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SAMPLE-SPECIFIC RATIO EFFECTS IN MATCHING TO SAMPLE

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In a symbolic matching-to-sample task, pigeons were trained using sample-specific, fixed-ratio "observing responses." Subsequently, in a mixed condition, each sample was presented equally often with each ratio requirement, i.e., the ratios were no longer correlated with the samples. In a second experiment, pigeons were trained initially in the mixed condition and subsequently shifted to the sample-specific condition in which the required ratios were correlated with the samples. Results of both experiments suggested joint control of choices by ratio value and by the exteroceptive stimuli. The discriminative properties of the ratios appeared to outweigh absolute ratio-size effects.

Key words: symbolic matching to sample, sample-specific responses, discriminative ratios, conditional discrimination, compound control, key pecks, pigeons

In the conventional three-key matching-to-sample procedure, the number and pattern of required pecks to the center key importantly affect matching accuracy. For example, Eckerman, Lanson, and Cumming (1968) reported greater accuracy when pecks to the sample key were required compared to the absence of such required pecks. Other investigators have reported that increases in the number of responses required on the sample key increases matching accuracy (e.g., Sacks, Kamil, & Mack, 1972; Wilkie & Spetch, 1978).

Additional studies have reported that sample-specific response requirements facilitate matching accuracy. Cohen, Looney, Brady, and Aucella (1976) imposed two different response requirements in the presence of two sample stimuli, respectively (e.g., DRL 3-sec in the presence of a green sample and FR 16 in the presence of an orange sample). Acquisition of matching was facilitated in this condition compared to conditions with nondifferential response requirements. Other studies have reported similar results (Lydersen & Perkins, 1974; Urcuioli & Honig, 1980) and suggest that response-produced stimulation from the sample-specific behavior constitutes a strong source of control of subsequent choice responses. Specifically, Lydersen and Perkins (1974) suggested that the functional sample may be a compound comprised of the schedule-induced response feedback and the exteroceptive stimulus on the sample key. On the other hand, Urcuioli and Honig (1980) and Cohen, Brady, and Lowry (1981) suggest that the response-produced feedback overshadows the exteroceptive stimulus and controls subsequent choice, at least within the conditions of their respective experiments.

The present experiments were undertaken to extend the generality of the above-mentioned experiments in several ways. First, the above-mentioned studies of sample-specific responses used only two distinct response requirements (e.g., DRL and FR), thus precluding the possibility of observing "graded" control by the response-produced feedback. Such stimulation, produced by meeting schedule requirements, may have graded or continuous properties similar to some dimensions of exteroceptive stimuli (see Hobson, 1975; Pliskoff & Goldiamond, 1966; Rilling & McDiarmid, 1965). Hence, we used three sample-specific response requirements (FR 3, FR 23, FR 51). If a particular sample is correlated with an FR-3 requirement during acquisition, subsequent presentation of that sample with an FR-23 requirement might show diminished control of choice responding. Presenting the same sample with an FR-51 requirement may show even less control of the subsequent choice response. Second, the above-mentioned experiments used between-subject designs; we used a within-sub-

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ject design that could extend the generality of prior findings.

A symbolic matching-to-sample task was used in the present experiments because some data in Cohen et al. (1976) and data presented by Ruhl and Paul (Note 1) suggested that in an identity matching task, with different schedule requirements for the different samples, an early preference is induced for those comparison hues that have the more favorable schedule when they appear as the sample (i.e., a low ratio required to a particular sample hue increases the likelihood that that hue will be pecked when it appears as a comparison stimulus). This preference would alter accuracy differentially, increasing it for choice stimuli that match a sample requiring a low ratio and decreasing it for choice stimuli that match a sample requiring a high ratio.

In Experiment 1, pigeons were trained on a zero-delay, symbolic matching task with a different ratio required for each of the three sample stimuli. After asymptotic performance was achieved, each of the three samples appeared equally often with each of the three ratio requirements.

