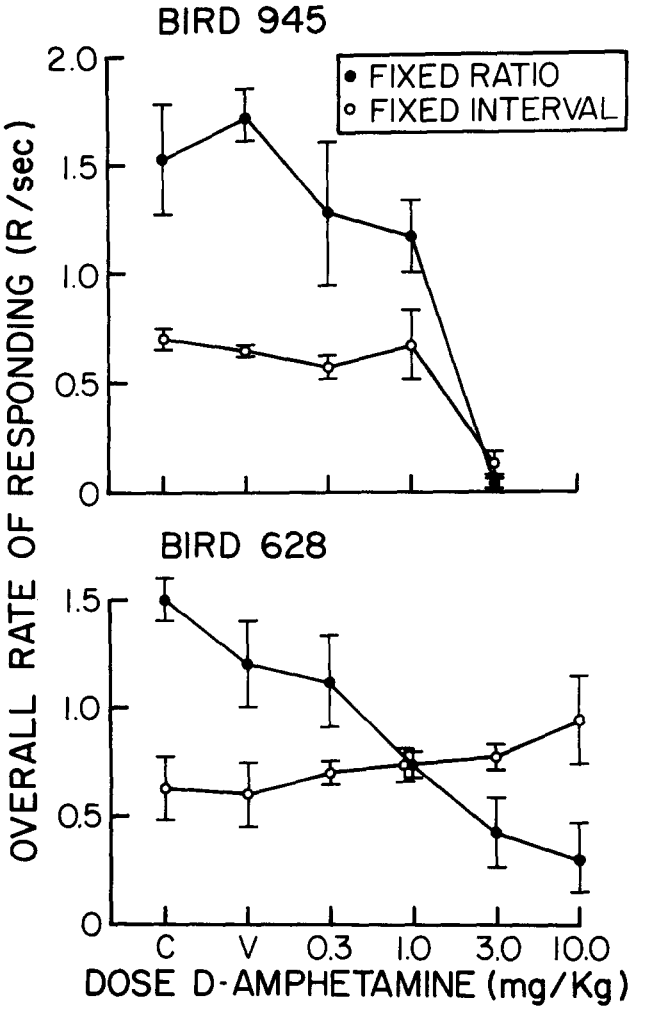


FIG. 1. Effect of d-Amphetamine on rate of pecking a key for food delivered according to fixed ratio (FR) and fixed interval (FI) schedules of a multiple FR FI schedule.

In fact, FI rate was increased for B628 at a relatively high dose (10.0 mg/kg).

The closer inspection of the performance allowed by cumulative records, however, shows that the overall rate does not adequately describe the changes (see Fig. 2).

The FR performance was largely reduced in rate because with d-Amphetamine, long pauses became frequent. Rate of responding during continuous runs was little affected. The FI performance was also determined by the effect of the drug on pausing. Pausing in FI was decreased (B628) or little changed (B945). These effects were especially clear for the first of the five reinforcers of each component, as summarized in Table 1. With 3.0 mg/kg, for example, B945 never completed an FR component (whether the FR or FI was presented first in the session) but completed the FI component about as normal. Pausing in the two schedules was clearly affected differently.

## DISCUSSION

Pausing in the FR was increased while pausing in FI was

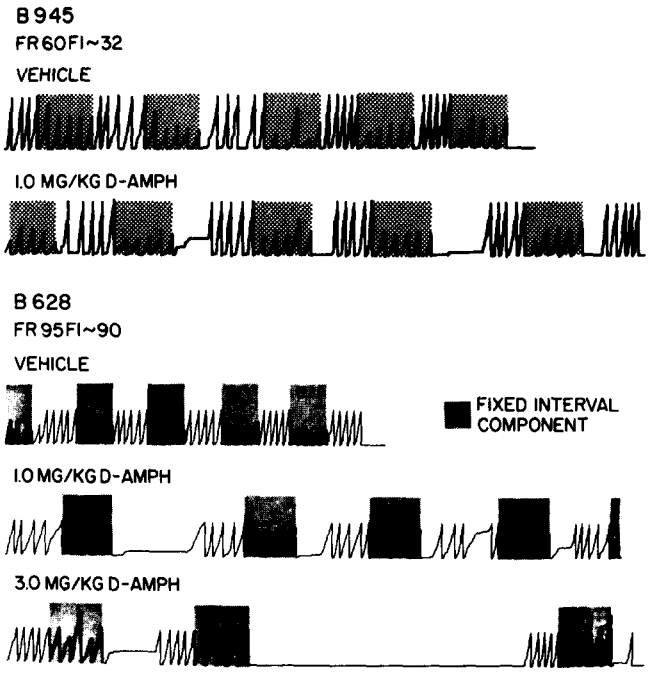


FIG. 2. Cumulative response records for two pigeons key-pecking under multiple fixed ratio fixed interval schedules.

TABLE 1

PAUSE BEFORE FIRST REINFORCER OF A COMPONENT

| | Fixed Ratio | | | Fixed Interval | | |
|---|---|---|---|---|---|---|
| Dose | Mean | SE | N | Mean | SE | N |
| | | | Bird 628 | | | |
| Control | 10.0 | 4.7 | 15 | 22.9 | 5.8 | 15 |
| Vehicle | 20.9 | 9.7 | 15 | 22.2 | 5.4 | 15 |
| 0.3 mg/kg | 74.2 | 28.7 | 14 | 13.8 | 3.8 | 14 |
| 1.0 mg/kg | 29.0 | 6.6 | 15 | 12.6 | 3.6 | 15 |
| 3.0 mg/kg | 63.8 | 28.3 | 12 | 16.5 | 6.2 | 13 |
| 10.0 mg/kg | 53.1 | 22.3 | 10 | 16.6 | 6.0 | 10 |
| | | | Bird 945 | | | |
| Control | 23.5 | 3.4 | 15 | 15.8 | 2.2 | 15 |
| Vehicle | 16.7 | 4.9 | 15 | 17.4 | 4.0 | 15 |
| 0.3 mg/kg | 34.1 | 17.8 | 15 | 12.0 | 4.6 | 15 |
| 1.0 mg/kg | 30.3 | 6.3 | 15 | 12.6 | 2.3 | 15 |
| 3.0 mg/kg | 4219.0* | – | 3 | 10.0 | – | 1 |

*The three values were 12,531, 14.5, and 111.1, with the latter two coming from sessions starting with the fixed ratio component. In none of these three sessions was a fixed ratio component (5 reinforcers) completed.

decreased or little affected. For control sessions, these two pauses are roughly comparable in length and therefore represent about equal tendencies to respond. The differential effect therefore is a schedule-dependent rather than rate-dependent phenomenon.

It seems of special interest that the first FR pause following an FI component was increased. Weiss and Gott [4] note the suggestive correspondence between the apparent aversiveness of periods before the start of the FR run (animals will escape from an FR schedule at this point), and the greater susceptibility of this period to an inertial effect such as increased pausing. In the present schedule, completing the five FR's may itself have been a ratio which, when completed, led to the FI component. An increased pause for the first FR would then be expected.

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