Fig. 4. Mean number of responses of experimental chicks reinforced for pecking the green key at 1, 3, or 5 days of age in an isolated or socialized group.

maturation, social facilitation, and associative learning. When the data are in total frequencies, the interpretation of good imprinting is not warranted and may be better explained in terms of associative learning. Food imprinting occurred only for the 3-day-old socialized groups when the data are transformed into percentage values.

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Discriminative effect of fixed-ratio feeder flash on DRL responding¹

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Two pigeons were initially trained under a DRL 20-sec schedule of grain reinforcement. Fixed-ratio (5 or 20) schedules of 0.5-sec magazine presentation (feeder flash) were then superimposed upon the DRL schedule. During the initial rate increase and the subsequent return to baseline, a significantly large proportion of the DRL reinforcements was obtained by the first response following a feeder flash.

Zimmerman (1963) demonstrated that when pigeons' responses on one key were reinforced with food, responding on a second key could be maintained indefinitely solely by presentations of the feeder magazine and associated stimuli for periods of time so brief (0.5 sec) as to preclude the obtaining of any food (feeder flash). In a single key situation, Randolph & Sewell (1965) superimposed a fixed-ratio (FR) 10 schedule of feeder-flash presentation upon responding maintained by a differential-reinforcement-of-low-rate (DRL) 20-sec schedule of grain reinforcement. Such a situation, in which two schedules operate simultaneously and independently on the same operandum, has been termed a conjoint schedule (Catania,

et al., 1966). Randolph & Sewell (1965) and Stubbs (1967), in a subsequent replication, found that response rate increased during probe sessions in which the conjoint schedule was in effect. This increased DRL rate was correlated with a decrease in the number of food reinforcements obtained. Pigeons with efficient, low DRL baseline rates showed lower rate increases during the probe sessions.

The present experiment was begun as part of a larger series of experiments examining the Randolph & Sewell (1965) procedure. During initial probe sessions, however, it was fortuitously noted that the pigeons were obtaining a large proportion of DRL reinforcements for the first response following the feeder flash. This relationship is not apparent from the data presented by Randolph & Sewell (1965) and Stubbs (1967). Our observation suggested that the feeder flash had discriminative properties for DRL responding, and a systematic examination of the effect was made.

SUBJECTS

The Ss were two male, experimentally naive White Carneaux pigeons. The pigeons were maintained at 80% of free feeding weight. Water was always available in the home cages.

APPARATUS

A standard pigeon chamber (Ferster &

Skinner, 1957) was located in a sound attenuating box. A Gerbrands response key was mounted in the center of the front panel, 25 cm above the wire floor, and was lit by a yellow 6-W bulb. The aperture of the grain magazine was directly below the key. A small metal "lip" at the bottom of the aperture prevented any grain from spilling out. Presentation of the magazine was accompanied by the offset of the key light, the noise of solenoid operation, and the onset of a white light located inside the magazine. This light remained on throughout the feeder cycle. Feeder cycles of two different durations were used: a 4-sec (regular) cycle and a 0.5-sec (feeder flash) cycle. White noise was continually present in the experimental room. Data were recorded on a cumulative recorder, digital counters, and a Sodeco printing counter.

PROCEDURE

All sessions were 1 h long and on consecutive days. On the first day, the birds were magazine trained, shaped to key peck, and given 25 reinforcements for pecking. On the following day, responses were reinforced under a DRL 20-sec schedule of reinforcement. Under this schedule, a response is reinforced if 20 sec or more have elapsed since the last response or since the termination of the magazine cycle if the previous response was reinforced. This schedule remained in effect until responding was judged to be stable across a 5-day period. Pigeon 9 then received 13 sessions in which an FR 10 schedule of feeder-flash reinforcement was superimposed upon the DRL 20-sec schedule for regular reinforcement (Conjoint DRL 20 FR 10). When a single

response satisfied both contingencies, the longer magazine cycle took precedence. Following these sessions, Pigeon 9 received 11 sessions under Conjoint DRL 20 FR 5. Pigeon 10 was given 7 sessions under Conjoint DRL 20 FR 10, and 18 sessions under Conjoint DRL 20 FR 20. Both birds were then given five additional sessions under the DRL 20-sec alone. During the sessions in which the conjoint schedule was in effect, it was noticed that a large proportion of the DRL reinforcements were obtained by the first response following a feeder flash, i.e., by the first response in the ratio requirement. A printing counter was then set up to record the ordinal positions in the FR of each response that satisfied the DRL requirement. Pigeon 9 was then given 15 sessions of Conjoint DRL 20 FR 5, followed by a return to the DRL 20 baseline, and 10 sessions of Conjoint DRL 20 FR 20. Pigeon 10 received 10 sessions of Conjoint DRL 20 FR 20, followed by a return to the DRL 20-sec baseline and 20 sessions of Conjoint DRL 20 FR 5. Conditions were changed only after response rates were judged stable over five sessions.