EXPERIMENT 1

METHOD

Subjects

Three White Carneaux pigeons, with prior autoshaping histories, were maintained at 80% of their free-feeding weights. One pigeon, No. 44, died shortly after completing training on the correlated condition; therefore, his data are presented for only this condition.

Apparatus

The experimental chamber was made of plywood, with sound-insulating material between the inner and outer walls of each of the six sides of the chamber. The inside dimensions of the chamber were the same as those of the Lehigh Valley Electronics chamber and accommodated a BRS three-key panel. Behind each of the transparent keys was an IEE 12-stimulus projector containing No. 44 bulbs. Mounted in the rear wall of the chamber was a fan that provided ventilation and masking noise. Experimental contingencies were controlled by a "bread board" containing TTL chips and by a tape reader. Control equipment was located in a room adjacent to that housing the experimental chamber.

Procedure

The initial phase of training consisted of random presentation of the three form stimuli to be used as samples on the center key; a single peck on this key produced 4.5-sec access to the food hopper, which contained mixed grain. Gradually the response requirement to each of three stimuli was increased to FR 60, and access to the food hopper was gradually decreased to 2.3 sec.

Correlated Training

The matching trials consisted of presentation of one of the three sample stimuli (square, ex, circle) on the center key. When the specified ratio was reached for the respective sample stimuli (FR 3 to the square, FR 23 to the ex, FR 51 to the circle) the center key became dark and simultaneously the two side keys were lighted with the comparison stimuli. These stimuli were nominally blue, red, and green. The stimuli on the two side keys were always different from one another (red-blue, blue-green, green-red). For two pigeons, the conditionalities were such that when the sample was square, ex, or circle, a single peck on the side key showing green, red, or blue, respectively, was designated correct and produced 2.3-sec access to the food hopper. A response to the alternate (nonmatching) color produced an 8.7-sec blackout during which all lights in the chamber were off. Following either a reinforcement or a blackout, an intertrial interval of 7.2 sec preceded the onset of the center key for the next trial. No houselight was used.

Each color served as the correct and incorrect alternative equally often and appeared equally often on the left and right side keys. With three sample stimuli and three comparison colors balanced for left-right presentation, there are 12 sample-comparison configurations possible. The 12 configurations were arranged in randomized blocks, with the constraints that the correct stimulus alternative could not occur on the same side on more than three consecutive trials. Eight such randomized blocks were arranged for a total of 96 trials. For reasons irrelevant to the experiment, the blocks of 96 trials were run irregularly: on some days two or three blocks of 96 trials were run consecutively, whereas on other days, one or no block

was run. Casual inspection of the data did not suggest greater variability between running days than within. Each block of 96 trials, for convenience, will be referred to as a session.

Mixed Condition

After performance under the conditions described above achieved asymptote, the mixed condition was introduced. In the mixed condition, each of the three ratios (3, 23, 51) was scheduled equally often in the presence of each of the sample stimuli. Thus, the ratio that would turn off the sample stimulus was nonpredictive with respect to the correct comparison stimulus. To accommodate a full counter-balancing of ratios, sample stimuli, and left-right position of comparison stimuli, the number of trials per session was increased to 108.

The first 12 sessions alternated between the correlated condition and the mixed condition; thereafter, sessions under only the mixed condition were run until performance appeared asymptotic.

Results and Discussion

Figure 1 shows acquisition performance for the three sub-problems comprising the matching task. All three pigeons showed somewhat faster acquisition when the smallest ratio (FR 3) was required on the center key. The two center-key stimuli correlated with the intermediate ratio (FR 23) and the highest ratio (FR 51) did not systematically differ from one another in the accuracy levels they controlled. Thus, matching was not more accurate in the higher as compared to the lower ratio subproblems. This finding suggests that the high-ratio facilitation effect, described in the introduction, is limited to procedures using simple rather than multiple schedules on the sample key.

Figure 2 shows performance in the mixed-ratio condition, under which each sample stimulus occurred equally often with each ratio requirement. A series of alternated sessions shows that performance within the session drops quickly as soon as the mixed condition is introduced. Further, the correlated-condition performance is quickly recovered (within the session) as soon as that condition is introduced. Figure 2 also shows that exposure to a relatively large number of mixed-ratio sessions resulted in apparent asymptotic performance,

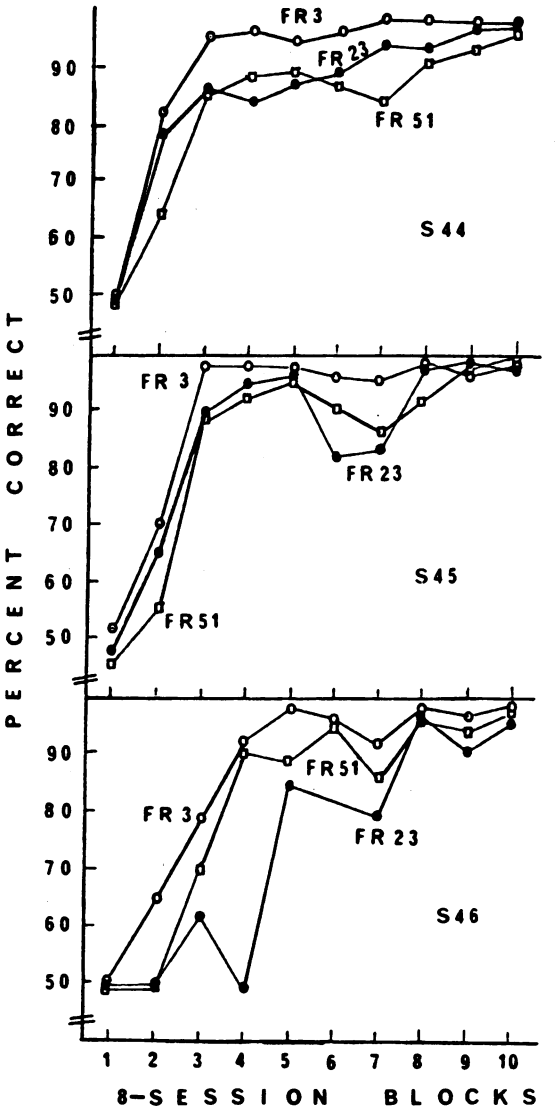

Fig. 1. Acquisition of performance for the three subproblems of the correlated condition.

well below that seen in the correlated condition.

In the mixed condition, with three ratios and three sample stimuli, there are nine cells or types of trials, three of which represent the stimulus-ratio relation that held in the prior correlated condition. Performance on these correlated trials was superior to that on the uncorrelated trials. The overall performance in the mixed condition appeared to result from an averaging of performance under the correlated-type trials and the novel trials. This suggests that the originally required ratios gained discriminative control of choice responses and

that this control was maintained well into the mixed condition.

Figure 3 shows the relation between the originally required ratio on each sample and performance on that sample under the mixed-ratio condition. It can be seen that performance is more accurate under the originally required ratio than under other ratios. Further, there appears to be a generalization function, seen most clearly for Bird S-46 with the square and with the circle samples. Performance with the square sample, originally requiring an FR 3, is most accurate when it occurred with an FR-3 requirement and least accurate when it occurred with an FR-51 requirement. Similarly, performance with the circle sample, originally requiring an FR 51, was most accurate when it occurred with an FR-51 requirement. Accuracy controlled by these samples was intermediate when they appeared with the intermediate ratio. These observations suggest that the ratios functioned, at least crudely, as a stimulus dimension partially controlling choice of comparison stimuli. The figure suggests a gradient of ratio control similar to a generalization gradient; since such gradients indicate stimulus control, one would conclude that responses to the comparison stimuli were at least partly controlled by the ratio (or some correlated feature of it) originally required to its respective sample stimulus.