RESULTS

With regard to the effects of the introduction of the feeder-flash contingency upon overall response rate, the present experiment replicated the findings of Randolph & Sewell (1965) and Stubbs (1967). The initial effect of the feeder flash was to increase the rate of response above the DRL baseline. After a few sessions, the rate gradually returned to the baseline. Subsequent reintroductions of the feeder-flash contingency produced smaller

and more transient increases. The overall rate of DRL reinforcement was decreased only during the initial sessions of a particular conjoint schedule.

The data of most interest concern the ordinal position of food-reinforced responses within the FR of responses that produced the feeder flash (Fig. 1). Under the Conjoint DRL 20 FR 5 for both animals, it was found that the first response in the FR, i.e., a response immediately following a feeder flash, obtained the largest proportion of DRL reinforcements. A χ^2 analysis of this effect proved significant for both Pigeon 9 ($\chi^2 = 112$, $df = 4$, $p < .001$) and Pigeon 10 ($\chi^2 = 45$, $df = 4$, $p < .001$). A similar effect was observed under the Conjoint DRL 20 FR 20. Since the cell frequencies were small in this condition, a binomial comparison (continuity corrected) of the proportion of reinforcements obtained by the first response in the FR (28% for Pigeon 9 and 25% for Pigeon 10) to the proportion of reinforcements obtained by the other 19 responses in the FR was made. This former proportion was greater than expected from chance alone for both animals ($z = 4.97$, $p < .001$; $z = 16.3$, $p < .001$).

The proportion of reinforcements obtained by a response following a feeder flash remained high across sessions under both the Conjoint DRL 20 FR 5 and the Conjoint DRL 20 FR 20 schedules.

DISCUSSION

The present data indicate that pauses of sufficient duration to satisfy the DRL requirement were more likely to follow responses that produced the feeder flash than to follow responses that did not produce the feeder flash. This finding was independent of the changes in overall rate of responding that were produced by the superimposition of the FR feeder-flash contingency, since this relationship was found both during the initial rate increases under the feeder-flash condition, and later during the subsequent return to baseline rate of responding.

Since the feeder flash was presented according to FR schedules, it may be suggested that the pause following a feeder flash is an instance of postreinforcement pauses generally found in FR schedules (Ferster & Skinner, 1957). When the feeder flash was first presented, rates were high, with a pattern marked by a rapid burst of responses until the feeder flash occurred, followed by a pause. Occasionally, the pause exceeded the 20-sec DRL value, so that the next response (the first response after the feeder flash) was reinforced. Over time, the feeder-flash stimuli may have acquired discriminative properties for pausing because, even after response rates

had dropped to near baseline levels, a large proportion of reinforcements continued to be obtained by the first response following a feeder flash.

It could be argued that, initially, the feeder flash would control behaviors, such as moving toward the magazine, which are incompatible with key pecking. To the extent that engaging in behaviors incompatible with key pecking makes more likely the occurrence of a pause of sufficient duration to meet the DRL requirement, these behaviors might become part of a chain of behaviors that terminates with a reinforced response. Casual observation revealed, however, no indication that the presentation of the feeder flash was consistently followed by such a chain of behaviors (see also Zimmerman & Hanford, 1966).

The feeder flash also provides feedback (cf. Staddon, 1969) concerning the duration of the preceding interresponse time (IRT), i.e., the occurrence of the feeder flash provides an exteroceptive stimulus to indicate that the preceding IRT was too short to satisfy the requirement for food reinforcement. It is difficult, however, to see why the feedback effect of the feeder flash would serve to lengthen mainly the subsequent IRT rather than all IRTs. Overall DRL performance should improve if the general effect of feedback is to lengthen IRTs, and this was not the case.

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NOTES

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Fig. 1. Per cent of total DRL reinforcements obtained by each response in the feeder-flash ratio under Conjoint DRL 20 FR 5.