EXPERIMENT 2

In Experiment 1 pigeons were exposed to the correlated condition at the beginning of training and the differential sample-required ratios gained discriminative control of choice responses. The effects of ratio size per se seemed to be obscured by their discriminative properties as well as by a possible ratio-induced preference effect. Further, accuracy during the mixed condition was lower than that in the correlated condition and did not improve over a reasonably large number of sessions. It is not clear whether this low asymptote is due to prior training in the correlated condition or is a property of the mixed condition.

Experiment 2 addressed the considerations above by training different pigeons first under a mixed condition and then introducing the correlated condition. The mixed condition was then reintroduced. Thus, the latter two conditions provided a replication of Experiment 1.

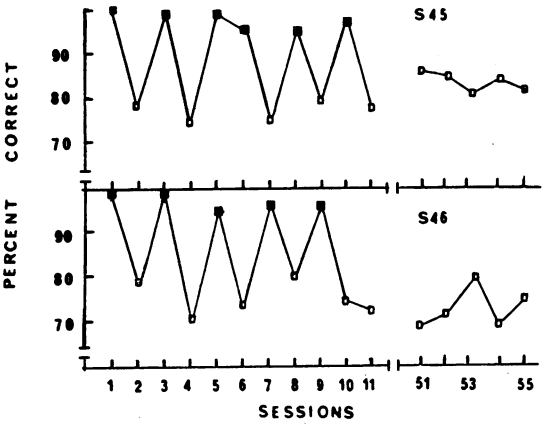

Fig. 2. Left side of the figure shows performance on alternating sessions of correlated and mixed conditions; right side shows last five sessions of mixed condition. Filled squares show correlated condition and unfilled squares show mixed condition.

METHOD

Subjects

Three White Carneaux pigeons, different from those used in Experiment 1, were maintained at 80% of their free-feeding weights. An apparatus failure late during the correlated condition occurred for Bird 87. A strong position bias developed and made subsequent data for this subject unusable.

Apparatus

Same as Experiment 1.

Procedure

The details of the procedure were the same as Experiment 1 except that after initial training on the FR 60 to the three sample stimuli, matching trials were given under the mixed condition. When performance reached asymptote, the correlated condition was introduced, after which the mixed condition was reintroduced.

RESULTS AND DISCUSSION

Figure 4 shows performance in the mixed condition for the different sub-problems. Although performance is variable, it can be seen that the lowest accuracy level occurred when an FR 3 terminated the sample stimulus. Indeed, little improvement was manifest over a reasonably large number of sessions. The curves for the higher ratios (FR 23, FR 51) appear close together with no clear indication that performance was more accurate under the

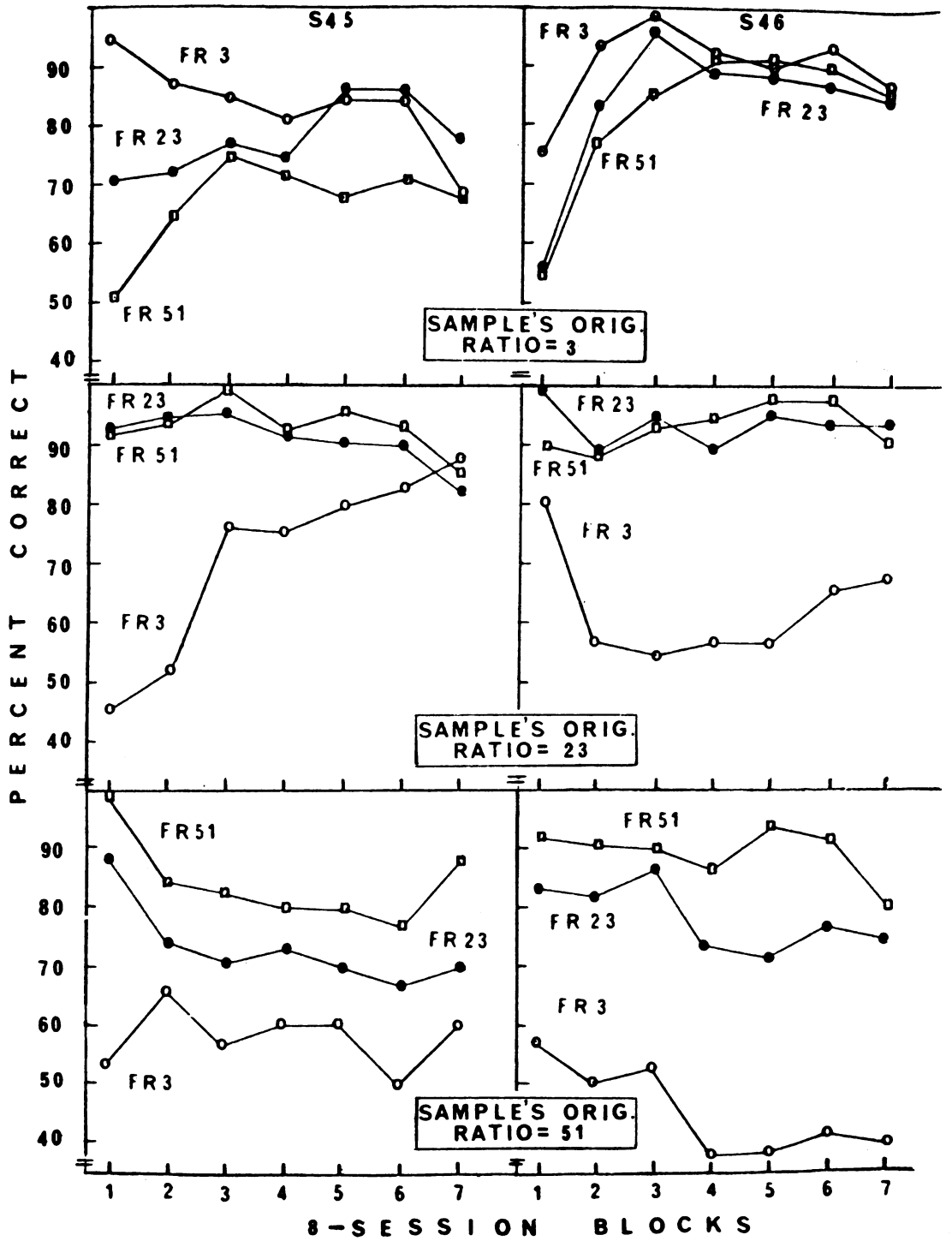

Fig. 3. The effect of each sample with each of the three ratios, in the mixed condition, on percentage correct. The ratio required to each sample during the prior correlated condition is indicated within the figure.

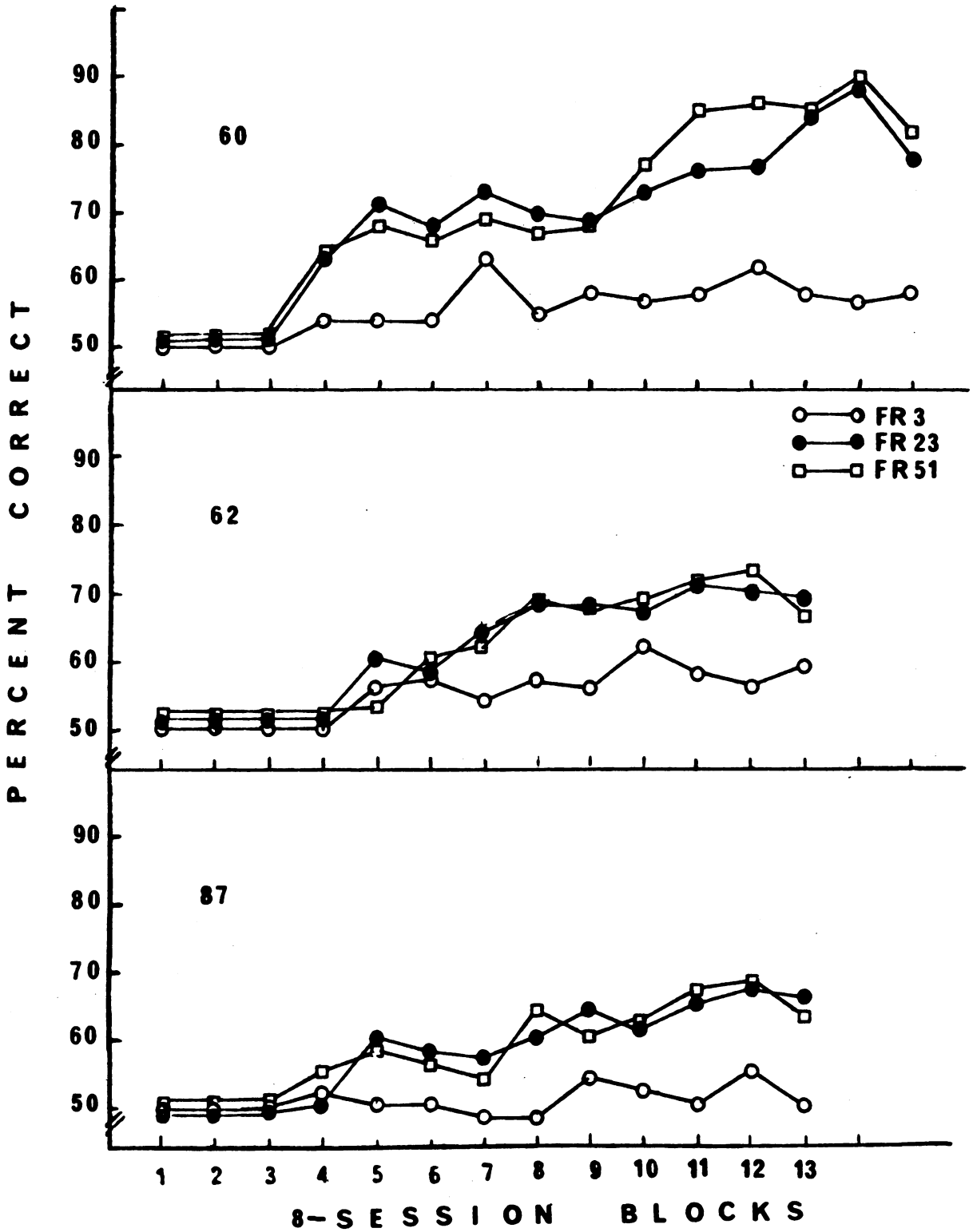

Fig. 4. Acquisition of the three sub-problems in the mixed condition of Experiment 2.

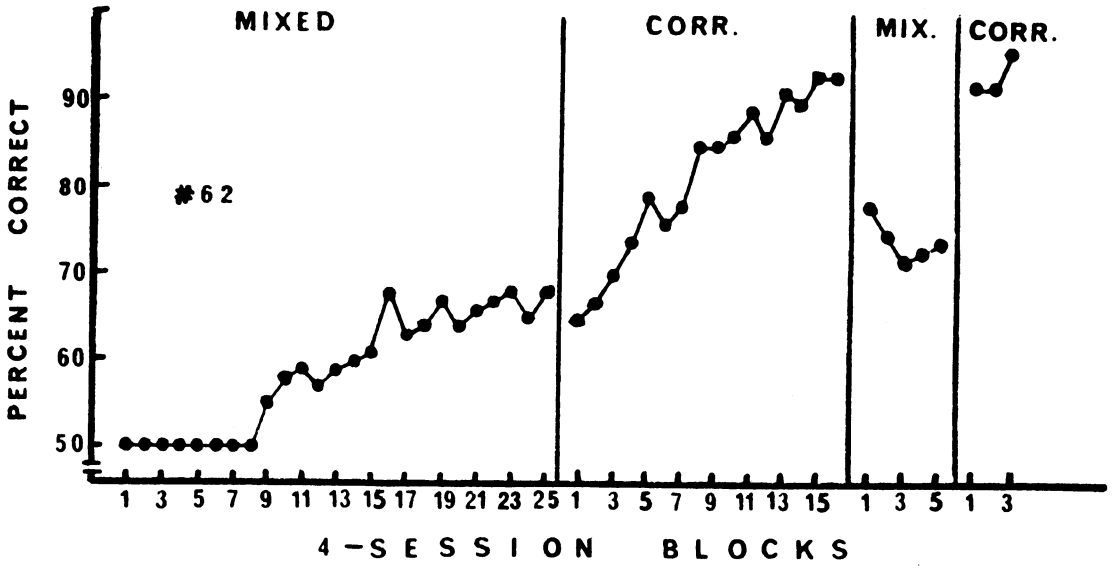

Fig. 5. Performance during the mixed and correlated conditions of Experiment 2.

FR-51 than under the FR-23 requirement. Thus, although this particular task yielded rather variable data (see also Lydersen & Perkins, 1974), there is some evidence that the high ratios facilitated matching accuracy in the within-subject procedure. However, there is no indication of a continuous function relating accuracy to ratio size. With respect to one of the questions generated by Experiment 1, the answer seems clear: A relatively low overall asymptote is produced by the mixed condition and is not dependent upon a prior history of training under the correlated condition.

Figure 5 shows, for Bird 62, the changes in percentage of correct responses under the mixed and correlated conditions. The same changes were shown by the other two birds, but these birds were not exposed to the final correlated condition (i.e., Bird 62 was exposed to the conditions in an ABAB sequence, whereas Birds 60 and 87 were exposed only to ABA). The changes in accuracy from the mixed to the correlated condition replicate the results of Experiment 1.

In the mixed condition of Experiment 1, control by a sample was generally stronger on those trials where that sample occurred with its previously required (in the correlated condition) ratio than on trials when the sample occurred with an alternative ratio requirement. Figure 6 shows that the same effect occurred in the second exposure to the mixed condition.

GENERAL DISCUSSION

A number of previous experiments (e.g., Cohen et al. 1976; Cohen et al., 1981; Lydersen & Perkins, 1974; Urcuioli & Honig, 1980) indicated that sample-specific response requirements, on the center key, facilitated matching-to-sample performance. In the present experiments, matching performance was more accurate when sample-specific ratios were required on the center key than when the three ratios were required equally often to each sample. Thus the present experiments, using a within-subject design and three rather than two samples, extend the generality of prior work. In addition, the present results suggest that the ratios used as sample-specific responses functioned, at least crudely, as a controlling stimulus dimension. The present results do suggest at least one difference from some of the prior studies. Cohen et al. (1981) and Urcuioli and Honig (1980) proposed that, within the context of their respective experiments, the sample-specific responses produced feedback stimuli that controlled subsequent choice responses and virtually overshadowed the exteroceptive, key stimuli. In the present experiments several observations indicate that the key stimuli were indeed effective. First, above-chance matching when the ratios were uncorrelated with the samples indicates some control by the samples. Second, the generalization-like

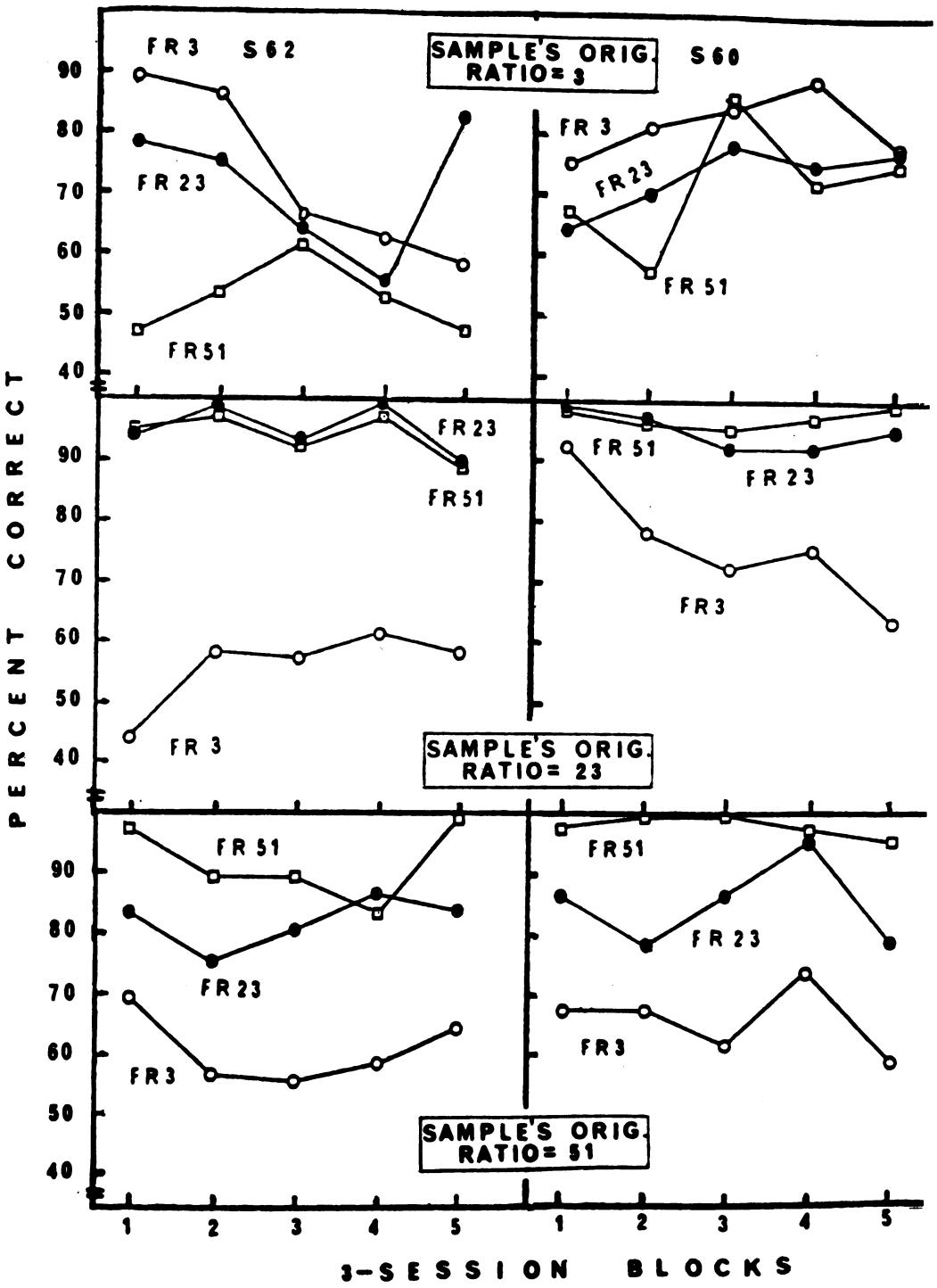

Fig. 6. The effect of each sample with each of the three ratios, in the reinstated mixed condition, on percentage correct. The ratio required to each sample during the prior correlated condition is indicated within the figure.

functions suggested by Figures 3 and 6 imply joint control by the ratio and the samples. Finally, cumulative records, not presented in this paper, showed reliable preresponse pauses when the stimulus requiring the highest ratio was presented in the correlated condition. Despite these indications of discernible control by the sample stimuli, it must be noted that accuracy in the mixed condition was unexpectedly low, whether the mixed condition preceded or followed the correlated condition. Hence, the tendency for the ratios, which were unreliable predictors of correct comparison stimuli, to interfere with control by the sample stimuli may be compatible with some form of the overshadowing concept.

REFERENCE NOTE

1. Ruhl, V., & Paul C. *The effect of fixed-ratio sample requirements on the acquisition of matching-to-sample in pigeons.* Paper presented at the convention of the Eastern Psychological Association, Washington, D.C., 1978.

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